The Role of Universities and their Research Work in the Generation of Innovation

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Abstract

The paper deals with the issue of generation of innovation. We analyze and assess the linear relation between innovation development and independent variables such as competitiveness of higher education (Ranking Universitas21) and productivity of scientific research (H-index according to the SCImago Journal & Country Rank). The aim of this paper is to highlight the relationship between universities, which plays a key role in the economic development and innovation process of the collected countries. And also as well as the significance of the research work of the scientists of the universities of country in the increasing the competitiveness of the higher education system in the whole, and, as a result, the level of innovation development of the country's economy. For the purposes of this paper the analysis of these indicators of 49 countries of the world is conducted. With regard to the aim, we have set the following hypothesis: we assume that there is a statistically significant correlation between university ranking and innovation process of country, the research work of the scientists of the universities of country and university ranking and between the research work of the scientists of the universities and innovation development of country. The analysis confirmed that the innovation development has strong relationship with university ranking of country and less notable relationship with research work.

Keywords: university, research work, innovation development, h-index, productivity of scientific research.

JEL Classification: A20, I23, O30.

1 Introduction

One of the main world tendencies of the last decades in the development of innovative activity was the transition from the "linear model" of management of the innovative cycle in the "cooperative" model, which was called the "triple helix". This transformation radically changed the role, forms and methods of interaction between the institutes of science, education and business in the innovation process.

In the "linear" model, the various stages of the innovative cycle are performed successively by the individual institutions which function for the ensuring that the activity is carried out at each of these stages. In such management format, there is a problem of special provision of

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"technology transfer", that is, the transfer of the obtained results at each stage, further along the chain.

The main problem of this model is the situation when the performed and completed activities at one stage did not take into account the features of the following stages and therefore the development did not move further to the final result, in particularly, the process of commercialization, that is, turning it into the innovation.

When the innovative cycle was long enough, the technology transfer intermediaries softened the contradictions between the stages and more or less ensured the completion of the innovative cycle. Today, when the dynamism of all economic processes has increased significantly, and globalization has led to an unprecedented increase in international competition, the long linear innovative cycle hinders its successful completion in a relatively short time and in accordance with the actual specific demand, which has also been changing dynamically in recent decades. The search for optimization of these relations of participants in the innovative cycle led to the management concept of the "triple helix" of the innovative cycle, the institutional basis of which is the organic interaction of the three actors in the process of the creative innovation in the form of a metaphorical spiral: the authorities (both central and local), business structures, and also the universities. The latest in this model is the central role in the ensuring of effectiveness of the entire innovative cycle.

Universities in industrialized countries have transformed their traditional role of teaching and research into actively participating in regional economic development since 1980s (Mian, 1997).

Although universities are recognized as one of the three important players in regional innovation systems, namely 2 universities, governments and industries (Etzkowitz, 2003; Looy et al., 2003; Gunasekara, 2006), most studies didn’t take into account the fact that the roles universities undertake in society can change and evolve over time, and the transformation of the university can influence regional economic development and innovation system (Youtie and al, 2008).

Any university intent in playing a strong role in economic development beyond simply the theoretical will have a sustained, positive impact on the regional economy only when its activities are guided by a reflective and on-going institution-wide and region-wide discourse” (Forrant, 2001).

To sum the researches, that were conducted in the recent years, the elements, which are in the focus of the most authors in the direction of changing of innovative cycle at the modern stage, can be determined (Edquist, 1997; Lundvall, 1992; Kumaresan & Miyazaki, 1999; Nelson, 1993; OECD, 1999). First of all, it is a set of institutions that are involved in the production, transmission and the using of knowledge, including government, enterprises, universities and research institutes. Secondly, these are all the other elements that impact on the innovative process: the context is created by the macroeconomic policies, the system of education and training, the system of financing innovations, communications and interaction with the international environment, the mechanism of innovation development, reflecting the system of relationships between these elements.

Almost all of the researches are devoted to the innovation system, focus on the fact that the flows of technology and information among persons, enterprises and institutions play a key

role in the innovation process (Etzkowitz &Leydesdorff, 1995; Etzkowitz & Leydesdorff, 1997).

Technological development is the result of a complex set of relationships between the system participants - companies, universities and public research institutions. Ongoing systemic transformation of the economy and society, transition to a post-industrial society, economy of knowledge, increase the value of the educational system to the society and economy (Etzkowitz, 2003; Mowery & Sampat, 2004).

