THE KNOWLEDGE ECONOMY IN THE EU MEMBER STATES IN THE PERIOD 2007 – 2018

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Abstract

In 2006, researchers of the Faculty of Business Administration, University of Economics, Prague created the FBA 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 EU-28 member states in a knowledge-based economy, using data for the years 2007, 2013, 2015, and 2018. This part of the paper provides also an analysis of the obtained data. The EU institutions deal with similar problems in the European Innovation Scoreboard. In the third part of the contribution, the results obtained from the application of the FBA Innovation Index are compared with the conclusions resulted from the last edition of the European Innovation Scoreboard (2018).

Keywords: innovation index, European Union, sigma convergence

JEL Code: O31, O47

1. Introduction

The economic growth theories formulated during the twentieth century can be divided into three groups. Keynesian concepts, where R. F. Harrod´s and E. Domar´s models can be considered representative, are historically the oldest. Both models were created in the 1940s. Interpretation of Harrod´s and Domar´s models can be found in (Domar, 1966) or in detail in (Allen, 1975). The development of neoclassical growth theory occurred in the 1950s, and the model of R. Solow and T. Swan became a representative for this approach (see Solow, 1956, and Swan, 1956)., The further development of the theories of endogenous growth occurred in the 1980s. In this case, the AK model (Romer, 1986) can be considered as a representative.

The macroeconomists have gradually changed their views on the role of technological progress and innovations from the 40s of the 20th century to the present. 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 fixed capital accumulation as a source of economic growth. Technological progress only affects labour (i.e., it is the so-called Harrod's technological progress).

The neoclassical models examine the role of technological changes, capital, and labour for economic growth. Technological progress affects as labour as capital, and technological changes are exogenous (i.e., it is the so-called Hick's technological progress).

In AK models, economic growth depends on technological progress (expressed through total factor productivity), and the amount of capital. The concept of capital is there much broader than in the neoclassical models, it includes not only physical but also human capital. Increasing capital stock (investments) creates new knowledge in the whole economy. Knowledge is so a positive externality for companies, widely available to individual firms. Policies supporting investment activity thus support technological progress and influence long-term economic growth positively. 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 increasing role of technological progress and innovations for economic growth are not projected only into theoretical models. We can identify many composite indicators which try to characterise the level and dynamics of the technological progress and innovations or knowledge economy in concrete countries or regions and attempt to describe and analyse quantitative aspects of their technological progress, for example, MERIT (2018), ITIF (2017), Cornell University, INSEAD, WIPO (2018) or WEF (2018).

In the next part, we will deal with two of them in more detail - the EU-28 Innovation Index and the European Innovation Scoreboard. The EU-28 Innovation Index will be applied as a core tool for our analysis and the European Innovation Scoreboard will be used as an instrument for feedback.

2. Methodology

The EU-27 Innovation Index was created at the Faculty of Business Administration (FBA) of the University of Economics, Prague to analyse the quantitative aspects of technological progress and innovations. This Index was published in the monograph (Kislingerová, 2011) for the first time and then in the monograph (Soukup, 2015).

A scheme that was used to evaluate knowledge economy in the FBA‘s project was inspired by the Information Technology and Innovation Foundation (ITIF, 2012)

methodology but we should underline the fact that both methodological approaches are not completely identical.

The structure of the current EU-28 Innovation Index is evident from Table 1. In the whole, 18 indicators were applied and for their computation were used Eurostat data for years 2017 and 2018.

The score of each country for each partial 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.

Tab. 1: The EU-28 Innovation Index 2018

Indicator	***Weight***
Module A. Knowledge jobs	***2,50***
Share of managers, professionals, technicians and associate professionals in total employment from 15 to 64 years (2018)	0,75
Workforce education (2018)	1,00
Labour productivity per person employed and hour worked (EU28=100), (2017)	0,75
Module B. Globalization	**1,00**
Exports of high technology products as a share of total exports (2018)	0,75
FDI flows intensity (FDI divided by GDP), 2017	0,25
Module C. Innovation dynamism	**2,00**
A number of European patent applications (EPO) per 1 mil. inhabitants (2017)	0,5
Number of patents granted by the American USPTO (2017)	1,00
Contribution of electricity from renewables to total electricity consumption (2017)	0,5
Module D. Digital economy	**1,75**
Level of Internet access – households (%), (2018)	0,50
Individuals using the Internet for interaction with public authorities (%), (2018)	0,50
Share of households with broadband access lines in the total number of households (2018)	0,50
Share of individuals using the Internet to seek health information in total population (2018)	0,25
Module E. Innovation capacity	**2,75**
Share of the employment in high and medium-high technology manufacturing in the total employment (2018)	0,75
Human resources in science and technology as a share of the active population – total (2018)	0,75
Share of business enterprises´ gross domestic expenditure on R&D in GDP (2017)	0,75
Share of government and universities´ gross domestic expenditure on R&D in GDP (2017)	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 (2018) with the weight 1, Persons with upper secondary education attainment (%), from 15 to 64 years (2018) with the weight 1.5, and Persons with tertiary education attainment (%), from 15 to 64 years (2018) with the weight 2.
Source: own computation, data from the Eurostat database

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 (it is 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 are positive.

