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BARBARA JANKOWSKA, ANNA MATYSEK-JĘDRYCH
KATARZYNA MROCZEK-DĄBROWSKA

Efficiency of National Innovation Systems – Poland and Bulgaria in The Context of the Global Innovation Index

Abstract

The purpose of this paper is to explain how national innovation systems may transform innovation input into innovation output in different counties. Using the Global Innovation Index (GII) we discuss what can be understood by the term 'innovation' and how it is translated into the national level. The research question is founded on the assumption that the higher the innovation input, the higher the innovation output attained by a country. We use cluster analysis to verify our assumption, referring to a total of 228 countries. Afterwards we conduct a more in-depth analysis of two cases (Poland and Bulgaria), where the research question does not find confirmation. Using the cross-comparison method we aim to verify how and why national innovation systems failed (or succeeded) in creating innovations.

Keywords: *national innovation system, Poland, Bulgaria, Global Innovation Index*

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[*] Ph.D., Professor at the Poznań University of Economics and Business, Department of the International Competitiveness, e-mail: barbara.jankowska@ue.poznan.pl

[**] Ph.D., Assistant Professor at the Poznań University of Economics and Business, Department of the International Competitiveness, e-mail: anna.matysek-jedrych@ue.poznan.pl

[***] Ph.D., Assistant Professor at the Poznań University of Economics and Business, Department of the International Competitiveness, e-mail: katarzyna.mroczek-dabrowska@ue.poznan.pl

1. Introduction

The background for concept of innovation can be found in the writings of Schumpeter, and his insistence that innovation revolutionizes the world through ‘the process of creative destruction’ (Schumpeter 1934, 1943). Innovation (through creation, then diffusion, and finally use of knowledge) has been perceived as a key driving force for economic growth. It also provides – at least in part – a response to many societal, technological and business challenges.

However, innovation was not only an issue in scientific and political discussions, but found reflection in economic theory as well. One might observe an intense increase in the popularity of studies of innovation as well as of the endogenous growth theory, in which knowledge, infrastructure, and innovation play a key role in spatial dynamics (Lucas 1988, Romer 1990, Stimson et al. 2002, Reggiani and Nijkamp 2009).

Innovation has been a driving force of the economic transformation in Central and Eastern European countries which commenced in the 1990s. However, at the beginning of this process the Central and Eastern European countries had to rely only on innovation (new technologies and ideas) which originated not from home-owned companies, but from the investment decisions of multinational corporations. This dependence made the whole region vulnerable and this forced governments, universities, as well as businesses to improve the environment for home-grown innovation.

The Central and Eastern European countries (as well as other emerging and developing economies) designed policies (and entire national innovation systems) aimed at increasing their innovation capacity and creating competitive advantages. These innovation policies have varied across countries, in relation to the elements playing active role in the process, the intensity of relations between these elements, institutional arrangements. This should come as a surprise, since innovation policies need to be context-specific, reflecting the heterogeneity among countries and countries’ patterns of development (Chaminade, Beng-Åke, Joseph 2009, Gault 2010). The impact of innovation policy has also varied, even at similar levels of development.

The remainder of this paper is organized as follows: We begin with a short overview of the literature, with a focus on national innovation systems, innovation policy, and their efficiency. Section 3 is devoted to a presentation of the methodology and variables used for assessing the efficiency of national innovation policies, while Section 4 presents the results of this assessment with the use of statistical methods like cluster analysis. Sections 5 and 6 discuss two cases of national innovation policy and its efficiency – in Poland and Bulgaria. Finally, Section 6 concludes by summarizing our results and outlining the remaining questions which should be addressed by different actors involved in national innovation systems and policies.

2. Literature review and the research question

A national innovation system (NIS) – as conceptual framework – is usually interpreted as a specific network or set of linkages among the actors involved in innovation processes, whose interactions determine the innovation performance (i.e. efficiency) (cf. Freeman 1987, Nelson 1993, Metcalfe 1995, Numminen 1996). This concept has attracted the attention of many researchers and politicians working on new architectures of the knowledge-based economies of both developed and developing countries (Foray 1994, Correa 1998, Lundvall 1998). The concept *per se* forced economists and policy makers to put emphasis on national policy strategies, in which knowledge and learning mechanisms are perceived as important factors enhancing the international competitiveness of domestic companies, industries and markets (Lundvall 2005). In this case, innovation policy (more specifically national innovation policy) can be treated as an element embedded into the broader innovation system. The term 'innovation policy' may however be interpreted in different ways. According to Edquist (2004) it may be defined broadly (as all policies that have any impact on innovation) or narrowly (as policy decisions and instruments created with the intent to effect innovation). Nevertheless, as we are interested in assessing the efficiency of national innovation systems (as well as policies), the former definition seems to be more appropriate for our purposes.

