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Research and development –a strong or weak position of the EU in comparison with global competitors

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Abstract:

Aim: The main purpose of the article is to make a comparative analysis of the European Union importance in R&D field in comparison to the United States, Japan and China.

Design/ Research methods: In the first section, the relation between R&D and socio-economic changes is discussed. In the next part, research and development funding is explored. In the last section, the discussion addresses the following factors: world share of researchers, world share of scientific publications, share of global patents. The main axis of investigation is a comparative analysis, which refers to the international statistical databases: the EUROSTAT, UNESCO and the OECD databases. The study period mainly covered the years 2007 – 2014.

Conclusions/Findings: In conclusion it is stated that the EU has the world's largest share in the number of researchers, as well as in the number of publications. European spending on research and development is not sufficient. Furthermore, the biggest threat to the European Union's global position in the area of R&D seems to be China, due to unusually dynamic progress in many areas of R&D.

Originality / value of the article: The article allows to understand better the international position of the European Union in R&D field.

Keywords: research and development sector, R&D funding, European Union.
JEL: O3

1. Introduction

The research and development sector is currently one of the key elements influencing economic growth and development; it nurtures the creation of knowledge-based economy. The

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competitiveness of country's economy is greatly determined by its capability to create innovative solutions or to set up a system of incentives to develop R&D activities. Implementation of research results boosts social life level, and also enhances implementation of environment protection solutions, thus conditioning care for sustainable development. Investments in research and innovations are one of the key elements for the EU socio-economic development in the future (Priede, Pereira 2013) the demonstration of which is the EU's priority set out in Europe 2020 strategy to be achieved by 2020 (Communication from the Commission - *Europe 2020 - A strategy for smart, sustainable and inclusive growth*, COM(2010) 2020). What is the position of EU in comparison with global competitors in the area of research and development? Is the level of research and development funding sufficient? What is the direction that the European Union is heading for? This paper endeavours to answer these questions.

The main purpose of the article is to make a comparative analysis of the European Union importance in R&D field in comparison to the United States, Japan and China. The reflections will be based on the examination of European Union reports and documents. The main axis of investigation is a comparative analysis, which refers to the international statistical databases provided by the EUROSTAT, UNESCO and the OECD. The period examined mainly covers the years 2007 - 2014 due to the availability of data, however subject to occasional changes. Due to a multifaceted nature of the subject discussed, reflections have been narrowed down to selected indicators only.

2. Research and development in view of socio-economic changes

The EU Member States point out the special role of R&D in achieving sustainable socio-economic growth and also recognize R&D as one of solutions to overcome the economic crisis of recent years (Priede, Neuert 2015). According to that vision, the concept of smart growth (under the Europe 2020 strategy) is being developed nowadays in the EU. The main assumption of smart growth is developing an economy based on knowledge and innovation. In a communication on *Research and innovation as sources of renewed growth* the European Commission on 10.6.2014 underlined that "(…) new growth opportunities come from providing new products and services derived from technological breakthroughs, new processes and business models, non-technological innovation and innovation in the services sector" (COM(2014) 339).

It seems that the development of economies and societies is determined by socio-economic, environmental, technological and political changes. These multidimensional trends also affect directions and pace of technological changes, determine research and innovation policy activities. The OECD indicates several megatrends, which will affect the development of science, technology and innovation (STI) in the coming years (Table 1).