University's opportunities for the region's development are considered in the following areas: universities are the main base for fundamental scientific research, creating conditions for regions' technological, socio-economic development in most countries. University studies are an important part of the scientific personnel's training, scientific and pedagogical potential of the region's accumulation. University often becomes a "pole of attraction" of knowledge-based industries' enterprises in its region (Armstrong & Taylor, 2000; Slaughter & Leslie, 1997).

Modern universities are expanding the goals and enriching features. Universities are not limited to the task of ensuring the highly qualified personnel to the economy, they are stepping up the activities in the field of research and development, ensuring the innovative development, becoming the regional centers of entrepreneurial activity (Armstrong & Taylor, 2000; Slaughter & Leslie, 1997; Clark, 1998).

System of higher education institutions is becoming not only a producer of educational services and a new knowledge to its customers (which has the own centers, powerful scientific centers and laboratories, where able to attract students of such universities), but also as their consumers through the creation the powerful research centers in such universities that are actively involved to the introduction of innovation in different spheres of economy and innovation activities (Levchenko and al, 2017).

The challenges of the economical present of a globalized economy, which are oriented on knowledge create the need to strengthen the aspects of innovation development, development of innovation infrastructure, the functioning of which would be aimed on the activating the innovation processes, which will be ensuring the high rates of economic growth. In these conditions the significant role in the development of research and innovation infrastructure is played by the system of higher education and the universities, in particular (Levchenko and al, 2017). Thus, a concept of the entrepreneurial university is being formed.

The aim of this paper is to highlight the relationship between universities, which play a key role in the economic development and innovation process of the collected countries. And also as well as the significance of the research work of the scientists of the universities of country in the increasing the competitiveness of the higher education system in the whole, and, as a result, the level of innovation development of the country's economy. For the purposes of this paper, the analysis of these indicators of 49 countries of the world. With regard to the aim, we have set the following hypothesis:

1. we assume that there is a statistically significant correlation between the effectiveness of universities activity in whole (system of higher education) and innovation process of country.

2. we assume that there is a statistically significant correlation between the research work of the scientists of the country's universities and the effectiveness of universities activity in whole (system of higher education).
3. we assume that there is a statistically significant correlation between the research work of the scientists of the universities and innovation development of country.

2 Methods

The research's methods comprise mainly descriptive statistic tools. The relationship between a Ranking Universitas21 (as indicator of the effectiveness of universities activity in whole (system of higher education) of analyzed country), the research work of the scientists of the universities of country and innovation development of country – representing the resources were analysed using Pearson correlation coefficient. The significance of correlations was tested with T- student's-test. Indicators have been selected from the Global Innovation Index 2017, the results of Ranking Univesitas21 and the SCImago Journal & Country Rank. The analysis has been carried out using Statistica Package and R.

3 Innovative development and the Research Work in University: statistical analysis

To quantify the strength of the relationship, we can calculate the correlation coefficient. In algebraic notation, if we have two variables x and y, and the data take the form of n pairs, then the correlation coefficient is given by the following equation:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}} \qquad (1)$$

where $\bar{x}$ is the mean of the x values, and $\bar{y}$ is the mean of the y values.

This is the product moment correlation coefficient (or Pearson correlation coefficient). The value of r always lies between -1 and +1. A value of the correlation coefficient close to +1 indicates a strong positive linear relationship (i.e. one variable increases with the other). Further, according to our hypothesis, calculate the degree of relationship between ranking Univarsitas21 and Global Innovation Index, than between the research work of the scientists of the universities and Univarsitas21 and between the research work and Global Innovation Index, taking into account the indicators of countries of the world according to the annual report, which is conducted by the Business School for the World (INSTEAD), the SCImago Journal & Country Rank Global, is conducted by the Scimago Lab and the Ranking of the system of higher education – Universitas21.

A correlation coefficient shows the degree of linear dependence of x and y. In other words, the coefficient shows how close two variables lie along a line. In our occasion, y (Innovation Development, which is measured by the Global Innovation Index) is dependent variable and x (Universitas 21, which evaluates the effectiveness of activities of the country's universities in whole and h-index as an indicator of scientific productivity of scientists) - independents variables.
From the Table 1, where are indicated the coefficients of correlation between all variables. So, looking at Table 1, there the following strong correlations, in particularly: Global Innovation Index and Universitas21 (r = 0.8970); Universitas21 and H-index' (r= 0.8158) and notable correlation between Global Innovation Index H-index (r= 0.7071).

