3 Expenditure on R&D vs. innovativeness of the economy – comparative analysis for selected countries

Introduction

In the modern global economy the competitiveness of economies relies less and less on raw materials and unskilled labor. Although international specialization based on those factors of production is still possible, as shown by Arab countries, Russia and Norway (raw materials) and some Asian countries (unskilled labor), nowadays economic growth is driven mainly by technological and scientific progress. According to endogenous growth models, this progress is a consequence of rational investment decisions made by producers and consumers, with the support of the state's long-term pro-investment economic policies. Among other things, these policies stimulate the accumulation of scientific and technological knowledge and human capital through appropriate investment in research and development (R&D).

The purpose of this article is to present the importance of spending on R&D (especially in terms of its volume and sources) for the innovation in the economy, as well as to show the dependence of the individual areas of the state's innovation policy on spending on R&D. This paper also shows disparities in the level of innovation between selected countries (including Poland) and presents reasons other than the obvious differences in the volume of expenditures on R&D. The study covers the period 2006–2013, using the data collected and published by various international institutions such as the World Bank, the OECD and the European Commission. The author's intention was to carry out the analysis of correlation and regression in relation to the largest possible group of countries, which, however, was hampered by the unavailability of some data or the lack of up-to-date data.

1. The role of innovation in economic growth

Endogenous growth models show that the pace of scientific and technical progress is closely related to the volume of investment.[1] Any economic policy of the state meant to stimulate economic growth should therefore focus on the appropriate allocation of capital within the economy, i.e. in sectors that are most in need of investment. This should not only increase the accumulation of physical capital, but also human capital; in other words, the objective of the government's policy should be to increase investment and development of human capital, which in turn may result in a faster pace of technological progress.

An absolute increase in investment made in order to intensify scientific and technological progress is not the only factor; the very quality of investment seems to be as important. This means, above all, the significance of investment in human capital, which very much depends on spending on R&D. In addition, the business practice of many countries shows that even at higher expenditure on research and development and increased total factor productivity, less developed countries have rarely succeeded at converging with the most developed countries.[2] Since the end of the World War II, a group of highly developed economies have been joined by relatively few countries, e.g. Germany, Japan, Finland, South Korea and Singapore, while the vast majority of countries aspiring to join this group are at risk of falling into the so-called middle income trap.[3] This risk is particularly high in countries, where the current rapid economic growth has been associated with the imitation of imported technologies, specialization based on cheap labor and high rates of return on investment resulting from high domestic demand for capital.[4]

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[1] More on this issue see P.M. Romer, *The Origins of Endogenous Growth*, "Journal of Economic Perspectives" 1994, Vol. 8 (1), pp. 3–22.

[2] See J.D. Sachs, A.M. Warner, *Fundamental Sources of Long-Run Growth*, "American Economic Review" 1997, Vol. 87 (2), pp. 184–188.

[3] See B. Eichengreen, D. Park, K. Shin, *Growth Slowdown Redux: New Evidence on the Middle-Income Trap*, NBER Working Paper 18673, January 2013.

[4] The middle income trap has been experienced by Greece, Portugal, Spain, Ireland and Israel, while currently it can be observed in the Czech Republic and Slovenia. Although the Polish economy has been doing well in the recent downturn

Avoiding the middle income trap, and thus the transition from a middle to high income economy, is possible by decreasing the dependence on imitating others' technologies and shifting to a path of growth based on innovation and high-tech capital accumulation, including human and social capital. In broader terms, the transition from imitation to innovation should take place in a three-step transformation:[5]

1. Replacing product diversification by endogenous specialization, in which manufacturing processes are carried out within the national innovation system. The success of such transformation requires companies to acquire advanced skills that are difficult to imitate and also the development of cooperation in the field of innovation.[6] In other words, it is necessary to increase the capacity for the absorption and diffusion of scientific and technological knowledge within the economy, which then allows to develop own innovative products and their fast launch on the market (commercialization).
2. Transition to a stage of economic growth driven by increasing productivity, i.e. replacing physical accumulation of factors by actions meant to improve their quality. In particular, this refers to the development of qualifications and skills (replacing unskilled labor by complex labor), aiming at fostering the creative class. Properly directed social and educational policy of the state, assisted as far as possible by the business sector, should not only encourage native high-skilled professionals to stay in the country, but also attract skilled workers from abroad.