Table 1. Some of megatrends affecting science, technology and innovation

Megatrend	Selected directions of changes and forecasts	Selected implications for science, technology and innovation
Demography	– the global population will grow from 7.4 billion in 2015 to 8.5 billion by 2030 and 9.7 billion by 2050, – ageing society - the number of people over-60 is projected to increase to 1.4 billion by 2030 and 2.1 billion by 2050, Europe is expected to have the largest proportion of over-60s (34% in 2050 compared to 24% in 2015), – the size of the working-age population (15-64) will begin to diminish, – climate change may have an influence on future international migration flows - moreover, projection assumes that inflows of migrant workers will be an important factor to mitigate ageing in most OECD countries	– the demands and needs of the centres of largest population growth could impact on innovation programmes, – changes in lifestyle and consumption patterns (ensuing form ageing society), will influence on demand on the new types of products and the direction of innovation – fewer people of working age will affect the labour market for STI skills,
Natural resources and energy	– population growth and economic development will expand global demand for water, food and energy and increase pressures on natural resources, – energy consumption will rise sharply, – global primary energy demand is projected to increase by 37% between 2012 and 2040, – the global energy mix will be transformed, mainly on account of the growing use of renewables (worldwide share of use of renewables for electricity generation will increase to over 33% in 2040)	– new markets for renewables will depend on technological innovations (significant investments in R&D will be important), – new STI knowledge could improve the monitoring, management and productivity of natural resources, – in future wide adoption of best available technologies for efficient resource use should be promoted
Climate change and environment	– there is a strong relationship between projected global temperature change and cumulative CO2 emissions - a stringent scenario (2°C target agreed at the Paris climate conference) requires a 40%-70% reduction in global greenhouse gas (GHG) emissions by 2050, – a series of severe climatic changes will accompany global warming (e.g. extreme precipitation events will become more intense and frequent in many regions)	- climate change and environmental degradation will require greater international R&D co-operation - climate change sets directions for further research, - energy technology innovation will be key in achieving the 2 °C scenario,
Globalisation	- export of goods and services is increasingly made of inputs from around the world,	- globalisation facilitates the wide diffusion of knowledge, technologies - international mobility of highly

	- global trade integration is expected to continue to grow in the future, - R&D and innovation activities are increasingly global (multinational enterprises are internationalising their R&D at a faster pace and on a larger scale than before) - the international co-invention of patents increased by 27% between 2000-2003 and 2010-2013, - average annual growth in demand for international higher education between 2005 and 2025 is expected to exceed 3% in Africa, the Middle East, Asia, Central America and South America - the number of internet users is expected to grow to 4.7 billion in 2025 (from 3.42 billion in 2016),	educated individuals affects knowledge circulation worldwide, - digital technologies help ease the strains of mobility, transfer of knowledge, international cooperation in R&D
Economy, jobs and productivity	– global growth is estimated to slow to 2.4% in 2050-2060, – by 2030, developing countries are expected to contribute two-thirds of global growth and will be the main destinations of world trade, – in the services sector, digital technologies have helped creation of new and more efficient businesses, boosted productivity growth, and facilitated international trade in services, – over the next 15 years firms will become predominantly digitalised (making them more productive), – research suggests that around one in ten jobs across the OECD is at high risk of automation,	– the development of digital technologies is likely to have impacts on productivity and income distribution, – the development of Asian economies will be linked to investments in STI, – future innovations may create more robust productivity growth and new jobs that, as yet, have not even been imagined
Society	– the number of students enrolled in higher education will double globally by 2025 to 260 million, – in 2050 about 70% the world population will be living in urban areas, – the global economy's middle class is expected to more than double, from 1.8 billion in 2009 to almost 5.0 billion in 2030, – two thirds of those middle-class citizens are expected to be found in Asia	– a growing middle class and increasing consumption will increase demand for innovative consumer goods worldwide, - urban areas will become increasingly "smart" (a new direction of innovation in sectors such as housing and transportation)

Source: Own elaboration based on: OECD (2016), *OECD Science, Technology and Innovation Outlook 2016*, OECD Publishing, Paris, p.21-76.

It seems that climate changes, clean energy and ageing societies will have an increasingly higher impact on determining directions of research and needs for innovations in a given field. Megatrends mentioned above are of global nature; the challenges do not refer to selected countries only. In the light of the above, international cooperation in the area of research and development is of key significance. Moreover, digital technologies impact on societies in a significant way, changing not only the way people work, but also how they live. They influence both their working and private life. The on-going globalisation process will result in wider access to science and

technology in the world. Development and dissemination of knowledge should be expected to gain in importance. It seems that income increase will be more and more related to development in science, technology and innovations. However, in the global perspective there is concern about possibly increasing inequalities regarding access to innovations. Simultaneously, ageing societies might additionally cause a necessity of raising medical care and social spending, which might result in lower research and development funding (OECD 2016).

It should be noted that progress of R&D cannot be perceived only in economic terms. Research and development are of particular meaning not only in the aspect of economic competitiveness, but above all, they are strongly related to social changes. Newly created innovations should be a practical reply to changes and challenges. In the light of the above, progress of research and development seems to be of key importance among the objectives of a country's national and international policy.

