

THE DEVELOPMENT OF THE KNOWLEDGE ECONOMY IN THE EU-27 MEMBER STATES (YEARS 2007 AND 2011)

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Abstract

The first part of the paper discusses the concept of knowledge economy and shortly describes several summary innovation indices which are provided by European, American and international institutions. The second part of the contribution deals with the methodology of The EU-27 Innovation Index which was created to analyse the quantitative features of the knowledge economy. This index was prepared by the researchers from the Faculty of Business Administration of the University of Economics, Prague as one of the outputs of their project „Competitiveness“. The third and fourth part of the contribution provides the results of The EU-27 Innovation Index for years 2007 and 2011. The comparison of these two years allows researchers to analyse the impacts of recession 2009 on the innovation capacity of the EU 27 member states. The third part of the paper provides results of the analysis based on the overall knowledge economy score achieved by each country. The EU-27 Innovation Index consists of five modules: knowledge jobs, globalization, innovation dynamism, digital economy and innovation capacity. The fourth part of the contribution describes more detailed results of the analysis based on each of these five modules.

Key words: knowledge economy, innovation index, Czech Republic

JEL Code: O31, O47

Introduction: Knowledge Economy

From the qualitative point of view, the knowledge economy is characterised by several typical aspects. The first one is the high value added in goods and services which production requires the implementation of extensive knowledge and education. The second aspect is a widespread application of information and communication technologies (ICT) in the production, distribution and sales of goods and services. ICT also have substantially decreased the significance of geographical distances and the role of mediators.

The knowledge economy has also the quantitative feature. Many scientific and statistical institutions have formulated the systems of indicators to characterise this aspect of knowledge

economy. We can analyse the Knowledge Index of World Bank (World Bank Institute, 2012), the Innovation Union Scoreboard of the European Commission (UNU-MERIT, 2013), the State New Economy Index (ITIF, 2012) and the Global Innovative-Based Competitiveness Index (ITIF, 2011) of the Information Technology and Innovation Foundation, the Global Innovation Index of the French economic school INSEAD (INSEAD, & WIPO, 2012), the Global Innovation Index of the Boston Consulting Group (Boston Consulting Group, 2009) and the Bloomberg 's Global Innovation Quotient (Bloomberg, 2013), for example.

The contribution deals with problems of existence and development of knowledge economy in 27 member states of the European Union. The stress is given to the Czech Republic.

The paper is concentrated toward the quantitative aspects of knowledge economy. We evaluate the level of knowledge economy in the year 2007 and in the year 2011. Then we compare the situation in both years and we try to indentify the positive and negative changes in innovation processes in EU-27 member states. For this purpose, we shall use the EU-27 Innovation Index.

1 The EU-27 Innovation Index

The EU-27 Innovation Index was created by the Faculty of Business Administration (FBA) of University of Economics, Prague to analyse the quantitative features of the knowledge economy. This Index was published in the monograph (Kislingerová, 2011) for the first time.

Scheme that is used to evaluate knowledge economy in the FBA's project is inspired by the Information Technology and Innovation Foundation (ITIF, 2012) methodology but we should underline the fact that it is not completely identical.

The structure of the indicators that are used for evaluation of the knowledge economy in the FBA's project is evident from Table 1. In the whole, 16 indicators are used to characterize the knowledge economy as well as Eurostat data for years 2007 and 2011.

The score of each country for each indicator was calculated with the formula:

$$\mathbf{H_{ij} = (X_{ij} - X_j) / S_{ij}}$$

where H_{ij} is the score achieved by the i -th country in the indicator j , X_{ij} is the original value of i -th country in the indicator j , X_j is the average value of the j -th indicator for the entire European Union and the S_{ij} is the standard deviation of the j -th indicator.

Calculation shows that according to individual indicators, approximately half of the states have a negative score (because it is below the EU-27 average) and approximately half has a positive score (above the average of the EU-27). The results of all partial specifications are

therefore treated the same way: number 15¹ was added to each value. This ensured that the values of all indicators were positive for the year 2011.