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when compared to the rest of the EU, it may soon experience a long-term stagnation in economic growth, if it does not introduce systemic changes oriented at increasing innovation. See M.J. Radło, D. Ciesielska-Maciągowska, *Polska w pułapce średniego dochodu? Perspektywy konkurencyjności polskiej gospodarki i regionów*, Difin, Warszawa 2013.

[5] See H. Kharas, H. Kohli, *What is the Middle Income Trap, Why do Countries Fall into it, and How Can It be Avoided?*, "Global Journal of Emerging Market Economies" 2011, Vol. 3 (3), pp. 281–289, and also M. Majewska-Bator, *Rozwój endogenicznej przewagi w handlu międzynarodowym a proces zmniejszania luki technologicznej*, Wydawnictwo Uniwersytetu im. Adama Mickiewicza w Poznaniu, Poznań 2010.

[6] See A.H. Jasiński, *Innowacje i transfer techniki w procesie transformacji*, Difin, Warszawa 2006, pp. 29–38.

3. The gradual shift from centralized model of economic governance towards a decentralized model, in which economic decisions (including investment) are taken by consumers and producers, and not by the state bureaucracy.

2. Innovation position of selected countries

The effectiveness of the aforementioned process of transition from the imitation to innovation economy may be indicated by a change in the innovation position of the country, resulting from the creativity of the nation and financial resources available in its institutional environment. The innovation position is reflected by synthetic innovation indicators, which are usually calculated based on dozens of parameters describing not only expenditure on the implementation of innovative processes (inputs), but also the results of these actions (outputs).[7]

Table 1 shows the rate of the Summary Innovation Index (SII), published for more than a decade by the European Commission. In period 2006–2013 the average annual growth rate of SII for European Union countries was 1.7%, which corresponded to a 12 percent increase over that period. As expected, the highest rates of innovation can be found in the economies of the "old" European Union, led by the innovation leaders – Nordic countries and Germany. However, assuming the SII growth in the EU-27 as an arbitrary line between the countries gaining in innovation and those losing distance in this respect, the vast majority of the developed EU countries showed a relatively low SII growth (except the countries of southern Europe and Luxembourg). Importantly, most of the new EU member states recorded a large improvement in the innovation index, the only exception being Slovakia, Croatia and Poland.

Poland experienced the lowest SII growth among all the member countries, its value being higher only in Romania, Latvia and Bulgaria. This may indicate that despite the measures taken to improve the

[7] More information on the methodology of calculating one of these sub-indices can be found in *The Global Innovation Index 2013: The Local Dynamics of Innovation*, Cornell University, INSEAD, and WIPO, Geneva, Ithaca, and Fontainebleau, 2013, pp. 3–7, 365–377.

Table 1
Summary Innovation Index (SII) for European Union members in period 2006–2013