3. Research and development funding

For a long time, the European Union has been attempting to achieve one of the best world's results in the field of R&D. It seems that research and innovation are particularly important elements of the policy pursued by the European Commission. In that case, it is interesting to conduct a comparative analysis of the importance of the efforts made by the European Union compared to those made by China, Japan and the USA in that regard. It is important to emphasize that those countries have over 50% share of global gross domestic product (GDP) (table 2). Moreover the USA, the EU and Japan are faced with similar challenges, such as an ageing society and are confronted with tough international competition (UNESCO 2015:5).

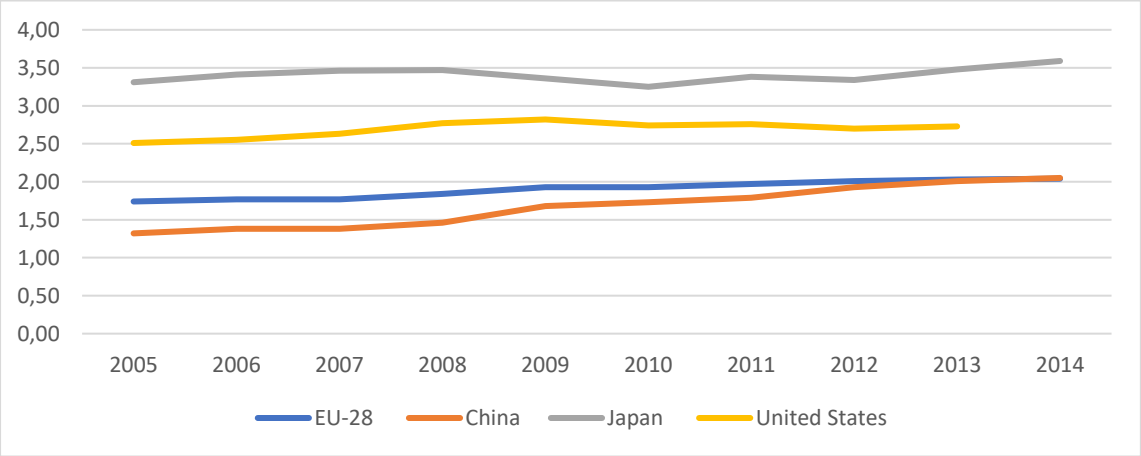
Table 2. Trends in population and GDP

	Share of global population (%)		Share of global GDP (%)			
	2007	2013	2007	2009	2011	2013
EU	7.5	7.1	20.4	19.1	18.1	16.9
China	20	19.3	11.5	13.4	14.8	16.1
Japan	1.9	1.8	5.6	5.1	4.9	4.7
US	4.6	4.5	18.9	17.9	17	16.7

Source: Own elaboration based on: UNESCO (2015), *UNESCO Science Report: towards 2030 – Executive Summary*, p.7.

R&D expenditure is one of the key indicators used to monitor resources devoted to science and technology worldwide. It is important to emphasize that according to the UNESCO's Report (2015:12): "the US still dominates, with 28% of global investment in R&D. China has moved into second place (20%), ahead of the EU (19%) and Japan (10%). The rest of the world represents 67% of the global population but just 23% of global investment in R&D."

Graph 1. Gross domestic expenditure on R & D, 2005–2014 (% of GDP)



Source: Own elaboration based on: EUROSTAT.

In comparison to other major economies (graph 1), R&D intensity in the EU (2.04% in 2014) was much lower than in Japan (3.59% in 2014) and lower than in the United States (2.73% in 2013), while it was about the same level as in China (2.05% in 2014). In 2014, gross expenditure on R&D (GERD) in China reached €277.6 billion (Huang et.al. 2016:3). In 2015, the Member States of the EU spent all together almost €300 billion on R&D (Eurostat 2016). According to the graph above, the most important problem is a wide gap between the EU, the US and Japan. However, an increase by 2020 of the R&D intensity in the EU to 3% of the GDP is one of the five headline targets of the Europe 2020 strategy. "The EU member states started from very diverse points in terms of R&D expenditures levels and that their economic systems were highly differentiated" (Zawalińska et al., 2018:41). It is generally agreed today that the development of R&D is dependent on funding (increasing expenditure), but there is a fear that individual governments will have to confront their decisions in this area with possible difficulties in financing public debt.

