THE KNOWLEDGE ECONOMY IN THE EU-28 MEMBER STATES IN 2015

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Abstract

In 2006 and 2007 researchers of the Faculty of Business Administration, University of Economics, Prague created the EU-27 Innovation Index to analyse the quantitative features of the knowledge economy. For the first time, the index was used in 2007 to analyze the state of the knowledge economy in the European Union member countries. The first part of the paper describes the structure of this index. The second part of the contribution contains the current results that have been achieved for all EU-28 member states in a knowledge-based economy, using data for the years 2014 and 2015. This part of the paper provides also an analysis of the obtained data. The EU institutions deal with similar problems in their three indices: the Innovation Union Scoreboard, the Regional Innovation Scoreboard, and the European Public Sector Innovation Scoreboard. In the third part of the contribution, the results obtained from the application of the EU-28 Innovation Index are compared with the conclusions resulted from the EU indices.

Keywords: knowledge economy, innovation index, European Union

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1. Introduction

The macroeconomics models of the economic growth have gradually changed views on the role of technological progress and innovations from the 40s of the 20th century to the present. Models of American E. Domar and Englishman Roy F. Harrod represent the macroeconomics development in the forties of the twentieth century. According to E. Harrod and R. F. Domar, the rate of economic growth increases with increasing level of savings, decreasing capital coefficient and decreasing level of capital depreciation. The above statements show the model put a significant emphasis on savings and capital accumulation as a source of economic growth. Interpretation of Harrod´s and Domar´s model can be found in (Domar, 1966) or in detail in (Allen, 1975).

Analysis of economic growth from the 50s of the 20th century is based on neoclassical models (e.g. Swan - Solow model, see Solow, 1956 and Swan, 1956). These models examine

the independent effects of technological changes, capital, and labour. The way in which all the factors are combined (i.e. the used technology) is also important. Technological changes are exogenous from their perspective.

In the mid-'80s Paul Romer´s article (Romer, P. M., 1986) encouraged a new perspective on the theory of economic growth. This concept has formed in theory the basis of different versions of the growth models called AK models. In these models, economic growth depends on technological progress (expressed through total factor productivity) and the amount of capital. The concept of capital is there much wider than in the neoclassical models, it includes not only physical but also human capital. AK models are tested on empirical data of many countries (e.g. Hartwig, J., 2014) but they have developed also theoretically - see e.g. Guerinni, l. (2010) or Zhang, X. (2014).

The growing role of technological change and innovation for the development of all economies are projected not only in the indicated qualitative changes in theoretical growth models. Simultaneously, new categories that reflect these ongoing processes appear in economics: it is mainly the concepts of knowledge (or knowledge-driven) economy.

The concept of a knowledge economy comes from Fritz Machlup. F. Machlup´s study The Production and Distribution of Knowledge in the United States (1963) grew out of five lectures he gave in 1959 and 1960.

Peter Ferdinand Drucker developed and popularized the idea of the knowledge economy. P. Drucker in his book The Age of Discontinuity: Guidelines to Our Changing Society (the first English edition in 1968). In the twelfth chapter of this book with the title The Knowledge Economy, Drucker is focused on forces, which are changing the present economy and creating the society of future (Drucker, 1992). Beside rapid development of technology, globalization, and creation of new economy, the appearance of new political and social challenges, which are changing society and present economy, Drucker emphasizes the need to put the knowledge and education and their implications on work, leadership, and society in general, in the centre of a new economy.

Starting with above mentioned F. Machlup´s article, many authors, and institutions analyze both the qualitative and quantitative aspects of the knowledge economy. If we regard quantitative aspects of the knowledge economy, we can identify many systems of indicators which try to characterise the level and dynamics of the knowledge economy reached in individual countries or regions. In the next part, we will deal with two of them - The EU-28 Innovation Index and Innovation Union Scoreboard 2015.

2. Methodology

The EU-27 Innovation Index was created by the Faculty of Business Administration (FBA) of the 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 and then in the monograph (Soukup, 2015).

A 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 current EU-28 Innovation Index indicators is evident from Table 1. In the whole, 18 indicators are used to characterize the knowledge economy as well as Eurostat data for years 2014 and 2015.

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

$$Hij = (Xij - Xj) / Sij \qquad (1)$$

where Hij is the score achieved by the i-th country in the indicator j, Xij is the original value of i-th country in the indicator j, Xj is the average value of the j-th indicator for the entire European Union and the Sij 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-28 average) and approximately half has a positive score (above the average of the EU-28). The results of all partial specifications are therefore treated the same way: number 15 was added to each value. This ensured that the values of all indicators were positive.