Country	2006	2008	2010	2012	2013	Annual growth rate (%)	Change 2006 = 100
Sweden	0.73	0.73	0.74	0.75	0.75	0.35	102
Denmark	0.68	0.66	0.71	0.72	0.73	0.89	106
Germany	0.65	0.67	0.70	0.71	0.71	1.34	110
Finland	0.63	0.66	0.68	0.69	0.68	1.18	109
Luxembourg	0.57	0.59	0.60	0.63	0.65	1.80	113
Netherlands	0.56	0.58	0.60	0.64	0.63	1.65	112
Belgium	0.59	0.59	0.61	0.63	0.63	0.92	107
United Kingdom	0.59	0.58	0.62	0.62	0.61	0.55	104
Ireland	0.57	0.55	0.57	0.59	0.61	0.95	107
Austria	0.52	0.58	0.57	0.60	0.60	2.15	116
France	0.52	0.53	0.57	0.58	0.57	1.43	110
Cyprus	0.41	0.49	0.48	0.50	0.50	2.76	121
Italy	0.38	0.39	0.43	0.45	0.44	2.22	117
Spain	0.38	0.39	0.39	0.41	0.41	1.42	110
Portugal	0.31	0.37	0.42	0.40	0.41	3.88	131
Greece	0.35	0.38	0.37	0.38	0.38	1.21	109
Malta	0.28	0.32	0.35	0.30	0.32	1.98	115
Slovenia	0.43	0.46	0.48	0.50	0.51	2.66	120
Estonia	0.39	0.41	0.45	0.49	0.50	3.75	129
Czech Republic	0.37	0.37	0.41	0.41	0.42	1.74	113
Hungary	0.30	0.31	0.34	0.34	0.35	2.37	118
Slovakia	0.30	0.30	0.30	0.35	0.33	1.48	111
Croatia	0.29	0.28	0.32	0.31	0.31	0.77	106
Lithuania	0.24	0.23	0.24	0.27	0.29	2.63	120
Poland	**0.26**	**0.27**	**0.27**	**0.27**	**0.28**	**0.85**	**106**
Romania	0.21	0.24	0.24	0.23	0.24	1.88	114
Latvia	0.17	0.20	0.22	0.23	0.22	3.47	127
Bulgaria	0.16	0.19	0.23	0.19	0.19	2.51	119
EU27	0.49	0.50	0.53	0.55	0.55	1.68	112

Source: own preparation based on *Innovation Union Scoreboard 2014*, European Commission, Brussels 2014, p. 92.

innovation position, Poland continues to lose ground both to the majority of the European Union countries as well as to a growing number of newly industrialized countries.[8]

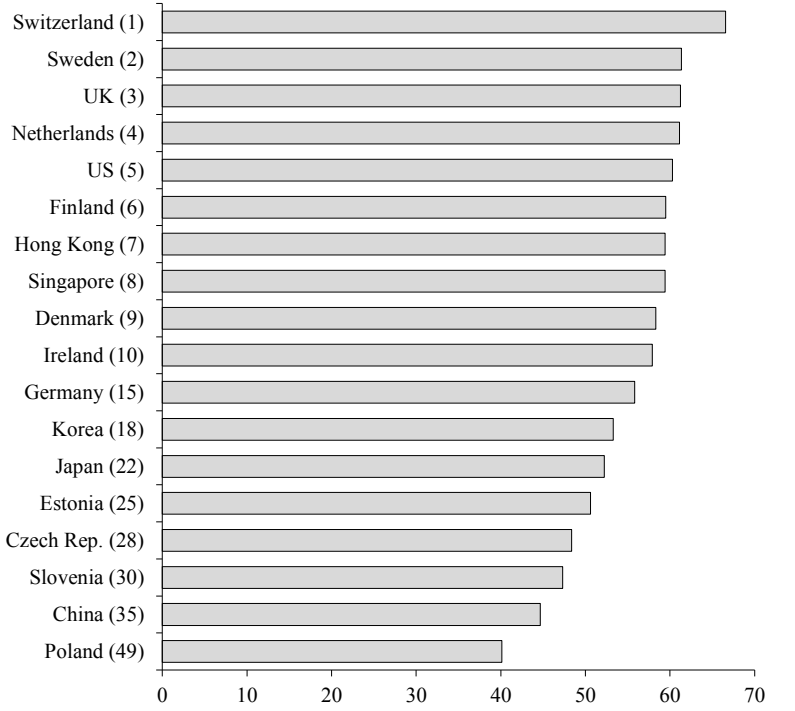

Figure 1. Global Innovation Index 2013 for selected countries (with rank in brackets)

Source: own preparation based on *The Global Innovation Index 2013...*, p. xx.