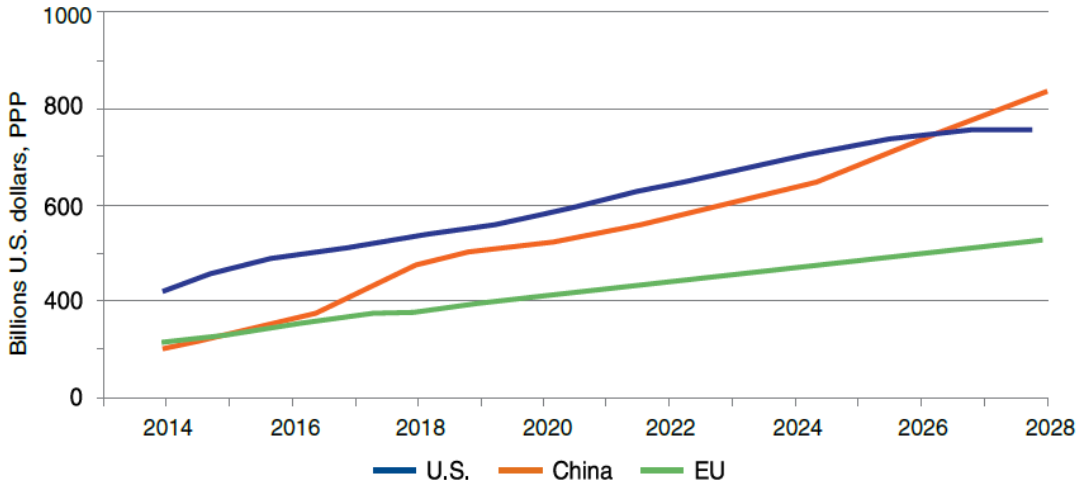
Table 3. Gross domestic expenditure on R & D by source of funds (% of total gross expenditure on R & D)

Time	BUSINESS ENTERPRISE SECTOR					GOVERNMENT SECTOR				
	2005	2007	2009	2011	2014	2005	2007	2009	2011	2014
EU - 28	54,1	54,9	54,1	55	55,3	34,4	33,3	34,9	33,3	32,3
United States*	63,3	64,9	57,9	58,5	60,9	30,8	29,2	32,7	31,1	27,7
China	67	70,4	71,7	73,9	75,4	26,3	24,6	23,4	21,7	20,3
Japan	76,1	77,7	75,3	76,5	77,3	16,8	15,6	17,7	16,4	16

*2013 Instead of 2014
Source: Own elaboration based on: EUROSTAT.

There is a marked difference between the structure of the gross domestic expenditure on R&D (GERD): In 2014, in the European Union about 55% of R&D was funded by the business enterprise sector, while in Japan - more than 75% (table 3). In the EU the government sector is committed to funding R&D on a bigger scale than in the US, Japan and China. From the figures it is apparent that the R&D expenditure and its structure in the following years shows relatively lower expenses within the EU when compared to its main competitors. It seems that the business sector is not sufficiently committed, which is one of the most important weaknesses of the European system.

Graph 2. Annual R&D budget in the US, the EU and China – forecast to 2028



Source: *The 2016 Global R&D Funding Forecast*, 'R&D Magazine', Winter 2016, pp. 23.

According to the international forecast, the graph 2 shows the presumptive development of annual R&D budgets in the USA, the European Union and in China. It seems likely that China will

surpass the U.S. (Odrobina, 2017) in R&D investments around 2025-2026. Such forecasts assumes that R&D investments in the U.S. will continue to grow at a level of 3 to 4% annually while China's R&D investments will continue to grow at their elevated rates of 6 to 7% annually (R&D Magazine 2016:23).

It is important to emphasize that in the Third Plenary Session of the 18th the Chinese Communist Party Central Committee held in November 2013, the decision was made to deepen the comprehensive reform in China in order to pursue the innovation-driven development strategy. One of the objectives of the reform is to reduce fragmentation and enhance harmonization of the science and technology funding (Huang et.al. 2016: 3-4). That decision can have a significant impact on further development of China.

Taking into account the statistical data, it can be surmised that the level of R&D funding is not sufficient in the European Union, especially in the global view. However, it is important to emphasize that the European Union budget for 2014-2020 marks a decisive shift towards research and innovation. Furthermore, the budget for Horizon 2020, the new EU programme for research and innovation, was increased by 30% in real terms. A further EUR 83 billion is expected to be invested in research and development through the new European Structural and Investment Funds (COM(2014) 339).

