INNOVATION AS A GENERATOR OF NATIONAL COMPETITIVENESS IN THE EUROPEAN UNION

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ABSTRACT
Innovation is perceived as one of the most relevant factors that influences competitiveness. National competitiveness is often associated to economic growth and is usually linked to productivity. The current research is focused on the connection between innovation and competitiveness and its intensity is tested through econometric analyses. The goal of the paper is to assess the impact of the innovation's determinants on the national competitiveness of the 28 Member States of the European Union. Consequently, the dimensions of the Innovation Union Scoreboard, and their corresponding indicators are tested in relation to the Global Competitiveness Index (GCI). "Human resources" and "intellectual assets" determinants are validated as having a positive impact on GCI. In terms of indicators, the population aged 30-34 having completed tertiary education, the patent applications and the community trademarks are the determinants with positive impact on national competitiveness in EU. The paper ends with several recommendations for the stakeholders to increase national competitiveness in EU by various ways of stimulating the validated determinants of innovation.

KEYWORDS: *determinants, European Union, innovation, national competitiveness.*

JEL CLASSIFICATION: *C20, C51, F63, O11, O30.*

1. INTRODUCTION

Competitiveness at the macro level represents the main focus of the current paper and is defined by the IMD as "a field of economic knowledge, which analyzes the facts and policies that shape the ability of a nation to create and maintain an environment that sustains more value creation for its enterprises and more prosperity for its people" (IMD, 2012, p. 502). According to Fagerberg and Nelson (2003) competitiveness at the micro level refer to "the ability of a firm to increase in size, market share and profitability", while competitiveness at the country level refers to "the way in which the pattern of international trade evolves over time to reflect changing patterns of capabilities and hence competitive advantage". Similarly, Herciu (2013, p. 274) defines competitiveness as "the institutional and policy arrangements that create the conditions under which productivity can grow sustainable". In terms of measurement, IMD (2012) highlights that competitiveness is measuring how a nation is managing its resources and competencies in order to increase the prosperity of its citizens.
As Porter (1990) stated competitiveness is usually linked to productivity. Competitiveness is often associated to economic growth that is influenced by factors such as "human capital, technological progress, macroeconomic stability, institutions, and innovation" (Charles & Zegarra, 2014, p. 5371). Innovation is defined as "the process of translating an idea or invention into a good or service that creates value or for which customers will pay" (http://www.businessdictionary.com/definition/innovation.html). Vieira et al. (2008) is highlighting

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that productivity and innovation are positively connected. Additionally, Oslo Manual (OECD; Eurostat, 2005) supports that innovation is central to the growth of output and productivity. Apart of innovation that is considered one of the main factors with influence on the current and future competitiveness of highly advanced economies there is location, specialization, and infrastructure (Becker, 2009, p. 133). Similarly, innovation is perceived as one of the main drivers of competitiveness of emergent markets, next to internalization and institutions (Kumar et al., 2013).

Two of the most influential contemporary economic approaches that study the patterns of innovation and its impact on competitiveness (of industries) are represented by the mainstream R&D spillovers approach and the evolutionary economic view. This topic is part of the Castellacci (2008) work and it shows that these two views have different perspectives on the theoretical background, the implications of research and policy. The traditional view on R&D spillovers is focused on the market, while the evolutionary view is based on institutional arrangements and policy interventions.

The goal of this research paper is to confirm, through econometric analyses, the main determinants of innovation that have a positive impact on national competitiveness in EU. Based on the results, policy makers, business, and academic community could place a special focus on some particular determinants of innovation for supporting a long-term economic growth.

Two of the main well recently known institutions that have developed models to measure the competitiveness of nations are the International Institute for Management Development – IMD that is elaborating the World Competitiveness Yearbook and the World Economic Forum – WEF that is publishing the Global Competitiveness Report. Based on the index of the second report the current research is conducted. The Global Competitiveness Index (GCI) is a complex indicator that includes 12 main pillars divided by three main categories, as follows: under the "basic requirements subindex" there are pillars referring to institutions, infrastructure, macroeconomic environment, health and primary education; "efficiency enhancers subindex" includes pillars focused on higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, and market size; and pillars referring to business sophistication and innovation belong to "innovation and sophistication factors subindex" (Schwab, 2013, p. 9). Within the context of this paper, the GCI is considered the explained variable in relation to the determinants of innovation part of the Innovation Union Scoreboard. According to the Global Competitiveness Index 2013-2014 Nordic countries, such as Finland, Sweden, and Denmark are characterized by a high level of competitiveness, while new comers in EU, such as Romania and Croatia, are placed on the last places within the EU ranking. Innovation at the European Union's level is measured through the Innovation Union Scoreboard (IUS), as the main instrument used to monitor the implementation of Europe 2020 Innovation Union initiative. It includes eight dimensions, respectively 25 indicators and offers an overview on the innovation performance among the 28 Member States of EU. The eight dimensions are human resources, research systems, finance and support, firm investments, linkages & entrepreneurship, intellectual assets, innovators, and economic effects (Hollanders & Es-Sadki, 2014). Each dimension has its corresponding indicators for each of the 28 Member States of EU. Summing up, the innovation leaders are represented by Sweden, Denmark, Germany, and Finland, while in the category of "modest innovators", Bulgaria, Latvia and Romania are placed.