These trends are confirmed in Figure 1, which shows the Global Innovation Index (GII) for selected countries. The top ten most innovative countries in the world include six countries of the European Union, with

[8] In the most recent edition of the Innovation Union Scoreboard 2014, Poland returned to the last position of *moderate innovators* (por. *Innovation Union Scoreboard 2014...*, pp. 4–5).

high places also occupied by Hong Kong and Singapore. Furthermore, South Korea is more innovative than Japan which is close to Estonia, the Czech Republic and Slovenia. It must be added that those three countries saw a decline in the ranking compared to 2012 year; by 6, 1 and 4 positions, respectively. The ranking also confirms the Poland's weak innovation position. Compared to the 2012 edition, Poland fell down by five places, staying behind nine countries of medium-high income (including Malaysia, China, Costa Rica, Montenegro and Chile) and even one low-income country (Moldova).[9]

Data found in the innovation rankings indicates that the quickly developing Asian countries such as Malaysia and China, base their growth mainly on the imitative growth and without a rapid transition towards a model based on innovation and creativity they may fall into the aforementioned middle income trap. It can be assumed that a similar threat concerns also the fastest growing new EU members, i.e. Estonia, the Czech Republic and Slovenia, but also Poland.

3. Determinants of innovation position

Expenditure on R&D is usually considered one of the main determinants of the innovation position. Taking into account the previous considerations and the data presented in Table 2, this relation seems to be true, in particular with regard to countries in the global forefront of innovation. Expenditure on research and development higher than 2% GDP makes it possible to obtain a high ranking position, as exemplified by countries such as Switzerland, Scandinavian countries, South Korea, the United States and Japan. On the other hand, Israeli expenditure on R&D in 2011 exceeded 4% GDP, which gave that country only the 14th place in the GII ranking in 2013.

[9] See *The Global Innovation Index 2013*..., p. 10.

Table 2

Gross domestic expenditure on R&D (GERD) in selected countries by source of funds

Country	Year	GERD (% of GDP)	UE-28 = 100	Year	Share in GERD (%)		
					business enterprise sector	abroad	govern-ment and higher education sectors
Israel	2011	4.39	212	2009	39.0	42.8	18.2
Korea (Republic of)	2010	3.74	181	2010	71.8	0.2	28.0
Finland	2012	3.55	171	2012	63.1	8.8	28.1
Sweden	2011	3.39	164	2011	57.3	11.1	31.6
Japan	2010	3.25	157	2010	75.9	0.5	23.6
Denmark	2011	2.98	144	2011	60.2	8.7	31.1
Germany	2011	2.89	140	2011	65.6	4.2	30.2
Switzerland	2008	2.87	139	2008	68.2	6.0	25.9
Austria	2011	2.77	134	2012	44.6	15.6	39.8
United States	2010	2.73	132	2011	60.0	0.0	40.0
China	2011	1.84	89	2011	73.9	1.3	24.8
Czech Republic	2011	1.64	79	2011	46.9	15.2	37.9
Hungary	2012	1.30	63	2012	46.9	15.4	37.7
Russia	2011	1.12	54	2011	27.7	4.3	68.0
Poland	**2012**	**0.90**	**43**	**2012**	**32.3**	**13.3**	**54.4**
Philippines	2007	0.11	5	2007	62.0	4.1	33.9
Kuwait	2009	0.11	5	2009	2.3	1.2	96.5
Sri Lanka	2008	0.11	5	2008	19.9	4.3	75.8
Salvador	2009	0.08	4	2009	0.7	11.3	88.1
Paraguay	2008	0.06	3	2008	0.3	12.3	87.5
EU-28	2012	2.07	100	2011	54.9	9.2	35.9

Source: own calculations based on Eurostat data, http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/main_tables (13.07.2014); Word Bank, http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS (11.07.2014).