Tab. 1: The EU-27 Innovation Index 2011

Indicator	Weight
Module A. Knowledge jobs	2,50
Share of human resources in science and technology in the total labour force (2007), share of managers, specialists and engineers in the total employment (2011)	0,75
Workforce education	1,00
Gross value added per employee FTE	0,75
Module B. Globalization	1,00
Share of the high tech products trade in the total foreign trade turnover (2007) Share of the high tech products export in the total export (2011)	0,75
FDI intensity (FDI divided by GDP)	0,25
Module C. Innovation dynamism	2,00
Number of patents granted by the American USPTO	1,00
Number of European patent applications (EPO) per 1 mil. inhabitants	0,5
Contribution of renewables to total energy consumption (2007), Contribution of electricity from renewables to total electricity consumption (2011)	0,5
Module D. Digital economy	1,75
Level of Internet access – households (%)	0,50
E-government availability – supply side (2007); the use of e-government by individuals (2011)	0,50
Number of broadband access lines per 100 inhabitants (2007), share of households with broadband access lines in total number of households (2011)	0,50
Share of individuals using Internet to seek health information in total population	0,25
Module E. Innovation capacity	2,75
Share of the employment in high-tech manufacturing sector in the total employment	0,75
Share of scientists and engineers in the total employment	0,75
Share of firms' gross domestic expenditure on R&D in total R&D expenditure (2007); share of firms' gross domestic expenditure on R&D in GDP (2011)	0,75
Share of government and universities' gross domestic expenditure on R&D in GDP	0,50
TOTAL	10

Source: own computation

Furthermore, the score was calculated in each of the five modules. All indicators had their relative weight. The reason was - again like in the case of the ITIF's method - an effort to ensure that the closely related indicators (e.g. number of patent applications or number of patents granted) did not affect the overall score significantly.

In the FBA's analysis, the same number of modules as in the ITIF's study is used. The relative weight of each module in the FBA project is similar to that in the ITIF analysis.

The total score for the knowledge economy for EU member states was then obtained by a simple summation of scores for individual modules.

2 The EU-27 Innovation Index 2011: overall results

¹ The number 10 was added in the year 2007. If we apply the same number for the EU-27 Innovation Index 2011 the value of the index stays negative. It was reason why the constant was increased. This fact evidently indicates the growing differences among the EU member states.

The table No. 2 provides the level of knowledge economy in all 27 EU countries in years 2007 and 2011. The result is based on the total score achieved in all 16 sub-indicators.

European countries are divided in terms of the overall result achieved in the EU-27 innovation index into four groups (quartiles).

Tab. 2: The level of the knowledge economy in the EU-27 member countries – years 2007 and 2011

EU-27: year 2007				EU-27: year 2011			
1st quartile	2nd quartile	3rd quartile	4th quartile	1st quartile	2nd quartile	3rd quartile	4th quartile
Germany	Belgium	Spain	Latvia	Sweden	France	Czech Republic	Poland
Sweden	France	Czech Republic	Lithuania	Germany	Ireland	Hungary	Portugal
Finland	Ireland	Italy	Poland	Finland	Austria	Spain	Greece
Denmark	United Kingdom	Hungary	Portugal	Luxembourg	Belgium	Malta	Bulgaria
Netherlands	Slovenia	Malta	Greece	Denmark	Estonia	Latvia	Romania
Austria	Estonia	Slovakia	Bulgaria	Netherlands	Slovenia	Lithuania	
		Cyprus	Romania	United Kingdom		Slovakia	
						Cyprus	
						Italy	

Source: own computation

The EU-27 Innovation Index 2011 shows Germany and its neighbours (the Netherlands and Luxembourg) accompanied by Nordic countries (Sweden, Denmark and Finland) and the United Kingdom take a major advantage of the knowledge economy. The United Kingdom is a country which is included in the countries that most effectively use opportunities of the knowledge economy for the first time in the year 2011.