The literature, as well as political discussions, seem to be optimistic in the case of a NIS, usually taking for granted that the system is set of institutions facilitating the creation and diffusion of knowledge, i.e. the process of learning. The conditions for improving learning effectiveness within an organization, such as an individual firm, have been intensively examined by management studies (cf. Cohen and Levinthal 1990, Dodgson 1993, Nonaka and Takeuchi 1996, Goh and Richards 1997), and the government learning process has been also studied. However, in relation to the latter aspect, scientists have concentrated more on identifying those organizational features that impede the learning process of government organizations (Gick 1998, Carayannis, Alexander and Ioannidis 2000, Scott 2003). Since the main actors of in a NIS consist of numerous institutions and linkages between them, there is a lot of space for non-optimal operations, e.g. providing the wrong incentives, providing faulty information, allocation of insufficient resources, or fuelling conflicts. Niosi (2002) called this phenomenon the x-efficiency (and x-effectiveness) of national innovation systems.

The concept of national innovation system efficiency is directly connected with the twin concept of productivity. An innovation system (or more narrowly – policy) is perceived to be efficient based on certain conditions: first, when with the same amount of innovation inputs generate more innovation outputs; second, when less innovation inputs are needed to create the same amount of innovation outputs (Niosi et al. 1993, Hollanders and Esser 2007, The Global Index of Innovation 2015).

There is of course a problem with selecting innovation inputs and outputs, especially in context of a comparative study. Almost all measures of innovation inputs implicitly or explicitly include an element of increasing R&D spending (or creating the conditions for increasing R&D spending). Some of these inputs were extensively analysed in empirical studies. Köhler, Laredo and Rammer (2012) review the experience of private sector R&D tax incentives and present findings that the use of this instrument is an important innovation input for achieving innovation policy objectives. Other innovation inputs were examined by Cunningham and Gök (2012), who present evidence on the effectiveness of publicly supported schemes that aim to enhance and promote collaborative innovation activities between private companies, research institutes and universities. A similar approach to innovation input can be found in the Rigby and Ramlogan (2013) survey of publicly supported policies that develop and promote entrepreneurship. A principal objective of this policy is to increase the level of entrepreneurship activity (with innovation being a consequence of entrepreneurship) to the country's optimum level. The three empirical studies mentioned above have one common feature – the authors use a qualitative approach to assess innovation inputs. While this approach is valuable, for practical reasons it cannot be used in a comparative dynamic analysis.

Innovation inputs cover a wide range of factors including, among others (OECD 2006) stable macroeconomic conditions, the availability of internal and external finance, expansion in public research, reduction of anti-competitive regulations, tax incentives, and openness to foreign R&D. Similarly, innovation outputs can be defined by different elements that can be perceived as the result of innovation within an economy (e.g. number of patents, number of trademarks, share of sales in innovative products, etc. (Mairesse, Mohnen 2002).

The concept of basing national innovation system efficiency on innovation inputs and outputs has been applied in the Global Innovation Index (GII) report prepared jointly by Johnson Cornell University, INSEAD, and WIPO. Since the GII 2015 report covers 141 economies around the world, it is a useful and rich dataset for comparing innovation efficiency and identifying innovation trends at both the national and global levels. The dataset presented in GII 2015 is also used in this article to identify: firstly, the efficiency of national innovation systems and policies; and secondly, the relationship between the efficiency of a NIS and competitiveness in selected countries.

This paper is related to the growing literature on national innovation systems, policies, and the efficiency and competitiveness of nations. In the rest of paper we are guided by the following research question: Does higher innovation input always go hand-in-hand with higher innovation output? The analysis is aimed at identifying those countries which had high (medium or low) innovation input, meaning they were well (moderately or poorly) equipped to create innovation output; and to verifying which of the countries did not match this pattern, i.e. although they were well (moderately, poorly) equipped, they performed worse (or better) than expected.

3. Methods and variables

In order to investigate whether the perceived level of innovation input translates into the level of innovation output, we applied a two-step clustering technique and descriptive statistics. Firstly, a hierarchical cluster analysis based on Ward's minimum variance technique was carried out in order to identify the most stable number of clusters for each proposed solution. Secondly, a K-means cluster analysis was performed to verify the hierarchical cluster analysis. Both the Ward's minimum variance technique and the K-means cluster analysis have been performed separately for input and output variables respectively.