Table 1 The matrix of correlations' ratio

Variable	GII	H-Index	U21
GII	1,0000	0,7071	0,8970
H-Index	0,7071	1,0000	0,8158
U21	0,8970	0,8158	1,0000

Source: Authors' own elaboration

Taking account the strength of correlation between the analyzed variables, the following conclusions can be made. First of all, the authors' hypothesis that strong positive correlations exists between effectiveness of universities activity in whole and innovation process of country, (which expressed through the Universitas21 and Global Innovation Index), the research work of the scientists of the universities of country and effectiveness of universities activity in whole (which expressed through the Universitas21 and H-index of the country according the SCImago Journal & Country Rank Global) and the research work of the scientists of the universities and innovation development of country can be accepted.

As we can observe the stated below scatter plots from the Figure 1, the relationship between all variables is linear, there is normal distribution.

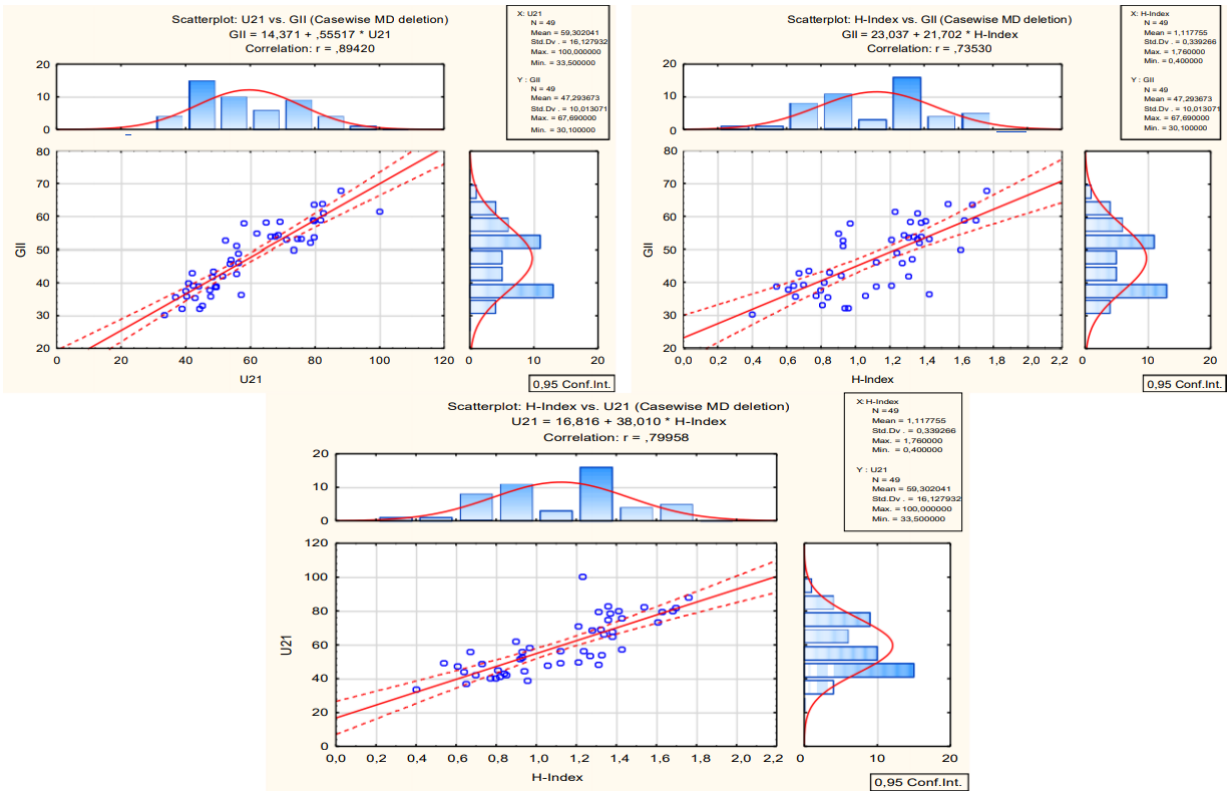

Figure 1 Linear regression model

Source: Authors' own elaboration

Besides, we consider, that the modeling of regression model can be useful in process of our analysis. The purpose of regression analysis is to analyze relationships among variables (in our analysis - Global Innovation Index, Universitas 21 and h-index), where the results serve the following two purposes: a) answer the question of how much y changes with changes in each of the x's (x1, x2,...,xk), and b) Forecast or predict the value of y based on the values of the X's.

