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Comparative Analysis of Selected Determinants of Innovation in EU Countries

Katarzyna Brożek[1]

[1] Kazimierz Pulaski University of Technology and Humanities in Radom; Chrobrego 42/10, 26-600 Radom, Poland; k.brozek@uthrad.pl

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Abstract Bearing in mind that modern economies are transforming at an incredible rate, and at the same time, permanent sources of development are weakening, innovations, and above all their commercialization, are what the EU countries see as an effective solution to the problem of achieving economic growth. When analyzing selected determinants of innovation, it is impossible to underestimate their role and importance. Consequently, the subject matter is relevant both from theoretical as well as practical point of view. The aim of the article is to deepen the definition and multifaceted examination of the relevance of selected determinants of innovation in EU countries. The essence of the research problem is therefore to examine the relationship between the level of innovation in EU countries and the following factors: GDP, number of applied patents, innovative products, or research and development expenditure. In the light of the theoretical research, the following were analyzed: the essence and definitions of innovation. The scientific effects of the study will be to broaden and consolidate current knowledge in this field, and the practical effects will be based on theoretical findings, even in identifying the most important determinants of innovation development in the EU countries.

Keywords Analysis, Innovation, European Union

1. THEORETICAL APPROACH TO INNOVATION: THE ESSENCE AND DEFINITIONS OF INNOVATION

There are many definitions of the subject in the literature, so it is important to find their common ground.

When analyzing the definitions of innovation, it is worthwhile to present the meaning of the word itself, which is derived from Latin. Innovatio or innovare means novelties or newly introduced things.

In the first years of functioning, the term innovation was seen in the macroeconomic context. It was analyzed how technological development affects the development of the economy. Over time, professionals have shifted away from perceiving innovation in macroeconomic terms, and microeconomic analysis has begun, where technological development has been perceived as a process.

The analysis of the problem of defining innovation is as follows: among foreign authors it is necessary to mention: J. Schumpeter [21], F. Machlup [15], P. Kotler [13], R.W. Griffin [7], S. Jobs [5] , P.R. Whitfield [24], R. Johnston [12], S. Shane [23], P. Drucker [1], [2], Ch. Freeman [4], E. Helpman [9], M.E. Porter [19]. In contrast, among Polish authors taking up this subject, one can distinguish, among others: Z. Pietrasiński [17], W. Grudzewski and I. Hejduk [8], A. Pomykalski [18], Z. Madej [10], A. Jasiński [11] and M. Goławska [6].

The concept of innovation was introduced by the Austrian economist Joseph Schumpeter at the beginning of the 20th century. His definition is the foundation on which the other terms are based, yet it is extremely versatile and current in the present day. The creator based the innovation on the following pillars [26]:

- introduction of new goods that consumers have not yet known or a new product of some kind;
- introducing a new method of production that has not yet been practically tested in the particular industry;
- opening up a new market, i.e. a market where a given type of industry of the relevant country was not previously introduced, regardless of whether the market existed before or not;
- gaining a new source of raw materials or semi-finished products, regardless of whether the source already existed or had to be created;
- Conducting a new organization of an industry, such as creating a monopoly or breaking it [20].

Schumpeter's theory can be summarized as the introduction of new methods. Typically, they were related to technology, but the use of imitation, i.e. the dissemination, implementation and use of new methods, was significant.

In addition to the above condensed presentation of the term innovation is Table 1, which contains the most popular researchers in innovation theory and the keywords that are included in their definitions. It can be seen that the basis of most of the analyzed definitions is "novelty" and "product" - (they occurred seven times), it becomes the main determinant of introducing the innovation in the enterprise. It is also worth noting that among the eleven selected researchers of this problem, much less frequent (because 4 times) the word "service" has appeared, and "improvement" only 3 times.

Incidentally, such terms as "good", "idea", "imitation", "failure", "progress" and "commodity" were scattered.

Table 1. Keywords of the term innovation by selected authorities of economic sciences

Creator	Keywords
J. Schumpeter	novelty, product, commodity, imitation
F. Machlup	rejection of the word innovation
Oslo Mannual	novelty, improvement, product, process
P. Kotler	novelty, good, service, idea, product
R.W. Griffin	development, novelty, product, service, use
S. Jobs	idea, lack of innovation system creation
P.R. Whitfield	workflow, problem resolution, novelty
R. Johnston	product improvement
W. Grudzewski & I. Hejduk	novelty, product, service, distinction from existing forms
Z. Madej	novelty, improvement, failure
Z. Pietrasiński	positive changes in products, services; progress

Source: Own analysis based on the literature of the subject; [14], [16], [22], [25].

