Chapter 11
Comparison of Innovation Performance Within Visegrad Countries

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Abstract The proposed paper deals with the innovation, innovation activities, and innovation performance in Visegrad countries (e.g., Czech Republic, Poland, Hungary, and Slovak Republic). Three of these countries are classified as the high-income countries and one as the upper middle-income country. The analysis is based on the global innovation index (GII) of both the input and output side indexes by the OECD and EUROSTAT data. The changes of indexes by the Visegrad countries are identified as well as the trends. The contribution discusses differences or distances between the indexes and their stability. The comparison of global innovation index in Visegrad countries shows the opportunities for better understanding of the innovation activity conditions as well as the performances in the innovation in the country. Two of Visegrad countries are ranked better by innovation output (IO) indexes and two by innovation input (II) indexes. All these countries are weak in market sophistication. It is the opportunity for non-technological innovation processes. This is also the challenge of optimizing the institutional systems and processes. In the context of innovation, the key challenge is developing skills for innovation in education and training systems and connected with the changes and expenditures on education and training. The aim is to connect the equipment of more people with the skills related to innovation and creativity in all its forms. All countries have to increase the outputs based on the knowledge, innovation, and creativity.

Keywords Innovation index • Identification the gap in innovation index • Visegrad countries

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11.1 Introduction

The changes of environment in terms of technology, policy, market conditions, etc. evoke and make new requirements on the economy of each country, on the inputs of production, and on the outputs for the market. They determine the combination as well as the importance of input production factors and require smart and balanced use of inputs and the newest information, knowledge, or permanent innovation of products, services, processes, etc. The changes of the combination of input production factors are characterized by their new proportion.

The growths of economy and the performance of production systems are based on the ability to innovate, to absorb the knowledge, and to use the innovation. The transfers of knowledge and technologies together with innovation are the terms that are presented in many strategic documents and presentations. They are perceived differently, but their content is explicitly or implicitly bound to the inputs and outputs of economic growth and employment.

The emphasis on knowledge, innovations, and enhancement of human capital is crucial for recovering the economic performance. Another important strategic field in Europe is to increase investment and employment which requires the completion of domestic market and improvement of business environment mainly through decreasing bureaucracy, improvement of infrastructure, and liberalization of services. The priorities in this context are clear: education, employment, science and research, as well as business and market environment. Healthy business environment which motivates people to carry business is one of the conditions in ensuring long-term competitiveness in the selected country. The business environment, business support, and the creation of suitable investment climate must enable an effective competition for businesses, which is the base engine of economy of each country.

In the proposed contribution, the indexes of competitiveness are compared between countries known as V4 or Visegrad countries. This configuration contains four countries: the Czech Republic, Hungary, Poland, and the Slovak Republic. They are located in Central Europe, and they entered the EU in 2004. In the years 1990–2004, they were included together between transitive economies. The economies of these countries are closely mutual related. Also the societal and cultural environment has a lot of similar marks.

11.2 Theoretical Background

The founder of innovation theory Schumpeter (1934) considered the innovation only the first entry of new product, raw materials, technological process, etc. on the market. It means the first materialization of idea and entry on the market. Many authors focused on innovation, and innovation management developed the original Schumpeter's theory, and nowadays their works are primarily focused on the successful innovation management in enterprises. For example, Baumol and

Blinder (1988) consider oligopolies as economic structures that support innovation. These large enterprises compete with each other through price differentiation and so stimulate creation of innovation and economic growth. The innovation activity is essential in order for the enterprises to survive.

According to Cooper and Edgett (2009), innovation includes the use of knowledge that generates new ideas, which brings benefit. Freeman and Soete (2005) said that innovation includes activities related with technology, design, production, management, and commerce aimed on the introduction of new or improved product on the market or the first commercial use of a new or improved process or equipment. Rothwell and Gardiner Classified the radical innovation (the commercialization of fundamentally new technology) and incremental innovation that means using less significant changes in technological know-how.

Porter said that enterprises achieve competitive advantages by innovation act and considered innovation in its widest sense, including both new technologies and new ways of realization of the things. Brandon and Lu (2008) regard innovative enterprise as one that considers and acts differently than others. It is not only about good ideas; it is a combination of good ideas, motivated employees, and intuitive understanding of customers' needs and requirements.

So, the term "innovation" has many definitions—according to survey there are around 200 of them. Their common features are application of new ideas (38 %), changes or improvements of products or processes (28 %), or invention (9 %). According to most contemporary authors, innovation is the key term for the entrepreneur or manager.