Germany and Sweden - followed by Finland – are at the forefront of the achieved level of knowledge economy. This is true both for 2011 and 2007 years. The German and Swedish economies have considerable capacity of technological innovations. They belong to the European top in both the private (corporate) and public (university) expenditure on research and development and in the share of employees working in science and research in the labour force. In addition, German businesses are able to convert these opportunities into real technology developments. Although Germany is the second in the number of applications for European patents (Sweden is the first) it dominates in the number of patents granted.

The Western Europe countries (France, Belgium, Ireland and Austria) create the second most successful group. The Austrian neighbour Slovenia and Baltic Estonia are also members of this group. Estonia benefits obviously from the co-operation with Nordic countries.

The countries of Central and East Europe (Czech Republic, Slovakia and Hungary), some countries from the South of the EU (Spain, Italy, Malta and Cyprus) and two remaining Baltic

countries (Lithuania and Latvia) constitute the third group. From this group, the Czech Republic takes a major advantage of the knowledge economy. The foreign trade and foreign direct investments are crucial for the Czech economy.

The minimal support of knowledge economy is applied in the countries which are (from the geographical point of view) on the periphery of the European Union, i.e. Portugal in the West, Balkan states (Romania, Bulgaria and Greece) in the South-East and Poland in the North-East. The smallest development of knowledge economy can be observed in all three mentioned Balkan states.

Now we compare the results that we have obtained on the basis of data from 2007 and 2011 years. The table No. 3 provides information about the dynamism of the knowledge economy in the EU-27 member states. It is evident that there are no significant changes in the division of countries into four groups (quartiles) in terms of their ability to exploit the opportunities of the knowledge economy.

The ranking for the most countries remains unchanged. This can be documented by the fact three countries which utilize the knowledge economy best have not changed. Nevertheless, we can observe two trends.

Tab. 3: Dynamism of the knowledge economy in the EU-27 member states

The best three countries		Countries with the greatest improvement			
2007	2011	Country	2007	2011	Increase
1. Germany	1. Sweden	1. United Kingdom	11	7	+ 4
2. Sweden	2. Germany	2. Lithuania	22	19	+ 3
3. Finland	3. Finland	2. Latvia	21	18	+ 3

Source: own computation and data from the monograph (Kislingerová, E., & kol., (2011))

Firstly, the rise of the United Kingdom is evident. The UK economy develops more dynamically than the economies of many other European countries. It is also evident from the analysis of individual sub-factors which is mentioned in the following text.

Similarly, the Baltic countries, Estonia, Lithuania and Latvia successfully utilize the knowledge economy for their development.

Secondly, countries from the South of Europe, especially Italy and Spain, quite significantly lose its position. A slight weakening of the position is evident in some countries bordering Germany (Belgium and Austria).

For the Czech Republic, the utilization of knowledge economy has not changed between the years 2007 to 2011 significantly. The EU-27 Innovation Index assigned to the Czech economy the fifteenth position in the year 2007. According to the same aggregate, the Czech economy is in the fourteenth place among the EU member countries in 2011.

3 The EU-27 Innovation Index 2011 in details

In the following text, we will look more closely at the results achieved by each country in individual modules of the EU-27 Innovation Index.

Knowledge jobs. In terms of education of the labour force, in 2011 the Baltic countries (Estonia, Lithuania) dominated to the European Union. They were accompanied by the Nordic countries (Finland) and two large western European economies, the United Kingdom and Germany. At the bottom of the ranking are Italy, Malta and Portugal.

Tab. 4: The EU-27 Innovation Index: knowledge jobs

The best three countries		Countries with the greatest improvement			
2007	2011	Country	2007	2011	Increase
1. Estonia	1. Luxembourg	1. Luxembourg	15	1	+ 14
2. Cyprus	2. United Kingdom	2. France	14	9	+ 5
3. Finland	3. Sweden	2. United Kingdom	7	2	+ 5

Source: own computation and data from the monograph (Kislingerová, E., & kol., (2011))

The aim is not an educated population itself but the utilization of well educated labour in the economy. If we follow the proportion of managers, professionals and technicians in total employment aged 15 to 64 years, Western Europe countries are in the forefront. Four Western Europe countries - Luxembourg, the United Kingdom, the Netherlands and France – and Sweden have the highest proportion of these professional groups in the labour force. Bulgaria, Greece and Romania are at the bottom of the ranking.