2. THE IMPACT OF SELECTED FACTORS ON THE LEVEL OF INNOVATION IN EU COUNTRIES

The impact on the level of innovation can be influenced by factors such as: GDP, number of patents applied, innovative products, or expenditure on research and development. The relationship between these factors is analyzed below. Table 2 shows these aspects on the example of EU Member States in 2012-2014. The highest average number of patents registered in Germany, it was 21.4 thousand and in France 9 thousand, while the lowest in Malta 5.19 and Cyprus 6.16. In Poland, the average for 2012-2014 was approximately 547. In terms of innovative new products for the market, the highest percentage was recorded in Ireland at 22.2 and in Austria at 21.9. The lowest percentage was recorded in Estonia 1.1 and Romania 1.3. Unfortunately, Poland also fell in the group of countries whose index was one of the lowest and amounted to only 5.2%.

Table 2. Selected indicators of product innovation and macro-economic measures for the EU-28 in 2012-2014

Country	Number of patents applied	Innovative products, new for the market (in %)	Innovative products, new for businesses (in %)
Austria	1912.56	21.9	8.9
Belgium	1528.65	22	9.8
Bulgaria	40.36	5.7	5.2
Croatia	17.48	8.2	10.6
Cyprus	6.16	14.9	8
Czech Republic	250.82	13.5	11.6
Denmark	1351.46	10.7	13.7
Estonia	25.28	1.1	9.9
Finland	1658.61	20.4	14.2
France	9000.66	18.5	9.2
Germany	21370.77	13.3	21.1
Greece	107.93	15	8.4
Hungary	215.23	7	4.9
Ireland	324.38	22.2	13.4
Italy	4289.89	15.5	9.2
Latvia	47.15	6.3	2.2
Lithuania	40.70	8.9	12
Luxembourg	64.50	18.4	10.3
Malta	5.19	8.1	11.5
Netherlands	3409.36	19	13.5
Poland	546.56	5.2	4.3
Portugal	119.25	14.5	13.9
Romania	86.21	1.3	2.3
Slovakia	47.14	7.5	5
Slovenia	129.90	17.5	7.7
Spain	1514.71	5.7	5.5
Sweden	3234.77	18.4	12.9
Great Britain	5377.64	10.8	16

Source: Own study based on [3].

Table 2. Continued

Country	GDP (million euro)	Expenditure on R & D (million euro)
Austria	323357.93	9652.97
Belgium	393339.00	9524.58
Bulgaria	42240.30	286.79
Croatia	43466.20	341.51
Cyprus	18384.20	83.75
Czech Republic	158611.97	2988.20
Denmark	259517.73	7714.80
Estonia	18861.10	331.16
Finland	202868.33	6676.03
France	2114049.7	47306.08
Germany	2836143.3	81098.01
Greece	183266.27	1430.67
Hungary	101840.73	1367.09
Ireland	183040.47	2822.81
Italy	1613230.3	21258.88
Latvia	22839.50	149.69
Lithuania	34980.10	335.87
Luxembourg	46878.13	598.98
Malta	7741.20	59.78
Netherlands	653640.00	12842.17
Poland	398359.90	3576.72
Portugal	170582.13	2270.28
Romania	142707.47	592.37
Slovakia	74273.27	621.91
Slovenia	36417.33	917.85
Spain	1034139.0	13074.72
Sweden	430594.63	13969.79
Great Britain	2124956.3	35087.50

Source: Own study based on [3].

When analyzing the level of new product innovation for enterprises, it should be noted that the leader in the ranking was Germany at 21.1% and Great Britain at 16%. The lowest recorded countries in this respect were Latvia with 2.2% and Hungary with 4.9%. Poland, as in the case of innovative products new for the market, came in second to last with 4.3%.

Considering the GDP level, the highest values were obtained in countries such as Germany (over € 2.83 trillion) and Great Britain and France, whose values were € 2.12 trillion and € 2.11 trillion, respectively. Table 3 presents the results of the correlation coefficient between GDP and individual innovation indicators.

Table 3. Results of the correlation coefficient between GDP and individual innovation rates in the EU-28 countries in 2012-2014

Number of registered patents and GDP	**0.88**
Innovative products new for the market (in %) and GDP	**0.15**
Innovative products new for businesses (in %) and GDP	**0.46**

Source: Own calculations based on statistics.

Pearson's correlation coefficient for the relationship between the number of patents applied and the country's GDP was r = 0.88. Correlation is therefore plus / positive, and the relationship is very strong. In the case of the relationship between innovative products new for the market and GDP, r = 0.15, which proves that the correlation is plus / positive and the relationship is very weak. As for the correlation between the innovative product new for enterprises and GDP, it was r = 0.46; which means that it is plus / positive, and the relationship moderately strong. Figure 1 is a supplement to the analysis because the scattering between the examined data is shown.