Tab. 1: The EU-28 Innovation Index 2015

Indicator	***Weight***
Module A. Knowledge jobs	***2,50***
Enterprises that employed ICT/IT specialists (NACE Rev. 2), Percentage of enterprises, all enterprises, without financial sector, 10 persons employed or more (2015)	0,75
Workforce education (2014)	1,00
Gross value added per employee FTE (2014)	0,75
Module B. Globalization	**1,00**
Share of the high-tech products export in the total export (2014)	0,75
FDI intensity (FDI divided by GDP), 2012	0,25
Module C. Innovation dynamism	**2,00**
Number of patents granted by the American USPTO (2014)	1,00
A number of European patent applications (EPO) per 1 mil. Inhabitants (2012)	0,5
Contribution of electricity from renewables to total electricity consumption (2013)	0,5
Module D. Digital economy	**1,75**
Level of Internet access – households (%), 2015	0,50
The use of e-government by individuals (2015)	0,50

Share of households with broadband access lines in total number of households (2015)	0,50
Share of individuals using The Internet to seek health information in total population (2015)	0,25
Module E. Innovation capacity	**2,75**
Share of the employment in technology and knowledge – intensive sectors in the total employment (2014)	0,75
Human resources in science and technology as a share of active population - Total, 2014	0,75
Share of business enterprises´ gross domestic expenditure on R&D in GDP (2014)	0,75
Share of government and universities´ gross domestic expenditure on R&D in GDP (2014)	0,50
TOTAL	**10**

Note: The indicator Workforce education consists of three partial indices: Persons with lower secondary education attainment (%), from 15 to 64 years (2014) with the weight 1, Persons with upper secondary education attainment (%), from 15 to 64 years (2014) with the weight 1.5 and Persons with tertiary education attainment (%), from 15 to 64 years (2014) with the weight 2.
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 a 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.

In the Innovation Union Scoreboard 2015, the innovation performance is measured using a composite indicator – the Summary Innovation Index. This Index distinguishes between 3 main types of indicators – Enablers, Firm activities and Outputs – and 8 innovation dimensions, capturing in total 25 indicators. The structure of the partial indices is evident from the table 2. The methodology used in the Innovation Union Scoreboard 2015 is described in detail in part 7 of this document.

Tab. 2: The Innovation Union Scoreboard 2015

Summary Innovation Index							
Enablers			Firm Activities			Outputs	
Human Resources	Open, excellent research systems	Finance and support	Firm investments	Linkages and entrepreneurship	Intellectual assets	Innovators	Economic effects
New doctorate graduates	International scientific co-publications	R&D expenditure in the public sector	R&D expenditure in the business sector	SMEs innovating in-house	PCT patent application	SMEs with product or process innovations	Employment in knowledge-intensive activities
Population aged 30-34	Top 10% most cited	Venture capital	Non-R&D	Innovative SMEs	PCT patent application	SMEs with marketing or	Medium/high product

with tertiary education	scientific publications	investments	innovation expenditure	collaborating with others	in societal challenges	organisational innovations	exports
Youth with at least upper secondary education	Non-EU doctorate students			Public – private co-publications	Community trademarks	Employment fast-growing firms of innovative sectors	Knowledge-intensive services exports
					Community design		Sales of new to market and new to firm innovations
							License and patent revenues from abroad

Source:The Innovation Union Scoreboard (2015)

3. Results

The table No. 3 provides the result of both above-described indices, i.e. the EU-28 Innovation Index 2015 and the Innovation Union Scoreboard 2015. The result is based on the total score achieved in all 16 sub-indicators (there is one composite indicator which is based on three indices).

European countries are divided in terms of the overall result achieved in the EU-27 innovation index into four groups (quartiles). Their division is based on their overall score. The range between the highest and lowest score was calculated and divided by four. That product was subtracted from the top score to calculate the range for the 100th to 76th percentile and likewise for the other three percentile ranges. The applied method results to the situation in which an equal number of states is not necessarily divided into the each percentile but rather indicate which country score falls into a particular range.

The Innovation Union Scoreboard 2015 divides EU countries into four groups, too. The first group represents “Innovation leaders”. These countries have their innovation performance more than 20% above the EU average. Countries from the second group, “Innovation followers”, exhibit innovation performance less than 20% above or more than 90% of the EU average. “Moderate innovators” are countries which innovation performance is between 50% and 90% of the EU average. Countries from the last group, with innovation performance less than 50% of the EU average, are indicated as the “Modest innovators”.

The EU-28 Innovation Index 2015 shows the Nordic countries (Sweden, Denmark, and Finland) accompanied by Germany and its neighbours (Luxembourg, the Netherlands, and Austria) take a major advantage of the knowledge economy.

The German and Swedish economies have a 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, they are able to convert these opportunities into real technology developments.

The Innovation Union Scoreboard 2015 provides the similar result. Only three Nordic countries (Denmark, Finland, and Sweden) and Germany are regarded as "Innovation leaders". The ranking is, therefore, more stringent than the first one.