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. a 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 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.

The distance between the highest and lowest result is split into four sections. Finally, all 28 countries are divided - according to the total score achieved - into these four groups (quartiles).

A similar procedure is applied in the European Innovation Scoreboard. The performance of EU national innovation systems is measured by the Summary Innovation Index which is a composite indicator obtained by taking an unweighted average of the 27 indicators (the structure of indices, see MERIT (2018). Also in this analyse, EU countries are divided - according to the total score achieved - into these four groups (quartiles).

The first group (the innovation leaders) includes member states where performance is more than 20% above the EU average. The second group of Strong Innovators includes member states with a performance between 90% and 120% of the EU average. The third group of moderate innovators includes member states where performance is between 50% and 90% of the EU average. The fourth group of modest innovators includes member states that show performance below 50% of the EU average.

3. Results

We shall present here three results of the analysis. Firstly, we will compare the results of our analysis with the results of the European Innovation Scoreboard (EIS) for the year 2018.

The results of both studies for the year 2018 are presented in Figure 1. By the EIS, the innovation leaders are Denmark, Finland, Luxembourg, the Netherlands, Sweden, and the United Kingdom – these countries are highlighted in dark green on the left part of the figure. Austria, Belgium, France, Germany, Ireland, and Slovenia are strong innovators; these countries are highlighted in light green. Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Italy, Latvia, Lithuania, Malta, Poland, Portugal, Slovakia, and Spain belong to the third group of moderate

innovators. These countries are highlighted in yellow. Finally, the fourth group of modest innovators includes Bulgaria and Romania (their colour is orange).

Slightly different results are connected with the EU-28 Innovation Index 2018 that was prepared at the Faculty of Business Administration. Here, Denmark, the Netherlands, and Sweden are among countries from the highest quartile. But it is not true for Luxembourg and the United Kingdom. Instead of these two countries, Germany – as a leader in innovation performance – is included in the top quartile.

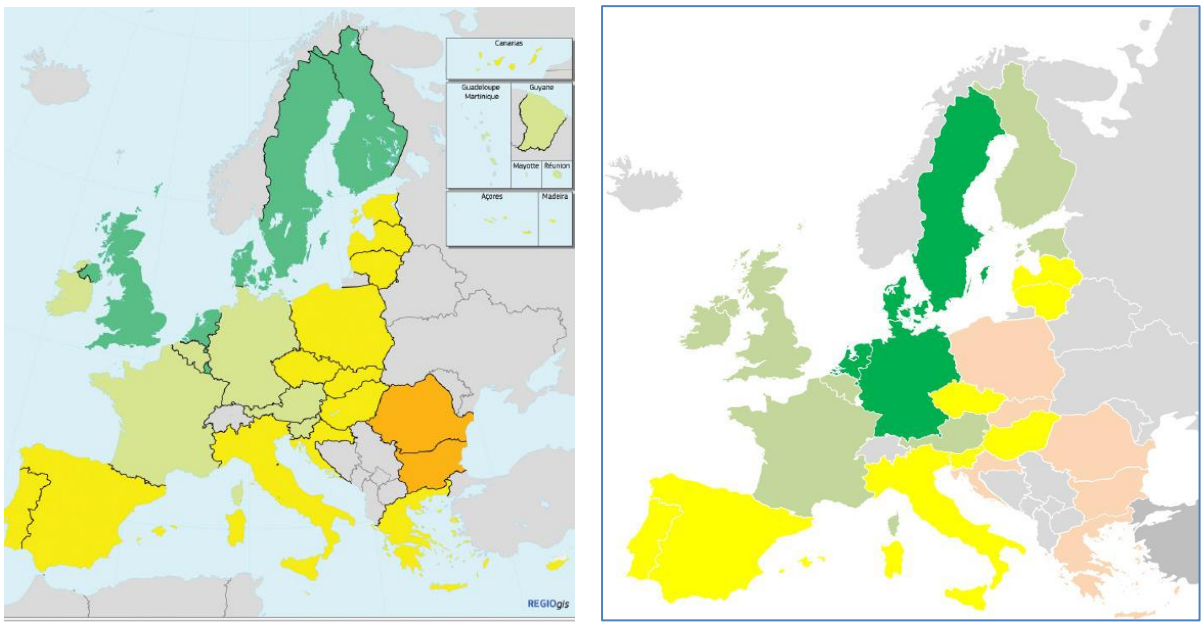
By the EU-28 Innovation Index 2018, the second highest quartile consists of the same countries as the EIS (Austria, Belgium, France, Ireland, and Slovenia), and there are included also the United Kingdom, Finland, and Luxembourg.