Although it is difficult to generalize from that single case, it seems that the structure of expenditures on R&D is also important. As can be seen in Table 2, highly innovative countries are characterized by a large share of the business sector in the financing of research and development. On the other hand, in countries considered to be less innovative,

a relatively large share of expenditure on research and development comes from abroad (this applies to Israel, and also to some extent to Austria, the Czech Republic, Hungary and Poland) or public sector (for example in Russia, Poland and less developed countries). It can therefore be concluded that the innovation position can be enhanced by both the volume of investment in R&D and involvement of domestic companies.[10]

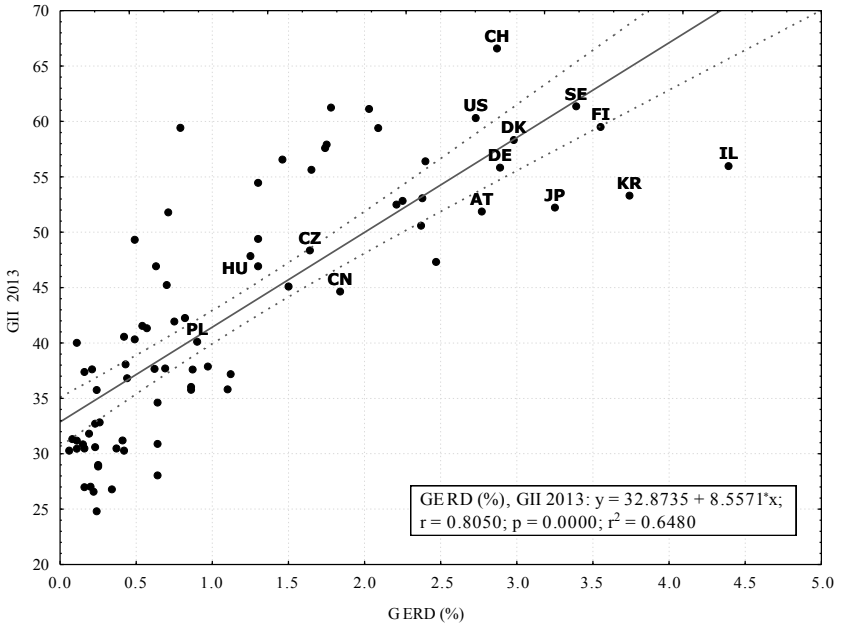

Figure 2. GII 2013 vs. GERD *s*catterplot

Source: same as under the table 2.

A strong positive correlation relationship between GII and gross domestic expenditure on R&D (GERD) is shown in Figure 2. The linear correlation coefficient for 80 countries is 0.81, while the coefficient of determination – 0.65. It means that as many as 65% of change in the

[10] More on the involvement of enterprises in R&D in Poland see *Badania i rozwój w Polsce. Raport 2014*, Deloitte Polska, Warszawa 2014, pp. 6–15.

dependent variable (GII) depends on change in expenditure on R&D. Furthermore, at the linear regression coefficient equal to 8.56, an increase in expenditure on R&D by 1 percentage point results in an improved GII by 8.56. In the case of Poland, an increase in expenditure on R&D by 1 percentage point should result in a GII exceeding 49, i.e. getting close to the results of Spain and Cyprus in the GII 2013 ranking.

Table 3

Correlation coefficients for sub-indices included in GII 2009
(data for n = 87 countries)

Itemization		Input Pillars					Output Pillars		
		institutions	human capacity	general and ICT infrastructure	market sophistication	business sophistication	knowledge	competitiveness	wealth
Input Pillars	institutions	1.00							
	human capacity	0.81	1.00						
	general and ICT infrastructure	0.86	0.85	1.00					
	market sophistication	0.83	0.85	0.86	1.00				
	business sophistication	0.93	0.92	0.88	0.87	1.00			
Output Pillars	knowledge	0.86	0.89	0.85	0.80	0.91	1.00		
	competitiveness	0.73	0.82	0.77	0.80	0.80	0.86	1.00	
	wealth	0.68	0.67	0.75	0.64	0.69	0.64	0.50	1.00

Source: own calculations based on *The Global Innovation Index 2008–2009*, Confederation of Indian Industry, and INSEAD, New Delhi, and Fontainebleau, 2009, pp. 8, 17–32.