The EU-28 Innovation Index 2015 indicates mainly other Western Europe countries (Ireland and the UK, France and Belgium) belong to the second most successful group in the innovation performance. The Austrian neighbour Slovenia and Baltic Estonia are also members of this group. Estonia benefits obviously from the co-operation with Nordic countries.

The Innovation Union Scoreboard 2015 ranks Austria, Belgium, France, Ireland, Luxembourg, Netherlands, Slovenia and the UK as "Innovation followers". As a result, both rankings provide practically the same result if we regard both groups (innovation leaders and followers) together. With the exception of Estonia, the same twelve countries belong to these two groups.

The EU-28 Innovation Index 2015, the countries of Central and East Europe (Czech Republic, Hungary, Slovakia, and Poland), countries from the South of the EU (Malta, Spain, Cyprus, Italy, and Croatia,) and two remaining Baltic countries (Lithuania and Latvia) constitute the third group. From this group, Malta and the Czech Republic take a major advantage of the knowledge economy. The foreign trade and foreign direct investments are crucial for the Czech economy.

From the point of view of the Innovation Union Scoreboard 2015, the third group or "Moderate innovators", consists of the almost the same Central and East Europe countries and member states from the South. The group also includes other southern countries (Portugal and Greece) and Estonia. On the other hand, this ranking does not regard Baltic countries (Lithuania and Latvia) as "Moderate innovators" but only as "Modest innovators".

By the EU-28 Innovation Index 2015, 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. The smallest development of knowledge economy can be observed in all three mentioned Balkan states.

Similarly, the Innovation Union Scoreboard 2015 regards Balkan states (Bulgaria and Romania) as "Modest innovators". In addition, two Baltic states (Lithuania and Latvia) belong to the group.

Tab. 3: Results of the EU-28 Innovation Index and the Innovation Union Scoreboard

	EU-28 Innovation Index 2015		Innovation Union Scoreboard 2015	
	Index	Rank	Index	Rank
Sweden	162,36	1	0,74	1
Luxembourg	162,26	2	0,642	6
Finland	161,47	3	0,676	3
Denmark	160,65	4	0,736	2
Netherlands	157,61	5	0,647	5
Germany	157,39	6	0,676	4
Austria	156,64	7	0,585	11
Ireland	155,58	8	0,628	8
United Kingdom	154,84	9	0,636	7
France	154,44	10	0,591	10
Belgium	154,26	11	0,619	9
Estonia	153,08	12	0,489	13
Slovenia	149,86	13	0,534	12
Malta	148	14	0,397	18
Czech Republic	147,69	15	0,447	14
Spain	147,06	16	0,385	19
Latvia	146,13	17	0,272	26
Hungary	145,89	18	0,369	20
Lithuania	145,32	19	0,283	25
Cyprus	145,06	20	0,445	15
Slovakia	144,55	21	0,36	22
Italy	143,67	22	0,439	16
Croatia	143,54	23	0,313	23
Poland	143,26	24	0,313	24
Portugal	142,26	25	0,403	17
Greece	141,31	26	0,365	21
Bulgaria	139,48	27	0,229	27
Romania	136,76	28	0,204	28
EU-28			0,555	

Source:The Innovation Union Scoreboard (2015) and own computation

Now we will focus on a little bit different but a relating question. We will be interested in what extent the explanatory power of both indices is similar or even equal. For this purpose,

we will apply the Spearman's rank correlation coefficient and the Kendall's coefficient of concordance (although it is designed rather for more than two orders).

If we use the formula published in (Hindls, Hronová & Novák, 1999) the value of the Spearman's rank correlation coefficient is $r_s = 0,9048$. If we use the formula published in the same book for the Kendall's coefficient of concordance the value of the coefficient is $r_K = 0,8284$.

Both coefficients confirm both rankings show significant similarity (if the rankings are the same the value of Kendall's and also Spearman's coefficient are 1). It may result in the conclusion the information capability of both indices is virtually the almost same. On the other hand, it means the explanatory power of the EU-28 Innovation Index is practically the same as one of its competitors.

4. Conclusions

Since the 40s of the twentieth century to the present, it is in the economic theory apparent the increasing emphasis on knowledge and technological progress as factors of economic growth. This process is reflected in the analysis of the knowledge economy and the innovation potential of individual countries. Analyses do not just concern the qualitative significance of technological progress for modern high-developed economies but they also examine the quantitative aspects of the knowledge economy.

The paper compares the results of two systems that measure innovation performance: the EU-28 Innovation Index and the Innovation Union Scoreboard. The comparison is made on data from 2015 and for the 28 EU countries.

The comparison shows that both systems show very similar results. According to the Innovation Union Scoreboard, 13 countries achieve innovation performance (they belong to the range for the 100th to 50th percentile). According to the EU-28 Innovation Index, the same countries belong to this zone.

The calculation based on the coefficients Kendall's coefficient of concordance and Spearman's rank correlation coefficient confirm the similarity of both composite indices.

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