Current understanding of innovation emphasizes connection to organization's way of life, thinking and behavior of people, and impact of dependence on major elements of system environment of organization that produces the innovation and provides it to market.

Green Paper on Innovation issued by the European Commission in 2004 defines innovation as synonym for a successful production, assimilation, and use of novelty in economic and social sphere. Innovations offer new solutions of problems and so make it possible to meet the needs of individuals and society (Rostášová et al. 2010).

11.3 Data and Methodology

In comparison of individual countries from the point of view of their living standard, economic development or growth several indexes connected to GDP and innovation index are used. Global innovation index expresses average value between the innovation inputs and outputs. The proportion between index of innovation inputs and outputs expresses the effectiveness. GII is evaluated by OECD within 141 countries in the world. The individual data related to the competitiveness and innovation in V4 countries are based on the OECD statistics.

Innovation input subindex includes five areas and each of them has three subareas. There are evaluated preconditions for innovation activities in economy of the country, e.g.:

- Institutions
- Human capital and research
- Infrastructure
- Market sophistication
- Business sophistication

Innovation output subindex includes two categories of output with three subareas:

- Knowledge and technology
- Creative outputs

Innovation subindex reflects the areas influencing and enabling innovation and competitiveness of national economy. Both sides, input and output, represent 81 individual indicators.

11.4 Comparison of Global Innovation Index for V4 Countries

Initial data for comparison of values of indicators and their development in V4 countries are shown in Tables 11.1 and 11.2. V4 countries represent 64.3 million EÚ inhabitants. The value of GDP per capita in USD ranks third of V4 countries to the high-income countries (CZ, SVK, PL) and one to upper middle-income countries (H). The top five economies by global innovation index include Switzerland, the United Kingdom, Sweden, the Netherlands, and the United States. V4 countries rank among the third up to the fifth of the ten countries.

Table 11.1 Main indicators for Visegrad countries in 2012–2015 (OECD 2012, 2013, 2014, 2015)

Country	Indicators	2012	2013	2014	2015
Czech Republic (CR)	Population (mil.)	10.5	11.0	10.5	10.7
	GDP per capita (USD)	25,933.8	27,164.8	27,200.1	28,086.5
Hungary (H)	Population (mil.)	10.0	10.4	9.9	9.9
	GDP per capita (USD)	19,647.1	19,754.0	20,065.1	20,817.4
Poland (PL)	Population (mil.)	38.1	39.7	38.5	38.2
	GDP per capita (USD)	20,136.9	20,976.1	21,214.3	22,201.1
Slovak Republic (SR)	Population (mil.)	5.4	5.6	5.4	5.5
	GDP per capita (USD)	23,384.1	24,283.6	24,605.3	25,524.7

Table 11.2 Innovation indexes and subindexes (score 0–100 or value) for Visegrad countries in 2012–2015 (OECD 2012, 2013, 2014, 2015)

Country	Index	2012	Rank	2013	Rank	2014	Rank	2015	Rank
Czech Republic	GII, global innovation index	49.7	27	48.4	28	50.2	26	51.3	24
	IO, innovation output subindex	46.1	23	43.3	26	46.8	17	48.5	17
	II, innovation input subindex	53.3	31	53.4	27	53.6	27	54.2	27
	Innovation efficiency ratio	0.9	22	0.8	53	0.9	18	0.9	11
	Institutions	68.2	44	76.1	31	76.2	31	76.4	32
	Human capital and research	49.1	31	45.7	30	45.7	29	45.8	29
	Infrastructure	52.0	24	49.0	24	50.8	25	51	30
	Market sophistication	44.2	**48**	48.9	**53**	49.1	**62**	52.4	**45**
	Business sophistication	53.0	22	47.5	20	46.2	20	45.3	28
	Knowledge and technology outputs	48.4	20	38.3	25	46.4	15	46.7	15
	Creative outputs	43.9	26	48.2	25	47.3	18	50.2	21
Hungary	GII, global innovation index	46.5	31	46.9	31	44.6	35	43	35
	IO, innovation output subindex	41.9	29	45.4	23	42.2	29	37.7	37
	II, innovation input subindex	51.2	37	48.5	36	47.0	41	48.2	42
	Innovation efficiency ratio	0.8	41	0.9	23	0.9	15	0.8	35
	Institutions	72.3	32	73.5	38	72.3	40	73.4	40
	Human capital and research	46.0	38	40.2	37	37.9	42	37.7	43
	Infrastructure	48.5	28	44.1	30	45.6	36	47.2	43
	Market sophistication	42.2	**56**	43.3	**87**	42.1	**115**	46	**77**
	Business sophistication	46.9	38	41.3	36	37.2	45	36.8	57
	Knowledge and technology outputs	46.8	21	44.9	13	41.9	24	34.7	40
	Creative outputs	37.0	43	45.8	37	42.5	35	40.7	36