Given that investment in R&D is not the only determinant of innovative position, it is worth analyzing the relationship between sub-indices used in calculating the Global Innovation Index. Tables 3 and 4 show the

results of the correlation analysis for the components of GII in 2009 and 2013. Importantly, the number of sub-indices and the scope of covered data changed over the period. In 2009, GII included five inputs and three outputs, while in 2013 it was five and two, respectively. In addition, the analysis of sub-indices concerned a different number of countries (87 in 2009, 80 in 2013), which resulted mainly from the non-availability of data.

Table 4

Correlation coefficients for sub-indices included in GII 2013
(data for n = 80 countries)

Itemization		Input Pillars					Output Pillars	
		institutions	human capital and research	infrastructure	market sophistication	business sophistication	knowledge and technology outputs	creative outputs
Input Pillars	institutions	1.00						
	human capital and research	0.83	1.00					
	infrastructure	0.84	0.89	1.00				
	market sophistication	0.76	0.77	0.77	1.00			
	business sophistication	0.81	0.83	0.83	0.77	1.00		
Output Pillars	knowledge and technology outputs	0.65	0.74	0.70	0.66	0.76	1.00	
	creative outputs	0.78	0.70	0.75	0.59	0.74	0.55	1.00

Source: own calculations based on *The Global Innovation Index 2013...*, pp. 6, 130–271.

Despite the problems with ensuring full comparability of data, Tables 3 and 4 show that the correlation coefficients between inputs were generally higher than between outputs. In addition, in 2009, the lowest

correlation coefficients were found for competitiveness and wealth creation, while in 2013 for technology, knowledge and creative activity.

In the analyzed period, the correlations between the variables increased, which is indicated by higher values of correlation coefficients. However, it could have also been due to a better selection of data that made up the individual sub-indices. On the other hand, correlation between outputs was lower than for inputs, which suggests that the transformation of expenditure on innovation (including expenditure on R&D) into concrete results, for example higher competitiveness, more efficient absorption, improved diffusion of knowledge and development of creative industries, may depend on factors that are difficult to measure and identify, and – more importantly – difficult to compare between countries.

Table 5

Correlation coefficients between sub-indices included in GII 2013 and GERD (data for n = 80 countries)

Sub-indices of GII 2013	Correlation coefficients		
	GERD (total)	business sector share in GERD	public sector share in GERD
Institutions	0.68	0.60	–0.57
Human capital and research	0.85	0.70	–0.60
Infrastructure	0.75	0.67	–0.55
Market sophistication	0.65	0.56	–0.44
Business sophistication	0.74	0.68	–0.68
Knowledge and technology outputs	0.75	0.67	–0.61
Creative outputs	0.58	0.45	–0.44

Source: own calculations based on *The Global Innovation Index 2013...*, pp. 6, 130–271, Eurostat data, http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/main_tables (13.07.2014); World Bank, http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS (11.07.2014).

In business practice, the origin of funds allocated to research and development has a significant impact on the effectiveness of innovation processes in the economy, as reflected in Table 5. Correlation between GERD and GII sub-indices is clearly positive, which is undoubtedly enhanced

by a large share of business sector expenditure on R&D. In turn, high negative correlation coefficients between GII sub-indices 2013 and the public sector spending on R&D indicate its low effectiveness in stimulating innovation. In other words, the data confirms that countries with a high share of the business sector in the financing of research and development tend to have significantly higher innovation than those, in which the main burden of the financing of R&D falls on the public sector (including higher education). For example, the low innovativeness of the Polish economy, especially against the background of the European Union, is largely a consequence of the relatively high share of public sector expenditure on R&D in Poland, which amounted to almost 55% in 2012, while the share of enterprise spending on R&D was only slightly more than 32%.

The aforementioned data may by summarized by analysis of changes in the innovation efficiency ratio for selected countries in 2009–2013. As can be seen in Table 6, in the analyzed period most developed countries reported deterioration in inputs and outputs, most strikingly in the United States, Japan, Germany and France. On the other hand, an improved innovation efficiency ratio was observed in Switzerland, Israel and Iceland, which indicates that high expenditure on innovation in those countries is increasingly accompanied by efforts meant to make the best use of the acquired technology and knowledge, improve the competitiveness of the economy and develop sectors related to intellectual property.