4. A discussion over research and development sphere

The figures reveal that nowadays there are about 7.8 million researchers worldwide (UNESCO 2015). The EU remains a world leader in the number of researchers, with a 22.2% share of global researchers in 2013 (table 4). However, in the EU there are much fewer researchers per one million inhabitants than in the US and Japan.

Table 4. World share of researchers

	Researchers per million inhabitants		Share of global researchers (%)			
	2007	2013	2007	2009	2011	2013
EU	2911.8	3388.3	22.8	22.5	22.1	22.2
China	852.8*	1071.1	N/A	16.7	17.9	19.1
Japan	5377.7	5194.8	10.7	9.5	8.9	8.5
US	3731.4	3984.4*	17.7	18.1	17	16.7*

*Data refers to a year previous to the stated one

Source: Own elaboration based on: UNESCO (2015), *UNESCO Science Report: towards 2030 – Executive Summary*, p.14-15.

Since 2007, the global number of researchers has risen by 21% (UNESCO 2015). This growth is also reflected in the number of scientific publications. UNESCO (2015:19) points to nearly 15% growth in publications by authors from Europe between 2008 and 2014. Moreover, that region has the greatest share of publications (over 39%). In 2014, the EU was leading the world in publications (34%), followed by the USA (25%) and China (20%). Despite these remarkable figures, the world share of both the EU and the USA has fallen over the past five years (table 5).

Table 5.World share of scientific publications

	Total publications		Change (%) 2008-2014	World share of publications (%)	
	2008	2014		2008	2014
EU	379 154	432 195	14	36.8	34
China	102 368	256 834	150.9	9.9	20.2
Japan	76 244	73 128	-4.1	7.4	5.8
US	289 769	321 846	11.1	28.1	25.3

Source: Own elaboration based on: UNESCO (2015), *UNESCO Science Report: towards 2030 – Executive Summary*, p.18.

Broadly speaking, the global volume of scientific production, as indexed in Scopus, increased over the 2003-2012 period by nearly 8% per year (OECD 2015:61). OECD indicated five major countries, which have a crucial role in global scientific publication (table 6). Between 2003 – 2012 the total number of publications rose by 50% in the USA, over 60% in the UK and Germany, only 25% in Japan, while the total output quadrupled (over 400%) in China. Top-cited publications provide a measure of "quality-adjusted" research output. China's excellence rate reached nearly 9% in 2012 over nearly 409 000 publications, in the US 17% over above 580 000 publications. In the United Kingdom, the excellence rate is close to 18% over nearly 167 000 publications, indicating that China has nearly 7 000 more top-cited publications than the United Kingdom and above 11 000 more than Germany.

Table 6. Trends in scientific publication, selected countries

	Scientific publication output		Average annual growth rate	Scientific publication output among world's 10% most cited documents		Share of domestic scientific publication output among 10% most cited documents		Percentage point difference
	2003	2012	2003-2012	2003	2012	2003	2012	2003-2012
United States	388 323	587 699	4,7	74 364	102 260	19	17	-1,8
China	75 890	409 301	20,6	6 041	37 574	8	9	1,2
United Kingdom	102 098	167 624	5,7	18 847	30 692	18	18	-0,2
Germany	95 583	154 423	5,5	14 557	25 742	15	17	1,4
Japan	103 707	129 801	2,5	10 516	12 370	10	10	-0,6

Source: Own elaboration based on: OECD (2015), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for growth and society*, OECD Publishing, Paris, p.61.

Patenting behaviour provides insights into the impact of innovation. Activity in patenting is one of the significant indicators, which shows a country's propensity to pursue technology-based competitiveness at the global level. The US remains a world leader in the number of patents, with over 50% share of global patents in 2013 (table 7), followed by Japan (19%) and the EU (16.3%). Chinese patents have a negligible share.

Table 7. Patents submitted to USPTO by region or country of inventor

	UPSTO patents			
	Total		World share (%)	
	2008	2013	2008	2013
EU	24 121	45 401	15.3	16.3
China	1 757	7 568	1.1	2.7
Japan	34 198	52 835	21.7	19
US	79 968	139 139	50.7	50.1

Source: Own elaboration based on: UNESCO (2015), *UNESCO Science Report: towards 2030 – Executive Summary*, p.20.