Table 1. Variables applied for the K-means cluster analysis

Variable	Description
Input innovation	
Institutions	Index composed of assessment of the political environment, regulatory environment, and business environment
Human capital and research	Index composed of the assessment of education, tertiary education, and research and development
Infrastructure	Index composed of the assessment of information and communication technologies, general infrastructure, and ecological sustainability
Market sophistication	Index composed of the assessment of credit, investment, and trade and competition
Business sophistication	Index composed of the assessment of knowledge workers, innovation linkages, and knowledge absorption
Output innovation	
Knowledge and technology outputs	Index composed of the assessment of knowledge creation, knowledge impact, and knowledge diffusion
Creative outputs	Index composed of the assessment of intangible assets, creative goods and services, and online creativity

Source: own study based on the Global Innovation Index.

The analysis is designed to group entities into internally homogenous and externally heterogeneous clusters. In order to check the differences between the variables in relation to the generated clusters, the F-test was applied. The F-values indicate whether the level of dispersion of a particular variable within one group is greater or smaller than in the underlying data sample, i.e. if $F>1$ (or $F<1$), then the group variance of the variable is greater (or smaller) than in the underlying entire data sample. This makes it possible to illustrate how strongly the particular variables differentiated particular clusters at the significance level of $p=0.05$. The variables applied in cluster analysis are described in Table 1 above.

The variables are based on secondary data and have been derived from the Global Innovation Index, developed jointly by the Johnson Cornell University, the

Business School for the World, and the World Intellectual Property Organization. The data has been prepared using mostly objective, quantitative indicators and index data that were afterwards supplemented by subjective measures obtained via surveys (Dutta, Lanvin and Wunsch-Vincent 2015). The clustering analysis was applied to 228 countries covering all the major regions of the world. The Global Innovation Index 2015 refers to the most recent data available; however in some particular sub-indexes they do not invoke the year 2014 as information for that period is yet unknown (Dutta, Lanvin and Wunsch-Vincent 2015).

4. Results of K-means clustering

In order to determine the appropriate number of clusters, we examined the fusion curve in the clustering processes and the dendograms. In our study we used the Euclidean distance and Ward's method. Since the results came in as inconclusive (as to whether use 3 or 4 clusters), we applied an additional measure suggested by Mojena (1977), known as the upper tail rule. According to this rule we selected the first number of groups that satisfied the Mojena's equation, which in our case amounted to 3 (both for the case of input and output innovation). Looking at the descriptive statistics we divided the groups into high, medium, and low innovation input; and with the second clustering into high, medium and low innovation output (Table 2).

In assessing the magnitude (and significance levels) of the F values in the first analysis (input innovation), we discovered that institutions and market sophistication were the variables which constituted the most significant criteria for assigning countries to clusters. Similarly, in the second analysis knowledge and technology outputs gave more weight to the division.

Table 2. Means for input and output measures in respective clusters

Variable	High innovation cluster*	Medium innovation cluster*	Low innovation cluster*	F-value	Signific. p
Input innovation					
Institutions	81.23044	52.84947	0.00000	1764.223	0.00
Human capital and research	47.42826	23.05895	0.00000	676.187	0.00
Infrastructure	54.21522	32.01368	0.00000	1025.07	0.00
Market sophistication	58.40870	43.78842	5.60000	1324.807	0.00
Business sophistication	45.71087	30.80842	16.70000	333.993	0.00

Variable	High innovation cluster*	Medium innovation cluster*	Low innovation cluster*	F-value	Signific. p
Output innovation					
Knowledge and technology outputs	45.09487	23.02609	1.08866	854.3764	0.00
Creative outputs	49.50513	28.48043	16.30515	365.5014	0.00

* *– data on each particular country comprises a score (0–100), with 0 being the lowest and 100 the highest value. Therefore clustering means suggest on average how well (poorly) a particular cluster performed in each criteria*

Source: own study.

The aim of our analysis was to determine which countries had high (medium or low) innovation inputs, meaning they were well (moderately or poorly) equipped to create innovation output (Table 3). Secondly, we intended to verify which of the countries did not match the pattern, i.e. although they had been well (moderately, poorly) equipped they performed worse (or better) than expected. Observing these inequalities enabled us to choose the economies for further, qualitative analysis.