Among the new members of the European Union, there was a significant increase in inputs in Bulgaria and Poland; in the latter mainly due to positive changes in the institutional environment including the political, regulatory and business environment.[11] In outputs, the greatest improvement was recorded in Bulgaria, Estonia and Hungary, while in the case of Poland and Slovakia, it noticeably deteriorated. As a result, the Polish innovation efficiency ratio in 2013 was not only the lowest among all the analyzed countries, but also recorded one of the biggest declines. This

[11] These factors include e.g. political stability, quality of law and ease of starting business. In the ranking regarding institutions Poland had the 35th place, the best achievement among other GII 2013 sub-indices. More on this issue see *The Global Innovation Index 2013...*, pp. 41, 232.

is undoubtedly associated with the aforementioned low expenditure on R&D, as well as the long-term problems with the commercialization and practical application of R&D in Poland.[12]

Table 6

Innovation Efficiency Ratio for selected countries in period 2009–2013

Country	Innovation input sub-index					Innovation output sub-index					Innovation efficiency ratio		
	2009		2013		change	2009		2013		change	2009	2013	change
	A	B	A	B		A	B	A	B		A	B	
	1	2	3	4	(4 – 2)	6	7	8	9	(9 – 7)	11	12	(12 – 11)
Finland	5.36	0.88	66.68	0.88	0.00	3.77	0.67	52.35	0.70	0.03	0.70	0.79	0.09
France	4.92	0.74	59.04	0.71	–0.03	3.78	0.68	46.65	0.58	–0.10	0.77	0.79	0.02
Israel	5.08	0.79	59.80	0.73	–0.06	3.26	0.52	52.10	0.69	0.17	0.64	0.87	0.23
Japan	5.18	0.83	62.82	0.79	–0.04	4.12	0.78	41.65	0.47	–0.31	0.79	0.66	–0.13
Germany	5.45	0.91	59.80	0.73	–0.18	4.54	0.91	51.90	0.69	–0.22	0.83	0.87	0.04
Iceland	5.17	0.82	59.64	0.73	–0.09	3.52	0.60	53.15	0.71	0.11	0.68	0.89	0.21
Switzerland	5.59	0.96	66.50	0.87	–0.09	3.86	0.70	66.65	1.00	0.30	0.69	1.00	0.31
United States	5.72	1.00	69.18	0.93	–0.07	4.84	1.00	51.40	0.68	–0.32	0.85	0.74	–0.11
United Kingdom	5.61	0.96	68.18	0.91	–0.05	4.04	0.75	54.30	0.74	–0.01	0.72	0.80	0.08
Bulgaria	3.37	0.26	43.96	0.39	0.13	2.32	0.23	38.70	0.41	0.18	0.69	0.88	0.19
Czech Republic	4.12	0.49	53.44	0.59	0.10	3.17	0.49	43.25	0.51	0.02	0.77	0.81	0.04
Estonia	4.60	0.64	55.68	0.64	0.00	2.78	0.37	45.50	0.55	0.18	0.61	0.82	0.21
Poland	3.58	0.32	47.82	0.47	0.15	2.72	0.35	32.45	0.28	–0.07	0.76	0.68	–0.08
Romania	3.37	0.26	42.82	0.36	0.10	2.49	0.28	37.85	0.39	0.11	0.74	0.88	0.14
Slovakia	4.10	0.49	48.32	0.48	–0.01	3.09	0.46	36.20	0.36	–0.10	0.75	0.75	0.00
Hungary	3.89	0.42	48.68	0.49	0.07	2.79	0.37	45.35	0.55	0.18	0.72	0.93	0.21
Korea (Republic of)	5.45	0.91	62.10	0.78	–0.13	4.01	0.75	44.55	0.53	–0.22	0.74	0.72	–0.02
Hong Kong	5.45	0.91	70.66	0.96	0.05	3.73	0.66	48.20	0.61	–0.05	0.69	0.68	–0.01
Singapore	5.60	0.96	72.28	1.00	0.04	4.02	0.75	46.55	0.58	–0.17	0.72	0.64	–0.08
China	3.85	0.41	45.16	0.41	0.00	3.33	0.54	44.15	0.52	–0.02	0.87	0.98	0.11
Russia	3.30	0.24	43.76	0.38	0.14	2.56	0.30	30.60	0.24	–0.06	0.78	0.70	–0.08
South Africa	4.06	0.47	43.96	0.39	–0.08	2.76	0.36	31.25	0.25	–0.11	0.68	0.71	0.03