(continued)

Table 11.2 (continued)

Country	Index	2012	Rank	2013	Rank	2014	Rank	2015	Rank
Poland	GII, global innovation index	40.4	44	40.1	49	40.6	45	40.2	46
	IO, innovation output subindex	33.6	52	32.4	64	34.0	48	31.9	56
	II, innovation input subindex	47.1	41	47.8	39	47.3	40	48.4	39
	Innovation efficiency ratio	0.7	80	0.7	110	0.7	76	0.7	93
	Institutions	68.1	45	74.4	35	74.7	35	75.3	34
	Human capital and research	40.5	53	37.6	45	37.9	43	37.2	45
	Infrastructure	39.7	48	38.0	47	41.9	49	45.5	47
	Market sophistication	44.8	44	50.5	46	48.2	**70**	49	60
	Business sophistication	42.3	52	38.6	40	33.7	64	35.2	**66**
	Knowledge and technology outputs	32.9	51	29.0	55	31.2	53	28.3	56
	Creative outputs	34.3	**60**	35.9	**78**	36.7	51	35.4	53
Slovak Republic	GII, global innovation index	41.4	40	42.2	36	41.9	37	43	36
	IO, innovation output subindex	35.4	43	36.2	45	37.0	38	37.1	38
	II, innovation input subindex	47.3	40	48.3	37	46.7	43	48.9	37
	Innovation efficiency ratio	0.7	65	0.7	84	0.8	45	0.8	48
	Institutions	69.8	38	77.4	27	74.5	36	75.1	36
	Human capital and research	42.6	46	39.5	41	32.9	55	33.2	53
	Infrastructure	46.3	33	42.2	38	43.5	45	49.3	37
	Market sophistication	38.1	**71**	49.1	52	48.6	**67**	50.4	**53**
	Business sophistication	39.7	63	33.4	59	34.2	61	36.7	58
	Knowledge and technology outputs	36.5	39	33.3	42	34.7	41	33.7	41
	Creative outputs	34.4	57	39.1	**61**	39.4	42	40.4	40

The Czech Republic is ranked on 24th position in 2015 and went up two positions from the 26th position in 2014, and in the last two years, it moved from the 28th to the 24th position. It indicates the changes in innovation activities in economy.

The strength of the country of 10.7 million inhabitants lies in the solid performance in six of seven areas excluding one area—market sophistication. However, the improvement of the market sophistication during the last year is significant (62nd place in 2014 and 45th place in 2015). The innovation efficiency ratio ranks Czech Republic on the 11th position among all countries, and innovation output as subindex was ranked to the 17th position. The knowledge and technology outputs as well as the creative goods and services played a major role in achieving its 17th place by the innovation output subindex. The strong position is a result of high-tech exports, that is, less reexports and creative goods export (4th).

From the point of view of innovation input subindex, the Czech Republic achieves a leading position on ISO 14001 environmental certificates. A very strong position is occupied by ecological sustainability, environmental performance, political stability, and the level of trade and competition.

The weak point of the country is market sophistication (only 45th in 2015, 62nd in 2014, 48th position in 2012), mainly in investment (118th), ease of protecting investors (75th), and market capitalization in percentage GDP (74th) (Fig. 11.1).

Hungary is ranked 35th in 2015 similar in 2014 and went down four positions from 31st in 2012 and 2013. Its major weaknesses are in market sophistication (77th), credit (73rd), and investment (132nd). These indices are related also with the