Based on the positive connection between competitiveness and innovation, the paper is accomplishing the following two objectives:

- Evaluating the impact of the innovation's determinants on the national competitiveness of the 28 Member States;
- Identifying the most relevant determinants of innovation, both as dimensions and indicators of Innovation Union Scoreboard (IUS), having impact on the national competitiveness in EU.

This section was focused on the link between innovation and competitiveness, while the following parts of the paper include the methodology and the results of the econometric analyses referring to the dimensions, respectively indicators of IUS as the explanatory variables of the national competitiveness in EU.

2. ECONOMETRIC ANALYSIS

2.1. Methodology

The methodology is designed in accordance to the main objective of the paper that is to assess the impact of innovation, through its determinants, on the national competitiveness of the 28 Member States of the European Union. It is often met in the scientific literature that indicators of competitiveness are associated and tested in relation to an innovation indicator, highlighting that the relationship between competitiveness and innovation is an actual challenging topic for researchers, policy-makers and practitioners. The two main sources that are used in order to test the connection between the competitiveness at the national level in EU and innovation, are represented by the Global Competitiveness Index (GCI), respectively the Innovation Union Scoreboard (IUS). The paper is elaborated based on the most recent data bases, identifiable in the Global Competitiveness Report 2013-2014, respectively Innovation Union Scoreboard 2014 that sums up the results from 2013.
Clark and Guy (1997, p. 12) summarize the three main types of studies corresponding to the relationship competitiveness-innovation, as follows: econometric and statistical analyses, economic models, such as "vintage" models related to technology, or evolutionary models, and micro or macro case studies, including retrospective and mixed-mode analyses. Out of these three directions, the econometric analysis is used as the main method within this paper. Moreover, taking into account the specific objectives that are established and the availability of data on this topic, the quantitative analysis proves to be the most suitable in the context of this paper. The impact of the innovation's determinants, represented whether by dimensions or indicators of IUS, on the national competitiveness and the identification of the most relevant determinants of innovation on national competitiveness are the main objectives settled for the present paper.
The explained variable is represented by the GCI, while the determinants of innovation are represented by the dimensions of the IUS or by the indicators of the validated dimensions. Documentary analysis and data bases available at both the international and the European level are the main tools to be used for this research. The intensity of the innovation – competitiveness connection is going to be tested through econometric model, by using the Eviews programme.

2.2. Data analysis

The series of data corresponding to the dependent variable GCI are encountered within the formulated equations as "COMP". The GCI registers a median score of 4.48, corresponding to Poland and very near to Malta. The maximum value is allocated to Finland, with a score of 5.54, and on the opposite side the minimum value corresponds to Greece, with an index of 3.93. Skewness indicates a distribution oriented towards left, registering more extreme values to the right side. The value of kurtosis of 1.74 corresponds to a platykurtic distribution, meaning that the data values are spread on a wider area around the mean, compared to a normal distribution.

In the case of the first regression based on the dimensions included in the innovation index, the independent variables are represented by the "human resources" and the "intellectual assets" variables. As regards the "human resources", Sweden is the member state of the EU with the highest performance score, while Malta is situated on the lowest position. In terms of "intellectual assets" Denmark is the leader, while Romania is situated on the last position. The probability corresponding to Jarque-Bera statistics is higher than 0.05, meaning that the series of data follow a normal distribution.

In the case of the second regression focused on the indicators part of the validated dimensions of the innovation index, the explanatory variables are represented by the population aged 30-34 having completed tertiary education, PCT patents applications, and community trademarks. Ireland occupies the first position in terms of population with completed tertiary education, while Italy is positioned on the last place. In terms of PCT patent applications, Finland is situated on the top position, and on the other side there is Romania. Regarding community trademarks, Malta is on the leading position, while Croatia is situated on the last place.