A – index value.
B – value normalized using zero unitarization method.

Source: own calculations based on *The Global Innovation Index 2008–2009*..., pp. 11–14; *The Global Innovation Index 2013*..., pp. 130–271.

[12] See also J. Staśkiewicz, *W kwestii finansowania działalności B + R w Polsce w latach 1991–2008*, Zeszyty Naukowe Uniwersytetu Szczecińskiego nr 645, Studia i Prace WNEiZ nr 23, Szczecin 2011, pp. 123–138.

The last group of countries in Table 6 shows the worsening of the innovation efficiency ratio (excluding China and South Africa). It should be noted that countries such as Singapore, Hong Kong and South Korea occupy the top rankings in terms of inputs (respectively 1st, 2nd and 16th position); a significant decrease in outputs in those countries translated into the deterioration of their innovation efficiency ratio (for comparison, among the three countries South Korea had the highest 95th place in the ranking of the effectiveness of the innovation, while Poland was classified at the 110th position, directly behind Hong Kong).

Conclusions

Data analyzed above indicates that the volume of expenditure on research and development is a key factor for the innovativeness of the economy. In addition, analysis of statistical data gives rise to the following conclusions:

1. In addition to the amount of expenditure on R&D, innovativeness is also influenced by the scale of the involvement of enterprises (business sector). Although this paper concerned only selected economies, analysis of volume and structure of expenditure on R&D indicates that the level of innovation in the economy is positively correlated with the role of the private sector in the financing of the R&D. Countries with a predominance of public sources in the financing of R&D have a low and also slow-growing index of innovation.
2. The lower correlation coefficients between outputs compared with inputs indicate that after reaching a certain stage of economic development the transition from an imitation to innovation economy is increasingly influenced by parameters that are difficult to measure, probably concerning not only the economic, but also social, cultural and political background. This is probably associated with the increasing role of investment in human and not just financial capital, development of social capital, networking, greater involvement in the processes of diffusion of knowledge on an

international scale, as well as the ability to effectively transform knowledge and new ideas into innovative goods and services.

3. The relationship between inputs and outputs in the innovation process is well reflected by the innovation efficiency ratio, which over the past five years has clearly improved in countries such as Switzerland, Iceland, Israel, China and some countries in Central and Eastern Europe. Such a trend was primarily due to better outputs of innovative activity, which helped those countries strengthen their position among knowledge-based economies. Deterioration or no changes in innovation efficiency in some of the world's leading economies, such as the United States, Japan, France or the United Kingdom suggests that they are slowly losing their current technological advantage, especially against the rapidly developing Asian countries.
4. The presented data confirm the low and deteriorating innovation position of Poland, despite the increased spending on R&D in recent years. This obviously results from a number of factors, which could not be fully analyzed in this article. Nonetheless, expenditure on R&D in Poland is still far too low, especially in comparison with other European Union members. In addition, despite many activities and incentives the financing of R&D in Poland comes mainly from the public sector, while the involvement of companies in this field is low. Finally, Polish companies are reluctant to cooperate with one another in R&D and ignore long-term benefits from the cooperation with Polish universities. This is reflected in the ranking of the innovation efficiency for 2013, in which Poland was ranked at the distant 110th place out of 142 countries. This indicates that Poland is still mainly the imitator of foreign solutions and exports few genuine solutions in the international flow of knowledge and innovation.

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