Table 3. Members of the clusters in the innovation input and output analysis

Cluster	Input innovation	Output innovation
High innovation cluster	Finland, Singapore, Norway, Denmark, New Zealand, Canada, Netherlands, Hong Kong (China), Sweden, Switzerland, Australia, Austria, Iceland, United Kingdom, Ireland, United States of America, Japan, Luxembourg, Belgium, Germany, France, Estonia, Malta, Portugal, Mauritius, United Arab Emirates, Barbados, Cyprus, Slovenia, Qatar, Latvia, Czech Republic, Republic of Korea, Poland, Spain, Slovakia, Chile, Italy, Lithuania, Hungary, Croatia, Malaysia, Greece, Israel, Saudi Arabia, China	Finland, Singapore, Norway, Denmark, New Zealand, Canada, Netherlands, Hong Kong (China), Sweden, Switzerland, Australia, Austria, Iceland, United Kingdom, Ireland, United States of America, Japan, Luxembourg, Belgium, Germany, France, Estonia, Malta, Portugal, Barbados, Slovenia, Latvia, Czech Republic, Republic of Korea, Spain, Slovakia, Italy, Hungary, Malaysia, Bulgaria, Israel, Republic of Moldova, China, Viet Nam
Medium innovation cluster	South Africa, Oman, Bulgaria, Romania, Montenegro, Botswana, Seychelles, Uruguay, Georgia, Namibia, TFYR Macedonia, Costa Rica, Armenia, Bahrain, Jamaica, Mongolia, Rwanda, Trinidad and Tobago, Bhutan, Serbia, Jordan, Mexico, Kazakhstan, Peru, Albania, Bosnia and Herzegovina, Tunisia, Panama, Lesotho, Republic of Moldova, Kuwait, Colombia, Morocco, Capo Verde, Azerbaijan, Russian Federation, Swaziland, Tanzania,	Mauritius, United Arab Emirates, Cyprus, Qatar, Poland, Chile, Lithuania, Croatia, South Africa, Oman, Romania, Greece, Montenegro, Botswana, Seychelles, Uruguay, Georgia, Namibia, TFYR Macedonia, Costa Rica, Armenia, Bahrain, Jamaica, Mongolia, Rwanda, Trinidad and Tobago, Serbia, Jordan, Mexico, Kazakhstan, Saudi Arabia, Peru, Albania, Bosnia and Herzegovina, Tunisia, Panama, Lesotho, Kuwait, Colombia,

Cluster	Input innovation	Output innovation
	Turkey, Brazil, El Salvador, Guyana, Fiji, Senegal, Uganda, Thailand, Dominican Republic, Belarus, Lebanon, Kenya, Burkina Faso, Ukraine, Madagascar, Nicaragua, Viet Nam, Philippines, Malawi, India, Kyrgyzstan, Uzbekistan, Zambia, Cambodia, Ghana, Guatemala, Argentina, Paraguay, Côte d'Ivoire, Gambia, Togo, Mozambique, Ethiopia, Burundi, Niger, Algeria, Nepal, Mali, Honduras, Ecuador, Cameroon, Iran, Tajikistan, Sri Lanka, Bangladesh, Indonesia, Egypt, Guinea, Nigeria, Pakistan, Angola, Yemen, Myanmar, Sudan, Bolivia, Zimbabwe, Venezuela	Morocco, Cabo Verde, Russian Federation, Azerbaijan, Tanzania, Turkey, Brazil, El Salvador, Guyana, Senegal, Uganda, Thailand, Dominican Republic, Belarus, Lebanon, Kenya, Burkina Faso, Ukraine, Madagascar, Philippines, Malawi, India, Kyrgyzstan, Uzbekistan, Zambia, Cambodia, Ghana, Guatemala, Argentina, Paraguay, Côte d'Ivoire, Gambia, Mozambique, Ethiopia, Algeria, Mali, Honduras, Ecuador, Cameroon, Iran, Tajikistan, Sri Lanka, Bangladesh, Indonesia, Egypt, Nigeria, Pakistan, Angola, Yemen, Myanmar, Bolivia, Zimbabwe, Venezuela
Low innovation cluster	Gabon, Syrian Arab Republic, Iraq, Belize, Suriname, Tonga, Afghanistan, Chad, Mauritania, Haiti, Isle of Man, Channel Islands, Gibraltar, Sierra Leone, Djibouti, Saint Lucia, Antigua and Barbuda, Central African Republic, Democratic Republic of Congo, Papua New Guinea, Saint Vincent and the Grenadines, Congo, Samoa, Eritrea, Solomon Islands, Vanuatu, Libya, Liberia, Guinea Bissau, Maldives, Saint Kitts and Nevis, Timor-Leste, Grenada, Bahamas, Dominica, Sao Tome and Principe, Comoros, Cuba, Bermuda, Kiribati, Puerto Rico, Aruba, Macao, Equatorial Guinea, Palestinian Territory, San Marino, Turkmenistan, Palau, Andorra, Micronesia, Liechtenstein, Marshall Islands, Taiwan, South Sudan, Democratic People's Republic of Korea, Somalia, Netherlands Antilles, French Polynesia, Monaco, New Caledonia, Anguilla, Cook Islands, Montserrat, Tuvalu, Cayman Islands, Faroe Islands, Guam, Nauru, Réunion, British Virgin Islands, U.S. Virgin Islands, French Guiana, Kosovo, Martinique, Curaçao, American Samoa, Greenland, Sint Maarten (Dutch part), Turks and Caicos Islands, Northern Mariana Islands, Tokelau, Saint Martin (French part), Sudan (pre-secession), Mayotte, Holy See (Vatican City State), Jersey, Niue	Bhutan, Swaziland, Fiji, Nicaragua, Togo, Burundi, Niger, Nepal, Guinea, Sudan, Gabon, Syrian Arab Republic, Suriname Iraq, Belize, Tonga, Afghanistan, Chad, Mauritania, Haiti, Isle of Man, Channel Islands, Gibraltar, Sierra Leone, Djibouti, Saint Lucia, Antigua and Barbuda, Central African Republic, Democratic Republic of the Congo, Papua New Guinea, Saint Vincent and the Grenadines, Congo, Samoa, Eritrea, Solomon Islands, Vanuatu, Guinea Bissau, Liberia, Maldives, Saint Kitts and Nevis, Timor-Leste, Grenada, Libya, Bahamas, Dominica, Sao Tome and Principe, Comoros, Cuba, Bermuda, Kiribati, Puerto Rico, Aruba, Macao, Equatorial Guinea, Palestinian Territory, San Marino, Turkmenistan, Palau, Micronesia, Liechtenstein, Marshall Islands, Taiwan, South Sudan, Andorra, Democratic People's Republic of Korea, Somalia, Netherlands Antilles, French Polynesia, Monaco, New Caledonia, Anguilla, Cook Islands, Montserrat, Tuvalu, Cayman Islands, Faroe Islands, Guam, Nauru, Réunion, British Virgin Islands , U.S. Virgin Islands, French Guiana, Kosovo, Martinique, Curaçao, American Samoa, Greenland, Sint Maarten (Dutch part), Turks and Caicos Islands, Northern Mariana Islands, Tokelau, Saint Martin (French part), Sudan (pre-secession), Mayotte, Holy See (Vatican City State), Jersey, Niue