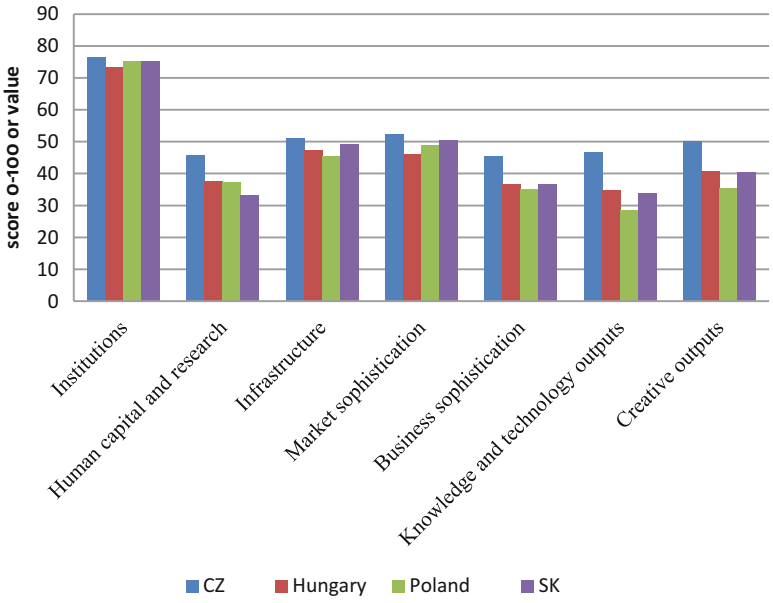

Fig. 11.1 Input and output innovation subindexes in the Visegrad countries in 2015

business sophistication, mainly with FDI net inflow as percentage of GDP (132nd), gross capital formation (103rd) in infrastructure area, and business sophistication related to the knowledge workers (60th) as well as innovation linkages (83rd) or state of cluster development (88th) or joint venture strategic alliance deals (69th). On the other hand, knowledge and technology outputs represent the good performances in knowledge impact (24th), high and medium high-tech manufactures (8th), and high-tech exports less reexports (8th). Other areas of concern are the tertiary education sub-pillar (63rd) with the graduates in science and engineering (67th).

Poland is ranked 46th (down one place from 2014) with the weaker performance in innovation outputs (56th) as in innovation inputs (39th). The business sophistication (66th) and market sophistication are the weakest areas of innovation index with the poor performance in investment (84th) as well as the microfinance gross loan in %GDP (67th). Its less good showing in the output subindex is the result of worsening position in intangible assets (108th) with poor performance in ICTs and business model creation (95th), knowledge impact (81st) with the new businesses (86th), and knowledge diffusion (89th) with the FDI net outflows in %GDP (119th).

The Slovak Republic is ranked 36th in 2015 similar in 2013. The subindex "human capital and research" is classified only on 53rd place because the expenditures on education as the percentage of GDP are on 85th rank (84th in 2014) among 141 OECD countries evaluated. Also the business sophistication area is influenced by the weak innovation linkages (69th) including the university/industry research collaboration (81st), state of cluster development (66th), royalty and license fee payments (92nd), or communication, computer, and information services import (105th). On the output side of innovation index, it is possible to see the impacts of the insufficient innovation and knowledge processes in the ranks of domestic resident patent application (59th), knowledge diffusion (69th), and FDI net outflows as %GDP (51st) in intangible assets (81st) and in printing and publishing manufactures (87th). The strengths of the Slovak Republic related to the innovation and knowledge are political stability (13th), ecological sustainability (10th), ISO 14001 certificates (7th), high-tech imports less reimports (14th), knowledge impact (19th) including high and medium high-tech manufactures in % (4th), and creative goods and services (17th) including creative goods export as % total trade (2nd).

The main problems in relation with the global innovation index and its areas of all V4 countries are connected with the market sophistication area in three countries, e.g., Hungary, Poland, and the Slovak Republic, and also with the business sophistication area. The values of the innovation indexes and subindexes in the V4 countries are determined by the gaps in the innovation and knowledge processes (creation, education, skills, diffusion, etc.).

The relations between the area of human resources and research represented by the following input indicator expenditures on education and research and development including the university ranking of top three and the area of knowledge creation represented by citation documents h-index are represented by Figs. 11.2 and 11.3.

The potential of the Slovak Republic to increase the GII level lies in supporting the linkages between education and research, research and innovation, and

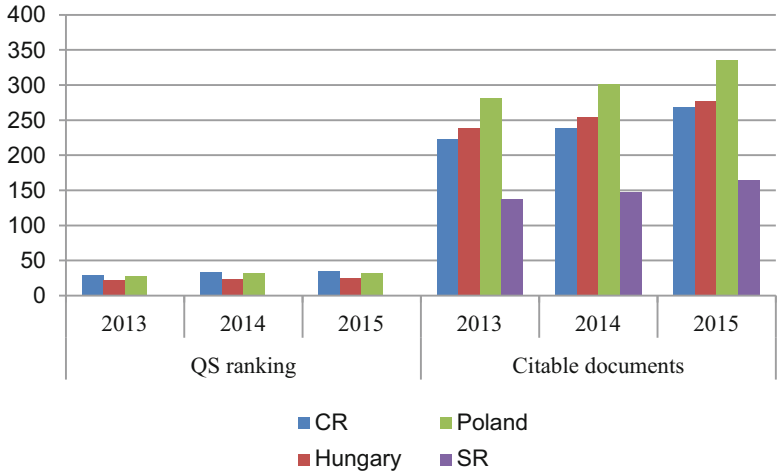

Fig. 11.2 QS university rankings (average score of top three) and citable documents h-index in Visegrad countries