The share of managers, professionals and technicians in total employment aged 15 to 64 years is quite closely linked to productivity. Only Western Europe countries – Luxembourg, Belgium, the Netherlands, France and Ireland – have remained among countries that have the highest hourly labour productivity. Countries that had the lowest share of managers, professionals and technicians in the workforce, i.e. Bulgaria and Romania also have the lowest labour productivity.

From this point of view, the Czech Republic is not very successfully country. In terms of education of the labour force, the Czech Republic is in the thirteenth place. However, the orientation of education does not seem too appropriate for the needs of the knowledge economy. In the terms of the proportion of managers, professionals and technicians in the workforce, the Czech Republic gets the seventeenth place. As a result, the Czech Republic gets the nineteenth place in hourly labour productivity between EU member states.

In the module which monitors the situation in the EU-27 by knowledge jobs there is evident the growing domination of Western and Northern Europe. These countries take the leading place in 2011 but - and especially - they are connected with the largest improvement

in the past five years. Countries of Southern Europe show the largest drop. The Czech Republic moved up due to decline of Southern Europe countries (by one position).

Globalization. The module contains two indicators: a) the share of high tech exports in country total exports outside the European Union, b) the foreign direct investment intensity calculated as the average value of FDI inflows and outflows divided by GDP.

Tab. 5: The EU-27 Innovation Index: globalization

The best three countries		Countries with the greatest improvement			
2007	2011	Country	2007	2011	Increase
1. Luxembourg	1. Luxembourg	1. Estonia	21	10	+ 11
2. Malta	2. Malta	2. Romania	25	15	+ 10
3. Ireland	3. Hungary	3. Cyprus	16	9	+ 7

Source: own computation and data from the monograph (Kislingerová, E., & kol., (2011))

Small economies usually have a higher degree of openness than large economies. It is reflected in the value of their exports. It can be observed in the first mentioned indicator which is the share of high tech exports in total country exports outside the EU territory. Not surprisingly, among the first five countries can be found four small economies: Malta, Luxembourg, Hungary and Ireland. The exception is France with its high developed aviation industry. The lowest share of high tech exports in total exports was in Greece, Bulgaria and Portugal.

This indicator assesses well the Czech Republic. It is ranked eighth among all 27 EU countries. This result is probably caused by the size of the Czech Republic and also by the variety of Czech industry and services. This indicator is linked to the best result achieved by Czech economy from all 16 characteristics of knowledge economy used in the EU -27 Innovation Index 2011.

The high intensity of foreign direct investments (FDI) is again connected with relatively small economies. Luxembourg, Belgium, Portugal and Cyprus were among five countries with the highest FDI intensity in 2011. Recall that the banking crisis in Cyprus which limited the inflow of capital started here in 2012. The lowest level of FDI intensity is in Greece (significantly affected by the crisis in the year 2011), Estonia and Romania. The economic downturn is also reflected in the Czech FDI intensity. The Czech Republic is ranked in this indicator to the twenties place.

Overall, Luxembourg, Malta and Hungary are evaluated as the most successful countries in globalization in the EU in 2011. The least successful countries are the Balkan countries: Romania, Bulgaria and Greece.

Innovation dynamics. The module contains three indicators. The first two indicate the ability of firms to generate innovation. The third indicator is the share of renewable energy in total electricity consumption. Growth in the share of renewable energy is a signal that the economy successfully absorbs innovations in one of its strategic areas, in the energy sector.

Tab. 6: The EU-27 Innovation Index: innovation dynamism

The best three countries		Countries with the greatest improvement			
2007	2011	Country	2007	2011	Increase
1. Sweden	1. Germany	1. United Kingdom	15	6	+ 9
2. Austria	2. Sweden	2. France	8	4	+ 4
3. Germany	3. Austria	3. Portugal	13	10	+ 3

Source: own computation and data from the monograph (Kislingerová, E., & kol., (2011))

The most of patent applications submitted to the European Patent Office (EPO) comes from the Nordic countries (Sweden, Denmark and Finland) and from Western Europe countries (Germany and the Netherlands). The smallest number of patent applications comes from the Balkan countries (Greece, Bulgaria and Romania).