Source: own study.

Changes were observed for 23 countries (see Table 4 below). Three countries (Bulgaria, Moldavia and Viet Nam) indicated moderate innovation resources but were able to achieve high innovation output. On contrary, ten countries (Poland, Mauritius, United Arab Emirates, Lithuania, Chile, Cyprus, Qatar, Croatia, Greece and Saudi Arabia) underperformed, having highly assessed innovation input but only managing a moderate outcome. Similarly, ten countries (Bhutan, Swazi, Fiji, Nicaragua, Togo, Burundi, Niger, Nepal, Guinea, Sudan) which were expected to claim membership in the moderate innovation outcome cluster (since their input was assessed similarly), also underperformed and were grouped as low innovators. No extremes (low input into high output or reverse) were observed.

Table 4. Changes in input-output cluster membership

Direction of change	Countries
Medium input → high output	Bulgaria, Moldavia, Viet Nam
High input → medium output	Poland, Mauritius, United Arab Emirates, Lithuania, Chile, Cyprus, Qatar, Croatia, Greece, Saudi Arabia
Medium input → Low output	Bhutan, Swazi, Fiji, Nicaragua, Togo, Burundi, Niger, Nepal, Guinea, Sudan

Source: own study.

5. The efficiency of innovation systems and policies – the case of Poland

The GII in 2015 classified Poland as 46th in the overall innovation analysis. According to the results of our cluster analysis and the data presented within the Global Innovation Index 2015, Poland represents a country which was characterized by a high innovation input and only a medium innovation output. This means that the country still has not fully exploited its potential to innovate. Being aware of the fact that the analysis was rather a kind of snapshot and that a longitudinal study is necessary, we try to investigate the reasons which could explain Poland's unsatisfactory results.