By the EU-28 Innovation Index 2018, the lowest quartile is much broader than in the EIS. It includes all EU member states from the Balkan Peninsula (excluding Slovenia) and Poland with Slovakia. The EIS includes here only Romania and Bulgaria.

The mirror-inverted statement is valid for the third quartile. Both analyses include here South European countries (Portugal, Spain, Italy, Malta), Baltic states (Latvia and Lithuania) and two CEE countries (the Czech Republic, Hungary). But the EIS includes here also Croatia, Greece, Poland, Slovakia, and Estonia.

We want to emphasize at this point two important aspects which are common to both analyses. Firstly, as shown on the maps in Fig. 1, the performance groups tend to be geographically concentrated. The average performance decreases with increasing geographical distance from the innovation leaders.

Fig. 1: Innovation performance of EU-28 in 2018



Source: MERIT (2018) (left) and own computation (right)

Secondly, both analyses include the same countries into two upper quartiles and into two lower quartiles. The main difference in innovation performance is between Western European countries (including Scandinavian ones) on the one hand and Eastern and Southern European countries on the other hand.

Now, we will explore the historical development of innovation performance of the EU member states during the period 2007 – 2018. In Table 2, we can see the movement of several countries between the first and the second quartile. Similarly, we can see the shift of several countries between the third and the fourth quartile.

Tab. 2: The EU-28 Innovation Index 2007 - 2018

	2007	2013	2015	2018
Sweden	2	1	1	2
Luxembourg	5	4	2	11
Finland	3	3	3	6
Denmark	4	5	4	3
Netherlands	5	6	5	4
Germany	1	2	6	1
Austria	7	10	7	5
Ireland	10	9	8	8
United Kingdom	11	7	9	7
France	9	8	10	9
Belgium	8	11	11	10
Estonia	13	12	12	12
Slovenia	12	13	13	14
Malta	18	17	14	15
Czech Republic	15	14	15	13
Spain	14	16	16	17
Latvia	21	18	17	18
Hungary	17	15	18	16
Lithuania	22	19	19	21
Cyprus	20	21	20	22
Slovakia	19	20	21	24
Italy	16	22	22	19
Croatia	**X**	**X**	23	25
Poland	23	23	24	23
Portugal	24	24	25	20
Greece	25	25	26	27
Bulgaria	26	26	27	28
Romania	27	27	28	26

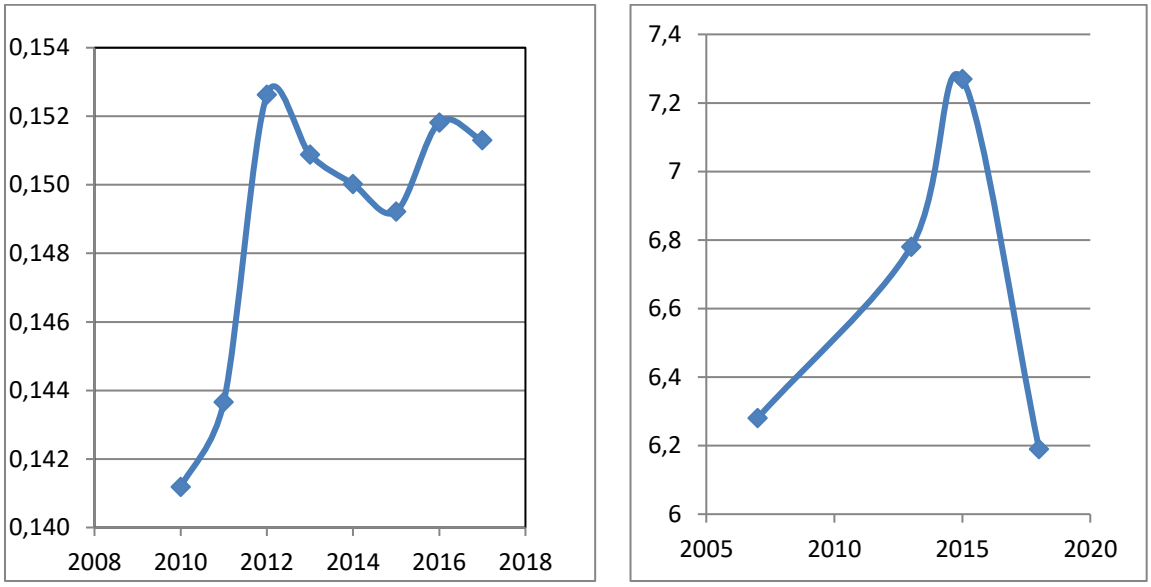
Source: own computation

However, one fact remains unchanged throughout the whole period. The countries in the first and second quartiles are still the same. Naturally, the countries in the third and fourth quartiles have to

be also the same. It means that the main difference in innovation performance between Western European countries (including Scandinavian ones) on the one hand and Eastern and Southern European countries, on the other hand, is stable and unchanged for the whole examined period.