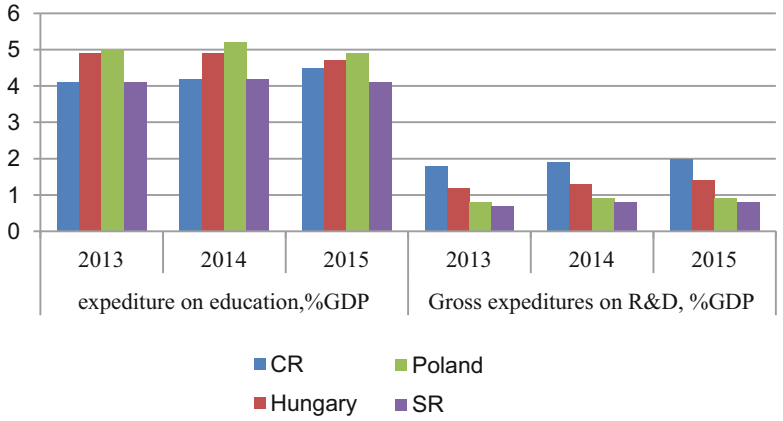

Fig. 11.3 Expenditure on education and R&D as a %GDP in Visegrad countries

education and innovation, e.g., to fulfill the concept of knowledge triangle. The level of citable documents as well as the domestic patent applications reflects the level of expenditures on research and development. In terms of university performance (citable documents and patent applications), the highest level among the V4 countries is achieved by Poland. The lowest level in expenditures on education as well as on research and development is achieved by Slovak Republic, and these levels influence the knowledge outputs represented by patent and citable documents (Table 11.3).

The knowledge is more and more important for competitiveness and performance of economy, industries, and business subjects of advanced countries. Certainly, the

Table 11.3 Selected indicators related to knowledge triangle relations in Visegrad countries in 2015 (OECD 2012, 2013, 2014, 2015)

Indicator	CR	Hungary	Poland	Slovakia
Inputs				
Expenditures on education (%GDP)	4.5	4.7	4.9	4.1
Graduates in science and engineering (%)	21.6	16.8	16.8	20.6
Gross expenditures on R&D (%GDP)	2.0	1.4	0.9	0.8
Knowledge-intensive employment (%)	37.8	35.6	35.9	31.8
University/industry research collaboration	50.0	54.6	41.7	39.3
State of cluster development	51.0	41.5	41.4	46.7
Royalty and license fee payments (% total trade)	0.6	1.1	1.1	0.2
Outputs				
Domestic resident patent app./bn PPP$ GDP	3.2	2.7	4.7	1.3
Citable documents h-index	268	277	336	165
Royalty and license fee receipts	0.2	1.0	0.1	0.0

knowledge can be the source of economic growth that leads to a new view on the role of information, technologies, and education in increasing of economic performance. The traditional production function was focused on work and capital; the knowledge and technologies had only intermediary effect on production itself.

The analysis of global innovation index including subindexes and individual indicators has to provide better understanding of the innovation processes, the relations between the knowledge inputs and outputs as well as measures of innovation. The innovation policies can be defined on identification of targets or best practices in innovation processes. On the basis of analysis of Visegrad countries' global innovation index, it is possible to show the importance of non-technological innovation processes. All four countries are weak in market sophistication. This is also the challenge of optimizing the institutional systems and processes. The key challenge is developing skills for innovation in education and training systems. The target is connected with the equipment of more people with the skills related to innovation and creativity in all its forms. The levels of GDP per capita in PPP$ and global innovation index score indicate that the Czech Republic ranks among the innovation leaders, Hungary and the Slovak Republic are on the way from achievers to leaders and Poland too, but Poland ranks among inefficient innovators. The Czech Republic, Hungary, and the Slovak Republic rank among efficient innovators.

From the comparison and analyses, the certain implication result for the V4 countries in relation to intellectual property and its creation and protection is an important production factor of the future. According to supported directions and focus on research (e.g., smart specialization), the outputs aimed to relevant industries influence the choice of form of transfer of knowledge, knowledge absorption, and university-industry research and development collaboration.

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