Within the innovation input a few of the institutions, human capital, and research factors represent visible strengths for Poland. The biggest strength is embedded in its human capital and is related to the 15-year-old students' performances in reading, mathematics, and science, which is measured by the PISA (the results come from the OECD Programme for International Student Assessment) (value 520.5, rank 9th) and the pupil-teacher ratio at the secondary level (value 8.7, rank 14th). Another strength within the pillar of human capital and research is Poland's tertiary enrolment (value 73.2, rank 21st). Some experts argue that the innovation input in Poland, which is strongly based on human capital, is unstable and unbalanced (Gasz 2015, p. 222). Poland's human capital potential is not sufficiently exploited, which could result partially from the fact that the cooperation between the R&D sector and business still needs improvement (Bukowski, Szpor, Śniegocki 2012, p. 16; Jankowska 2013; Kowalski 2013). This statement accords with the below-mentioned biggest weaknesses of the Polish innovation system, which are innovation linkages. The growth in the number of educated people – which is a quantitative measure – doesn't accord with the lower level of qualitative changes. Two other strengths can be indicated within the market sophistication and business sophistication pillars. Firstly we can mention the ease of obtaining credit (value 75.0, rank 16th), and secondly royalty and license fees payments as a % of total trade (value 1.1., rank 23rd). Nevertheless, the business sophistication pillar also embraces a big and significant weakness, which is the lack of sufficient innovation linkages. The whole sub-pillar was evaluated as a weakness (value 24.8, rank 102nd). The relatively weak innovation input in terms of innovation linkages can be explained by the state of cluster development (value 41.4, rank 89th) and by the number of deals on joint ventures and strategic alliances (factor – JV–strategic alliance deals/tr PPP$ GDP; value 0.0, rank 76th).

The innovation output of Poland is characterized by four visible strengths and six visible weakness. One strength is related to the sub-pillar knowledge and technology outputs and is reflected in the cited documents' H-index (value 336.0, rank 24th). The next three strengths are related to the pillar creative outputs and are as follows: cultural & creative services exports measured as % of total trade (value 1.0, rank 14th), creative goods exports measured as % of total trade (value 3.9, rank 12th) and last but not least, country-code top level domains scaled by the population aged 15–69 (value 37.2, rank 21st). As far as weaknesses are concerned, two of them are related to the knowledge and technology outputs and four are characteristic for the creative outputs pillar. Within the knowledge and technology outputs the new businesses with population aged 15–64 with a value of 0.5 and ranked as 86th represents one weakness, and the FDI net outflows as % of GDP (value –0.8; rank 119th) is the second weakness. The weaknesses within the creative output pillar are the national feature films per mln population aged 15–69 (value 0.9, rank 80th) and printing and publishing output as % of total manufactures output (value 1.1., rank 71st).

When trying to explain the medium innovation output despite the high innovation input it is important to underline that the weaknesses are embedded in the innovation linkages. While the active innovation policy is very well-developed in Poland, it is not very coherent and transparent. There are nine different strategies and programmes (NBP 2015, p. 140). The main strategies are the Strategy for the development of the Country, and Strategy for the Innovation and Effectiveness of the Economy. However the interdependencies between them are not transparent and not properly linked when taking into account their content. The lack of transparency and coordination among different strategies and programmes can partially explain the high innovation input and medium innovation output. According to the study conducted by the experts of National Bank of Poland, this Strategy is not accompanied by other executive documents which are crucial for the stability and continuity of public support for innovation (NBP 2015, pp. 140–142). Another problem is the responsibility of particular institutions while implementing the strategies and programmes, as such responsibility is also neither transparent nor clear. The lack of clearly-delineated responsibilities results in a lack of proper enforcement of activities performed by the institutions dedicated to innovation support. The interdependencies among the institutions are not transparent and it is difficult to indicate the hierarchy among them. The lack of coordinated strategies and actions performed by different institutions is accompanied by a dispersion of the public support for innovation. The financial support can be obtained by enterprises of different size, possessing different experiences and operating in different industries. On one hand this could be positive as it is open to a diversified group of entities, but on the other hand it can result in the waste of scarce resources and limit economies of scale within the R&D efforts. Thus the lack of coherency, transparency, and coordination within the whole system of active innovation policy contributes negatively to the innovation output. While the innovation input is high, the negative issues highlighted above reduce potential synergy effects.

A big barrier within the innovation system in Poland which hinders the transformation of high innovation input into high innovation output is the still low level of development of the venture capital and private equity market (Stryjek 2015), which is crucial from the perspective of gaining capital for innovation activities. The growth of this market requires a transformation of the culture of investment. It is visible that innovative start-ups and more mature businesses are taken over by foreign investors, who later exploit the innovation capacity of these companies (Jankowska et al. 2016).