The similar result we can receive if we apply the principle of sigma convergence for our analysis. Sigma convergence describes a situation where the variability of a given indicator between countries decreases over time. The degree of variability is typically measured by a standard deviation. In the simplest case, convergence occurs when the value of standard deviation decreases and divergence occurs when the value of standard deviation increases; for a detailed explanation of this concept, see (Rojicek, 2016).

Fig. 2: Divergence of EU national innovation systems



Source: MERIT (2018) (left) and own computation (right)

Figure 2 illustrates the development of standard deviations of innovation indices for EU member states. The standard deviations for the Summary Innovation Index (from the European Innovation Scoreboard) are increasing in years 2010 – 2012 (immediately after the recession 2019) and then remains stable at a higher level for period 2012 – 2017. The results based on the EU-28 Innovation Index 2018 are more optimistic but very slightly. Also, the value of standard deviations based on this index was increasing in 2005 – 2013 but it returned back to its original value in 2018.

We can discuss whether there is divergence among the performance of EU national innovation systems or the situation is stable. But the convergence processes among the performance of EU national innovation systems are not indicated by any of the summary innovation indices.

4. Conclusions

The contribution presents the findings of an analysis of the performance of EU-28 national innovation systems. For the analysis, the composite indicator, the EU-28 Innovation Index was developed.

The results derived from the application of the EU-28 Innovation Index were compared with the conclusions of the Summary Innovation Index which was published in the European Innovation Scoreboard. We can formulate fllowing core findings:

Firstly, performance groups tend to be geographically concentrated. The average performance decreases with increasing geographical distance from the innovation leaders.

Secondly, both analyses include the same countries into two upper quartiles and into two lower quartiles. The main difference in innovation performance is between Western European countries (including Scandinavian ones) on the one hand and Eastern and Southern European countries on the other hand.

Finally, convergence processes among the performance of EU national innovation systems are not confirmed by any of the summary innovation indices used.

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Annex

Tab. 3: The EU-28 Innovation Index 2018 in Detail

	Module	A	B	C	D	E	Total	Rank
1	Austria	38,28	15,25	31,94	27,04	43,96	156,48	5
2	Belgium	37,97	14,87	29,89	26,15	43,20	152,08	10
3	Bulgaria	34,90	14,39	28,79	22,49	38,84	139,41	28
4	Croatia	34,62	14,63	29,54	25,09	39,32	143,20	25
5	Cyprus	36,36	14,89	28,53	26,12	39,14	145,05	22
6	Czech Republic	37,13	15,68	28,87	26,37	42,52	150,57	13
7	Denmark	39,45	14,77	31,58	28,54	44,16	158,50	3
8	Estonia	38,41	15,01	28,86	27,73	41,16	151,18	12
9	Finland	38,47	14,40	30,97	28,70	43,82	156,35	6
10	France	37,80	15,98	31,55	26,47	42,27	154,07	9
11	Germany	39,26	15,39	35,36	27,66	44,64	162,30	1
12	Greece	33,24	14,23	28,98	24,47	39,13	140,05	27
13	Hungary	36,17	15,43	28,60	25,90	41,16	147,26	16
14	Ireland	39,70	17,47	29,66	26,61	40,96	154,41	8
15	Italy	35,88	14,59	30,35	24,74	40,30	145,85	19
16	Latvia	37,16	14,96	29,79	25,39	38,75	146,06	18
17	Lithuania	37,06	14,60	28,78	24,99	40,03	145,45	21
18	Luxembourg	40,43	13,22	28,99	27,72	40,99	151,35	11
19	Malta	39,08	16,42	28,49	25,95	39,14	149,08	15
20	Netherlands	39,67	16,27	30,54	29,40	42,23	158,11	4
21	Poland	36,02	14,66	28,77	25,00	40,50	144,94	23
22	Portugal	37,44	14,18	29,82	24,54	39,78	145,76	20
23	Romania	35,01	14,66	29,43	23,68	38,39	141,17	26
24	Slovakia	34,79	14,79	28,88	25,20	41,00	144,65	24
25	Slovenia	37,37	14,37	29,44	26,39	42,81	150,39	14
26	Spain	35,70	14,35	29,68	26,47	40,39	146,58	17
27	Sweden	40,57	14,99	32,50	28,13	44,61	160,79	2
28	United Kingdom	39,25	15,57	31,43	28,06	41,80	156,11	7

Source: own computation, data from the Eurostat database

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