Call:
lm(formula = form.log, data = data)

Residuals:

Min	1Q	Median	3Q	Max
-0.241666	-0.066031	0.006358	0.057505	0.211534

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.913456	0.340758	2.681	0.0102 *
log(H)	-0.001151	0.068164	-0.017	0.9866
log(U21)	0.721653	0.084936	8.496	5.54e-11 ***
Signif. codes:	0 ‘***’	0.001 ‘**’	0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1	

Residual standard error: 0.09649 on 46 degrees of freedom Multiple R-squared: 0.8095, Adjusted R-squared: 0.8012 F-statistic: 97.73 on 2 and 46 DF, p-value: < 2.2e-16

Statistical significance of the model:
H0: model is not statistically significant H1: model is statistically significant
p-value: 2.2e-16 < 0.05 we reject null hypothesis and we approve alternative hypothesis that model is significant

This model describes that 80 % of variability of dependent variable (Global Innovation Index), which is due to the differences in our independent variable – U21, while the rest 20% are other factors that were not taken into account in this case (H-index).

Statistical significance of the variables: H0: variable is not statistically significant H1: variable is statistically significant
p-values: 0.98 > 0.05 (H-Index), 5.54e-11 <0.05 (U21) we reject null hypothesis for variable – U21 and we approve alternative hypothesis that variable of U21 is significant. And also we reject 1 hypothesis for variable – H-index and we approve alternative hypothesis that variable of H- index is not significant.

Interpretation of the results:
Ceteris paribus: if the U21 rate will increase by one score GII (GII – dependent variable) will increase by 0.72 score.
Besides, we can see, that mean value of Global Innovation Index is 47.29. The lowest value of Global Innovation Index among the countries is 30.10 score (minimum), the highest is 67.69 score (maximum). The highest value is on 37.59 score higher than the lowest value (dimension). The standard deviation is 10.01. Consequently, the variance, the square of the standard deviation, is (10.01) * 2 = 20.02. The asymmetry and the coefficient of variation are given with the corresponding standard errors. The mean value of Universitas21 is 52.30. The lowest value of Universitas21 among the countries is 33.50 score (minimum), the highest is 100.00 score (maximum). The highest value is on 66.50 score higher than the lowest value (dimension). The standard deviation is 16.13. And the mean value of H-Index is 1.11. The lowest value of Universitas21 among the countries is 0.40 score (minimum), the highest is 1.76 score (maximum). The highest value is on 1.36 score higher than the lowest value (dimension). The standard deviation is 0.34.