The related question of whether to support R&D with public money is widely discussed in the literature (e.g. David, Hall & Toole 2000). The results of the studies are inconsistent, but the need to financially stimulate these kinds of operations is unquestionable (Klette, Moen & Griliches 2000). However, in the most developed countries the share of public money in the financing of R&D is very low (Tylec 2015, p. 247). Nevertheless, not only is the value of the financial support important, but also the structure of financing. Statistics reveal that for the EU–28 countries 61.9% of the financial support comes from the business sector, 24.1% from the higher education sector, 13.1% from the government, and 1.1% from the non-profit organizations. For Poland the structure is different, as the share of the business sector is only 30.1%, with 35.1.% coming from the higher education sector, 34.5% from government funds, and 0.2% from non-profit organizations (Tylec 2015, p. 248). The most visible difference is thus the lower involvement of enterprises in R&D. When firms invest in R&D, it is rather a form of imitation (Bukowski et al. 2012, p. 16). Another challenge lies in intellectual property, and in particular patents, not in trademarks or industrial design and the export of innovative services and know-how. It reflects Poland's involvement in the manufacturing of high-tech products which are designed in other locations. Hence the revenues are transferred from Poland (Bukowski et al. 2012, p. 17).

In 2013 KPMG conducted research among Polish companies focused on their maturity in the field of innovation (KPMG 2013). The study covered 248 manufacturing firms and 239 firms from the retail and services' sector, using CATIs (computer assisted telephone interviews). As many as 44% of the respondents expressed their unwillingness to perform innovative activities since they are afraid of the risk of not achieving an adequate return on their investment (KPMG 2013, p. 5). These findings can indicate that while Poland's innovation input is classified as high, perhaps it is not of the proper profile and not adequate to the expectations of Polish firms. Thus the input, although high, is not adjusted to the needs of Polish firms, which generate just a moderate output.

6. The efficiency of innovation systems and policies – the case of Bulgaria

In 2015 the GII classified Bulgaria as 39th in its overall innovation analysis. With a population exceeding 7.1 mln persons and GDP per capita of about 15,000 USD (Dutta, Lanvin, Wunsch-Vincent 2015), Bulgaria varies significantly in terms of its innovation framework. The cluster analysis (Table 4) indicates explicitly that although the level of innovation input relatively low, the innovation outcome of the country is much higher. The efficiency ratio, understood as the ratio of the Output Sub-Index over the Input Sub-Index, amounted to 0.8. This indicates how much innovation output a particular country creates out of its innovation inputs. In case of Bulgaria this was the third highest ranking among the upper-middle-income economies, after Angola and China.

In taking a closer look at the ranking we can quickly observe that in comparison to other similarly developed countries, Bulgaria lacks a human capital and research framework, infrastructure, as well as market and business sophistication (Dutta, Lanvin, Wunsch-Vincent 2015). However, it scores relatively high in the institutional context and reveals a special strength in its regulatory environment (e.g. cost of redundancy dismissals).

As has been mentioned above, the human capital and research framework are, together with infrastructure, the main causes for concern from the input side. The quality of Bulgaria's workforce is relatively low, and only about 20% of its employees take part in continuous vocational training. The highest rate in this regard can be observed in companies hiring more than 250 people. Therefore, after 2013 separate industry initiatives were undertaken in high-tech sectors (e.g. ICT) in order to boost the intellectual potential of the existing workforce. The government plans to expand them to other industries. The infrastructure is said to be developed in seven main areas, however details on specific actions are yet to be determined. Taking the above into account, the question arises: How was Bulgaria able to achieve a high innovation output with moderate input factors.

Firstly, it is worthwhile to take a look at the breakdown of the Output Sub-Index. Bulgaria scored relatively high in both knowledge and technology outputs, as well as creative outputs. It especially stands out in knowledge impact (e.g. quality certificates, new business density) and intangible assets (e.g. trademark applications). The first major improvement was noticeable in 2014. Previously Bulgaria was ranked significantly lower in terms of both input and output. The government attributes the recent improvement to its innovation strategy implementation.

Policies implemented by the government emphasise and reflect the need for industrial differentiation. Having signed an agreement on technical assistance with the World Bank, the Bulgarian government developed programs aimed at particular niches and industries that could boost the country's innovative performance (Ministry of Economy 2015). Special attention is paid to mechatronics and clean technologies, ICT, bio- and nano-technologies, pharmacy, the food industry, and creative industries. As studies among entrepreneurs in Bulgaria have indicated, scientific research is not perceived as the key driver to achieve a high innovation output. More emphasis is put on importing and absorbing foreign capital and knowledge into the more "traditional" industries (Ministry of Economy 2015). Thus the national level of R&D expenditure is relatively low and has not exceeded 0.7% of GDP, whilst the European Union's average is above 2.0% (Eurostat 2016). The government fears that the innovative capacity of the firms is low. Only 16% of the registered firms undertook innovative activities, which is the lowest rate in the EU. Most of these innovators were "lonely riders", meaning that they did not share or cooperate with any external partners (Ministry of Economy 2015).