Taking into account the statistical data, one may hardly say that the EU has a dominating position in R&D field. The EU has the world's largest share in the number of researchers, as well as in the number of publications. However, European results are not very encouraging with regard to the quality of scientific activities. The US are the undisputed leaders in patenting and the number of top-cited publications. Furthermore, China is rapidly developing in the R&D field, with a recorded impressive change between 2008 and 2014 in number of publications and a very high average annual growth rate between 2003-2012 in scientific publication output. It seems that this impressive growth may reflect the coming of age of the *Chinese research system*, be it in terms of investment or publications. This might mean a significant weakening of the position of the EU.

5. Findings

Guided by the above reflections on R&D, it has to be clearly highlighted that the importance of that sector will probably increase in the future, not only in the context of sustained economic growth, but also resulting from a growing need to face global challenges such as climate change, demographic changes, or globalisation. Taking into account the important impact of R&D on economic competitiveness, progress in the research and development sphere might contribute to geopolitical change of meaning of the world's most important economies. It might also lead to change the European Union's position in world in that aspect.

Nevertheless, it is difficult to precisely assess the position of the European Union in comparison with its global competitors. With reference to presented data, the following issues need, however, to be pointed out:

- A relatively big number of researchers as well as the capability of creating new scientific publications is the European Union's strength; however, the EU's further development should be focusing on improving efficiency and quality of research to an even greater extent.

- European spending on research and development is not sufficient; this also refers to private sector funding; in addition, there is a fear that in spite of strategic assumptions regarding an increase of spending on R&D up to 3% of GDP in the future, the current position of the EU will not be maintained as a result of China's dynamic development. It seems that to fully capture the potential of research and development as sources of economic growth, the EU needs to prioritise the growth of expenditure on R&D, including by leveraging business investment in research and

innovations; moreover, those investments need to go hand in hand with reforms stimulating an increase of the quality of research.

- The data analysis of selected years carried out in a global perspective allows concluding that R&D activity in the EU is characterized by maintaining a stable level of growth. This implies that the position of the EU is likely to remain unchanged in comparison with its global competitors. The share of the EU in the global number of researchers or creation of patents has been almost stable percentage.

- The biggest threat to the European Union's global position in the area of R&D seems to come from China, due to an unusually dynamic progress in many areas of R&D, such as the overall level of spending or the rapidly growing number of scientific publications.

Bibliography

Communication from the Commission - Europe 2020 - A strategy for smart, sustainable and inclusive growth, COM(2010) 2020, Brussels, 3.3.2010.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Research and innovation as sources of renewed growth, COM(2014) 339 final, Brussels, 10.6.2014.

Gross domestic expenditure on R & D by source of funds, EUROSTAT (online data code: rd_e_fundgerd), [29.03.2017].

Huang C., Jin X., Li L. (2016), RIO Country Report 2015: China – Executive Summary, European Union.

Odrobina, A. (2017). Stany Zjednoczone versus Chiny: rywalizacja o prymat w globalnej działalności badawczo-rozwojowej (United States v*ersus* China: competition for primacy in global R&D activities), „Horyzonty Polityki", Nr 8(23), pp. 101-120, DOI: 10.17399/HP.2017.082305, [30.04.2018].

OECD (2015), OECD Science, Technology and Industry Scoreboard 2015: Innovation for growth and society, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_scoreboard-2015-en [26.03.2017].

OECD (2016), OECD Science, Technology and Innovation Outlook 2016, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_in_outlook-2016-en [23.03.2017].

Priede J., Pereira E.T., (2013), Innovation as a key factor in the international competitiveness of the European Union, "European integration studies", No. 7, pp. 212 – 221., http://dx.doi.org/10.5755/j01.eis.0.7.4228 [30.04.2018].

Priede J., Neuert J. (2015), Competitiveness Gap of the European Union Member Countries in the Context of Europe 2020 Strategy, "Procedia - Social and Behavioral Sciences" Vol. 207, pp. 690 – 699.

Research and development expenditure, EUROSTAT (online data code: tsc00001), [23.03.2017].

UNESCO (2015), UNESCO Science Report: towards 2030 – Executive Summary, UNESCO Publishing, http://unesdoc.unesco.org/images/0023/002354/235407e.pdf [26.03.2017].

Zawalińska K., Tranb N., Płoszaj A. (2018), R&D in a post centrally-planned economy: The macroeconomic effects in Poland, "Journal of Policy Modeling" Vol. 40, pp. 37–59.