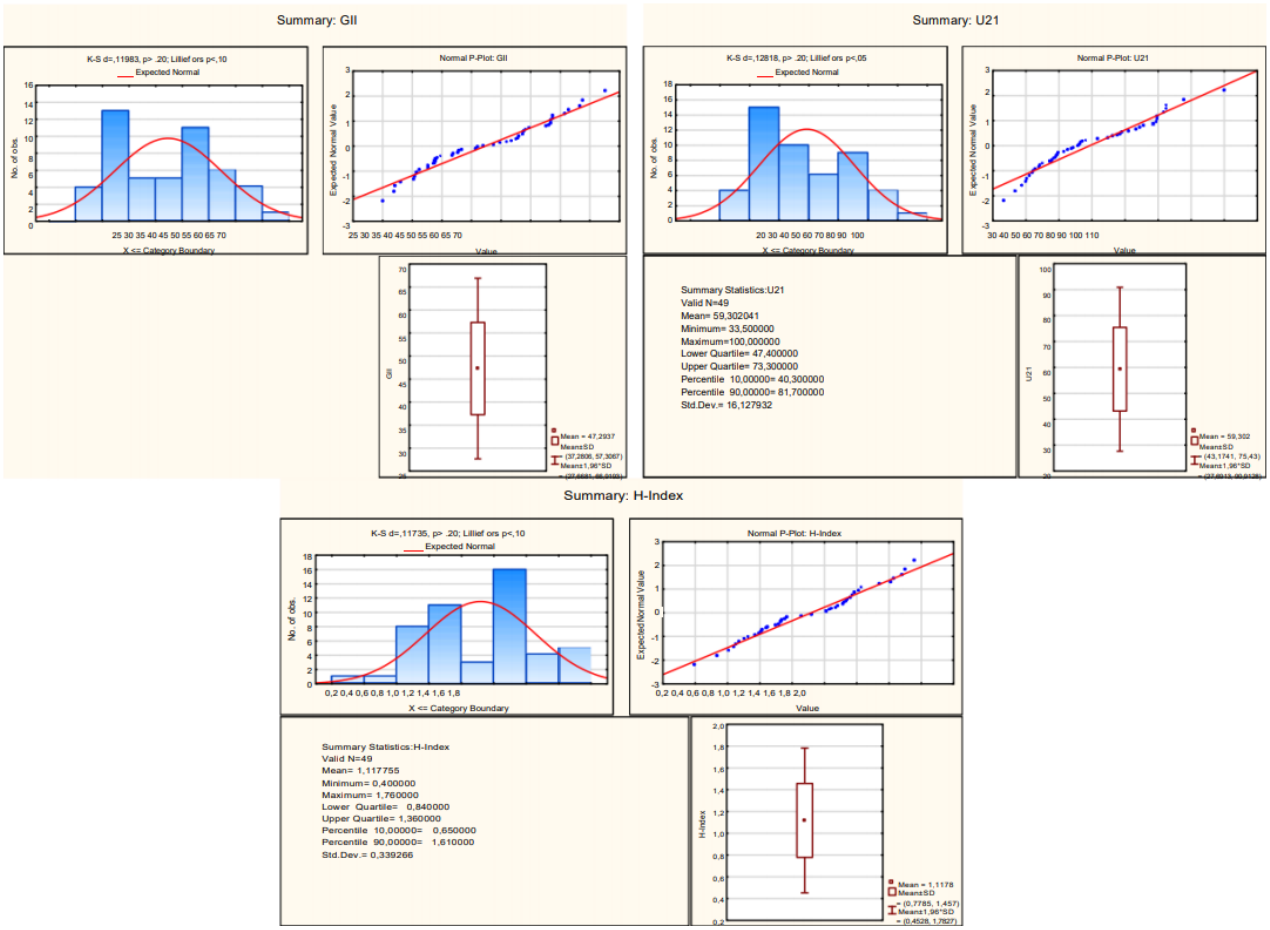

Figure 2 Descriptive statistics of such indicators as Global Innovation Index, Universitas21 and H-Index
Source: Authors' own elaboration

According to the Figure 2, we can see the highest of countries with level of Global Innovation Index level in the range of 35-40 score, the lowest is 65-70. Accordingly, the level of Universitas21: the highest of countries are in the range of 40-50 scores, the lowest are in 90-100. The level of H-Index: the highest of countries are in the range of 1.2-1.4 scores, the lowest are in 0.2-0.6.

Thus, the obtained calculated results of our research indicate about influence not only the universities in the generation of innovation but also their research work, and could be used by stakeholders as an instrument for the improving of innovation development. First of all, by governments of countries as one of the element of mechanism of ensuring the innovative process at the current stage of economy's reforming, because if the state will implement an effective policy for improving the competitiveness of higher education, to encourage scientists to the research work, in result - will increase Universitas21 (as an evidence of the effectiveness of the system of higher education), that as a whole will lead to activation of the generation of innovation (1 point of Universitas21 to 0,72 score of Global Innovation Index). Therefore, we think, that our results can be used by the state in elaboration a mechanism for the accelerating innovation to the economy. Furthermore, the received results strengthen the role of universities and their research work and the necessity of realization an effective state policy in the field of education. First of all, pay more attention to the last aspect because all innovations which are actively used now we have been born out of pure, strategic and applied research, it means without any research work - any innovation impossible.

4 Conclusion

The challenges of the economical present of a globalized economy, especially under the condition of the 4th Revolution, a new era of the knowledge, create the necessity in the generation of innovation for any country, which could be enhance the strengthening of the competitiveness of its economy, in a result - the level of social of prosperity of country's population. In these aspects the significant role in the generation of innovation is played by the system of higher education and the universities, in particular and their research work. The aims of increasing the effectiveness of socio-economic and scientific and technical policy through the the innovative process, based on the links of scientific institutions and operating enterprises in the network structure for the production of goods, services and innovations and become more significant in the context of the “triple helix”. Thus, the correlation-regression analysis showed a strong relationship between innovation development and Universitas21, which indicate on the impact of higher education on the innovative process in the country, besides - a notable relationship between innovation development and h-index, which indicate on the impact of research work of scientists of the universalities on the level of innovation development of the country. Also, we can admit about a strong relationship between a level of the competitiveness of higher education and h-index of whole country (researchers of universities of this country). Nowadays the process of innovation’s generation is an effective tool for ensuring the sustainable the country's development. In this regards, according to the idea of triple helix, the development of scientific ideas are becoming from the researchers’ works in each universities, the results of the popularization of which are conducted through the publishing in the well-recognized journals, then – the modern universities make their approbation on the practice in the laboratories of universities or in collaboration with the enterprises, with the aim of commercialization in result. So, any country’s innovation policy is not possible without the involving of such a powerful instrument in the conditions of the knowledge economy as the universities and their scientific potential (research work), are capable to the generation of new ideas and innovations.

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