Submit an application does not mean that the proposal is reasonable and that the responsible authority decides to grant a patent. Therefore, the second indicator is used in the module. This indicator indicates how many applications is accepted by the prestigious institutions operating outside the European Union (in this case the United States Patent and Trademark Office, USPTO is used). USPTO has assigned the most patents in Germany, the United Kingdom, France, Italy and the Netherlands. Entities from the Baltic countries (Latvia and Lithuania) and Malta received at least USPTO patents.

The highest share of renewable energy in total electricity consumption is in Sweden, Austria, Portugal, Latvia and Denmark. At least renewable resources are used in Luxembourg and island countries (Cyprus and Malta).

The Czech Republic occupies the 16th place in the number of filed patent applications to the EPO. However, the Czech Republic is doing better in patents assigned by USPTO, where the Czech Republic is on the 13th position. It can be partially interpreted as quite reasonably oriented research and development in the country. For completeness, we can add that in the use of electricity from renewable resources, the Czech Republic occupies to 17th place.

From the perspective of innovation dynamics, Sweden, Germany and Austria with Denmark and France dominate the EU in 2011. Bulgaria, Cyprus and Malta show the lowest innovation dynamics in the same year. The Czech Republic is on the weaker average again and it has the 19th position. Major economies (the United Kingdom and France) report the largest shift towards the top of the EU in the years 2007-2011.

Digital economy. The first indicator of the digital economy is the percentage of households with access to the Internet. Without connecting to a computer network, Internet services can not be used. Households in the Nordic countries (Sweden, Denmark, Finland) and in the Northwest Europe countries (the Netherlands and Luxembourg) were best equipped by the Internet connection in 2011. The same countries (except Luxembourg) are between the five countries whose households use broadband connection to Internet at the largest range. Greece, Bulgaria and Romania are the worst among EU countries in both indicators.

The third and fourth indicators provide information on the extent of use of the two selected key Internet services. We regard the communication of households with the public administration and with institutions operating in the healthcare services.

Tab. 7: The EU-27 Innovation Index: digital economy

The best three countries		Countries with the greatest improvement			
2007	2011	Country	2007	2011	Increase
1. Netherlands	1. Denmark	1. Hungary	20	15	+ 5
2. Denmark	2. Sweden	1. Latvia	23	18	+ 5
3. Finland	3. Netherlands	3. Estonia	13	10	+ 3
		3. Ireland	17	14	+ 3
		3. Poland	24	21	+ 3

Source: own computation and data from the monograph (Kislingerová, E., & kol., (2011))

The most developed communication of households with public authorities (e-government) is in the same countries where nearly every household is connected to the Internet, i.e. in Sweden, Denmark, Finland, the Netherlands and Luxembourg. A similar argument applies to the countries from the bottom of the ranking. Households from countries with the worst quality connection to the Internet (i.e. from Greece, Bulgaria and Romania) use at least the possibility of e - government.

Similarly, people from Denmark, Finland and the Netherlands use the Internet to search for information in the field of health care most. It is also true for Germany and Austria. Citizens from Italy, Bulgaria and Poland seek information on health in Internet at least.

Let us compare the Czech Republic and other EU Member States. Czech households are relatively well equipped as in the connection to the Internet as well as in its broadband version. In number of households connected to the Internet, the Czech Republic is to 15th place. In the percentage of households using broadband, the Czech Republic is also 15th.

The situation in the application of Internet services is far worse. The Czech Republic is one of the poorer countries from this point of view. The Czech Republic is 23th in the use of e-government and in the 21st position among the EU member states for the medical

information seeking. It is not only households' problem of but it is mainly the problem of the range and quality of services offered by public or health authorities.