A so far under-used tool for increasing innovativeness and productivity is the networking offered by clusters. Although there are only few effectively operating clusters in Bulgaria (e.g. "Electric Vehicles", "Marine Cluster", "Automotive Cluster Bulgaria"), the policy makers see clustering as a potentially fruitful form of cooperation. Therefore, assistance can be expected at the institutional level to expand their scope of activities. A further step, desired by the government but still hard to be framed in a forthcoming timeline, is the establishment of transnational clusters which would enable Bulgaria to penetrate the EU markets with their products and services and create even closer technological partnerships.

Although Bulgaria's Output Sub-score is a definite success, the policymakers perceive the need for more overall innovative development. Thus plans have been made for the 2014–2020 period aimed at enhancing also the input side. Special emphasis is laid on financial support, creating scientific and business linkages, and absorbing innovations.

7. Conclusions

The analysis of the GII 2015 reveals that a higher innovation input does not necessarily result in a higher innovation output. Poland is an example of a country where the innovation efforts are quite intense, while the results of these efforts are still not satisfactory. Despite the fact that Poland was relatively well equipped for innovation activities it was not able to attain a ranking among countries with a high innovation output. On the one hand, this can mean that Poland needs to be patient and wait for the results of exploitation of its innovation input. Another interpretation, which seems to be less optimistic, is that the support arising from the innovation input is not properly tailored to the expectations and needs of the main actors – such as firms and R&D institutions.

In the case of Bulgaria the situation is reverse. According to the governmental projections the country is still behind in developing its innovation input side, but it has already been able to achieve a satisfactory output result due to technology and knowledge imports.

In comparing the findings for Poland and Bulgaria we can observe that in terms of innovation input Poland's strength is its human capital, which is a visible weakness of Bulgaria. Within the pillar of human capital and research Poland has three outstanding strengths, and Bulgaria no strong points. However, the strength of human capital in Poland in the field of innovation is not being yet translated into knowledge and technology output. The knowledge and technology output, on the other hand, is Bulgaria's source of strength.

In referring to the broader issues, we can also state that a higher innovation output doesn't always go hand-in-hand with higher competitiveness of an economy. That can be proved by the Competitiveness Ranking of the World Economic Forum where in 2015 Poland was ranked 41st, and Bulgaria considerably lower at 54th (http://reports.weforum.org/global-competitiveness-report–2015–2016/economies/#economy=POL; http://reports.weforum.org/global-competitiveness-report–2015–2016/economies/#economy=BGR).

Thus taking under consideration the broader set of factors and departing from just the innovation efficiency perspective, we can state that the Polish economy performed better than Bulgaria's. Thus it is misleading to simply conclude that a higher innovation output translates into a higher competitiveness of an economy, since the latter issue is a multi-faceted and complex phenomenon.

Our study suffers from some limitations. It provides rather a snapshot of the state of affairs, thus it is necessary to conduct similar analyses covering longer periods of time. Another issue is the number of countries we have compared. It would be useful to identify more countries that vary significantly in terms of the results of evaluation of their innovation inputs and outputs. An interesting project could be the identification and more in-depth analysis of other economies which, despite lower innovation inputs, were able to achieve higher innovation outputs, and then compare the findings with their competitiveness. Bearing in mind the limitations of this study it nevertheless constitutes a starting point for studies aimed at identifying the dependencies between the innovativeness and competitiveness of economies.

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Streszczenie

SKUTECZNOŚĆ NARODOWYCH SYSTEMÓW INNOWACJI – POLSKA I BUŁGARIA A GLOBAL INNOVATION INDEX

Celem niniejszego artykułu jest wyjaśnienie, jak narodowe systemy innowacji (NSI) są używane do kreacji innowacji. Posługując się wskaźnikiem Global Innovation Index (GII) omówiono, co można rozumieć pod pojęciem innowacji oraz zasygnalizowano, jak innowacje mogą oddziaływać na gospodarkę. Pytanie badawcze oparto na założeniu, że im wyższe nakłady na innowacje, tym kraj jest w stanie osiągnąć lepsze efekty aktywności innowacyjnej. W celu weryfikacji tego założenia zastosowano metodę analizy klastrowej w odniesieniu do 228 gospodarek. Następnie przeprowadzono pogłębioną analizę dwóch przypadków (Polski i Bułgarii), które odbiegały od wzorca zidentyfikowanego w wynikach analizy klastrowej. Stosując analizę porównawczą próbowano nakreślić jak i dlaczego NSI nie zdołały (lub odwrotnie) wykreować pożądanego poziomu innowacji.

Słowa kluczowe*: narodowy system innowacji, Polska, Bułgaria, Global Innovation Index*