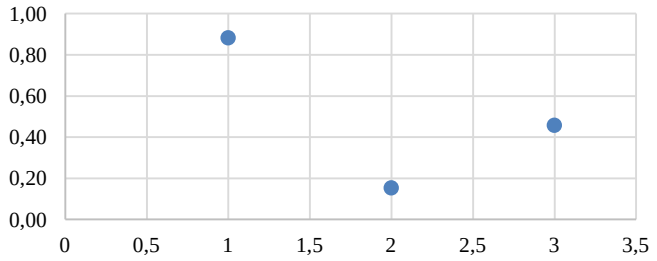

Fig. 1. The relationship between GDP and individual innovation rates in the EU-28 countries in 2012-2014

In the next stage, further dependencies were investigated, but this time they concerned R & D expenditure. The strength of the relationship between research and development spending and the three selected innovation indicators were also examined. It should be noted that, as in previous analysis, all positive correlation coefficients were obtained, so that in each analyzed case a positive correlation was obtained. The coefficient of the first tested relationship (i.e. between R & D spending and the number of patents applied) was r = 0.98; so the relationship is very strong. The analysis of the relationship between R & D expenditure and the innovative products new for the market was characterized by a correlation coefficient of: r = 0.21, and therefore a very weak relationship. The last tested relationship was between R & D spending and innovative products new for businesses. The correlation coefficient was at the level of r = 0.55, so the relationship between these features is strong. The analysis is detailed in Table 4 and Figure 2, which shows the scattering between the surveyed data.

Table 4. Results of the correlation coefficient between R & D expenditure and individual innovation indicators in EU-28 countries in 2012-2014

Number of applied patents and R & D spending	**0.98**
Innovative products new for the market and R & D spending	**0.21**
Innovative products new for businesses and R & D spending	**0.55**

Source: Own calculations based on statistics.

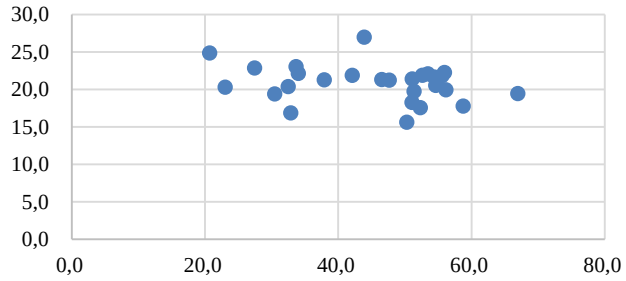

Fig. 2. The relationship between R & D expenditure and individual innovation rates in the EU-28 in 2012-2014

The above analysis suggests that in every case, together with increasing GDP or R & D expenditure, there is an increase in all tested innovation ratios. However, it should be borne in mind that in each case the relationships between the individual elements are strong. In many cases, the development of innovation may be linked to the economic situation of a particular country. Therefore, the economic factor may be significant, but its complement should be, for example, the knowledge and experience of human capital. It can be stated that this idea and the involvement of employees together with adequate financial contribution are the appropriate catalyst for the formation of new products / processes.

3. SUMMARY AND CONCLUSIONS

Innovations are present in every aspect of life today. They reflect the dynamic changes taking place in the world. One can get the impression that every successive product or every next thought is related to innovation, and consequently the meaning has to some degree been depreciated. This word is often used by marketing agencies, which in the dynamically developing markets are trying to overtake the competition.

Comparative analysis of selected determinants of innovation in EU countries has been started with three indicators of innovation, namely: the number of patents applied, innovative products new for the market and innovative products new for enterprises. The research period was limited to three years (i.e. 2012-2014) and the innovation rates were reported by twenty-eight EU countries. The stated purpose of the discussions was achieved by applying statistical analysis, with particular emphasis on the use of Pearson's correlation coefficient. The study was divided into two phases. The first focused on demonstrating the strength of the relationship between GDP and (separately) the three selected indicators of innovation. On the other hand, the second part of the analysis was to determine the scale of dependence between R & D expenditures and again the three variables mentioned above.

Correlation analysis allowed us to identify the most important innovation determinant of all the surveyed ones. The strongest correlation was with the number of patents applied. For both in the first case, when examining the correlation index between the number of patents and GDP, and in the second case when the number of patents applied and the R & D expenditure were analyzed, correlation coefficients showing a very strong correlation between the tested variables were obtained. There was a positive correlation, so both features grew or diminished in the same direction.

Moderately strong relationship depicted innovative products new for businesses and GDP and R & D expenditure. On the other hand, the lowest correlation coefficient results were obtained when comparing innovative products new for the market and GDP and R & D

expenditure. So there was a very weak connection between these features. Therefore, on the basis of the obtained results, it can be stated that the innovative products new for the market are the least important determinants.

The proposed analysis does not exhaust the totality of the examined matter, but it is an indication of the rightness to continue further and extend the research in this field.

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