It is evident that the Nordic countries (Denmark, Sweden, Finland) and the Northwest Europe countries (Luxembourg and the Netherlands) benefited in 2011 from the digital economy. The Balkan countries Greece, Bulgaria and Romania were the worst in the use of the digital economy. The Czech Republic occupies the 19th position.

If we examine the development in the period 2007 – 2011 we see that the greatest progress was recorded in the Baltic countries (Latvia, Estonia), Poland, Hungary and Ireland. Countries in Southern Europe – Italy, Portugal, Slovenia and Spain – show the slowest development of digital economy (and also the drop in the ranking).

Innovation capacity. In this module we deal with the human and financial resources which determine the economy capacity to generate innovations. In detail, (Lukeš, 2012) deals with human resources for the innovation capacity.

Tab. 8: The EU-27 Innovation Index: innovation capacity

The best three countries		Countries with the greatest improvement			
2007	2011	Country	2007	2011	Increase
Sweden	Finland	Estonia	23	7	+ 16
Austria	Sweden	Ireland	16	4	+ 12
Germany	Denmark	Malta	27	17	+ 10

Source: own computation and data from the monograph (Kislingerová, E., & kol., (2011))

The Nordic countries (Finland, Sweden and Denmark) and Luxembourg and the Netherlands report the largest share of science and research workers in the labour force in 2011. The lowest proportion of these workers is in Bulgaria, Portugal and Romania.

The highest share of employment in high-tech and knowledge-intensive sectors in total employment is reported in Ireland, Malta, Hungary and the Nordic countries (Finland and Denmark) in 2011. Greece, Portugal and Romania are at the bottom of the ranking.

The Nordic and Western Europe countries dominate in the expenditure on R & D. Business sector in Finland, Sweden and Denmark spends the highest share (relatively to the GDP) of expenditure on R & D. Companies from Germany and Austria are on the top in Western Europe. The same countries also report relatively the highest financial support of research and development in government institutions and universities. Companies from Greece, Romania and Cyprus spend the lowest share of expenditures on research and development. Universities and government institutions in Greece, Romania and Bulgaria receive the smallest financial support for research and development.

The Czech Republic is in the share of science and research workers in the labour force in the 19th position. The situation in the employment in technology and knowledge-intensive sectors is far better. The Czech Republic is on the 9th position.

The expenditures on Czech science and research are on the EU average. The Czech Republic is in state institutions and universities' R & D expenditure on the 14th place. Better situation is in the business sector, where the share of expenditure on R & D in GDP ranks the Czech Republic in the eleventh position in the EU.

The greatest technological innovation capacity (expressed in the use of financial and human resources) is clearly formed in the Nordic countries (Sweden, Finland, Denmark), Germany and Austria in 2011. The Balkan countries (Bulgaria, Greece and Romania) were endowed with low technological innovation capacity in the same year.

Conclusion

The paper deals with quantitative features of the knowledge economy in the EU-27 countries. In the whole, 16 indicators and data of Eurostat for years 2007 and 2011 are used to characterize the knowledge economy. The EU-27 Innovation Index was applied to analyse the quantitative aspects of the knowledge economy.

There are two main findings in the paper. The first statement concerns the whole European Union. Germany and its neighbours (the Netherlands and Luxembourg) accompanied by Nordic countries (Sweden, Denmark and Finland) take a major advantage of the knowledge economy. The smallest development of knowledge economy can be observed in three Balkan states Romania, Bulgaria and Greece.

If we compare the results obtained on the basis of data from 2007 and 2011 years the rise of the United Kingdom is evident. From the opposite site, countries from the South of Europe (Italy and Spain) quite significantly lose its position. A slight weakening of the position is evident in some countries bordering Germany (Belgium and Austria).

The second statement concerns the Czech Republic. The utilization of knowledge economy has not changed significantly between the years 2007 to 2011. The EU-27 Innovation Index assigned to the Czech economy the fifteenth position in the year 2007. According to the same aggregate, the Czech economy is in the fourteenth place among the EU member countries in 2011.

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