3. RESULTS

3.1. Connection between GCI and the dimensions of IUS

The correlation between the competitiveness at the national level in the European Union and the determinants of innovation is represented through two out of the eight dimensions of the Innovation Union Scoreboard. Only two dimensions were statistically confirmed and included in the linear regression (see Equation 1).

$$COMP= C(1)+C(2)*HR+C(3)*IASSETS \quad (1)$$

Applying the least square function the results exposed in table 1 are obtained.

Table 1. The results of the correlation between national competitiveness and the dimensions of innovation

Dependent Variable: COMP
Method: Least Squares
Sample: 1 28
Included observations: 28

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.352555	0.195080	17.18558	0.0000
HR	1.054443	0.347934	3.030586	0.0056
IASSETS	1.628282	0.214576	7.588369	0.0000
R-squared	0.797816	Mean dependent var		4.695357
Adjusted R-squared	0.781642	S.D. dependent var		0.499463
S.E. of regression	0.233393	Akaike info criterion		0.028772
Sum squared resid	1.361808	Schwarz criterion		0.171508
Log likelihood	2.597198	F-statistic		49.32494
Durbin-Watson stat	1.939355	Prob(F-statistic)		0.000000

Source: results obtained by using the Eviews programme

The stability of the model is tested by Ramsey test that generated the results exposed in table 2.

Table 2. Ramsey RESET Test

F-statistic	0.037770	Probability	0.847542
Log likelihood ratio	0.044030	Probability	0.833798

Source: results obtained by using the Eviews programme

The corresponding Ramsey test hypothesis are the following:
Null hypothesis (H_0) is that the correct specification is linear, while
the alternative hypothesis (H_1) is that the correct specification is non-linear.
F statistic < F critical, as 0.037 < F (0.05; 2, 25) = 3.39, meaning that the null hypothesis is accepted, and the model is correctly specified as linear.
After testing the stability of the model, by using the Ramsey test, and the linear relationship between the explained variable and the explanatory variables was confirmed, other tests are going to be applied on the regression. The purpose of the tests is to determine whether the regression is good or has some minuses.
Firstly, a good regression must be strongly fitted to data, meaning a high value of R^2. In this particular case, R^2 registering a value of 0.79, it can be said that the regression is very good. This means that 79% of the dependent variable, namely national competitiveness in UE, could be explained by the influence of the explanatory variables included within the model, human resources, intellectual assets and free term.
Furthermore, in order to have the dependent variable explained through the regression, most of the independent variables should be individually significant. So, for each explanatory variable the following set of hypothesis is formulated:
H_0: C(n)=0
H_1: C(n) $\neq$0
All three explanatory variables included within the model are validated, each of them having a p-value less than 0.05.
Moreover, to influence or to explain the dependent variable, the independent variables should be jointly significant. This aspect is tested by using F-test, with the following hypotheses:
H_0:C(1)=C(2)….=C(9)=0
H_1: Not all C(n)'s are simultaneously equal to zero
The p-value of F statistic is less than 5 percent, meaning that the null is rejected and the alternative hypothesis is accepted. As a result, all the three independent variables can jointly influence the dependent variable "COMP".
Another aspect that is tested refers to auto-correlation in the residual (u) by using the Breusch-Godfrey serial correlation LM test (table 3). Further on, the hypotheses are formulated:
H_o: no serial correlation (no correlation between residuals (ui and uj))
H_1: serial correlation (correlation between residuals (ui and uj))

Table 3. Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.081202	Probability	0.778120
Obs*R-squared	0.094416	Probability	0.758636

Source: results obtained by using the Eviews programme

The p-value registered for Obs*R-squared at the Breusch-Godfrey serial correlation LM test is higher than 0.05, meaning that the null hypothesis is accepted, and the residuals are not correlated. The situation is ideal for a good regression.

Moreover, the Durbin-Watson stat of 1.93 is positioned between 1.8-2.2, meaning that the autocorrelation between the residual terms is lacking.
The homoscedasticity, meaning the variance of the residual (u) is constant, is another aspect that needs to be tested for defining a good regression.
H_0: the model is homoscedastic;
H_1: the model is heteroscedastic.
In order to test the hypotheses the White test is applied and its results are exposed in table 4.

Table 4. White Heteroskedasticity Test

F-statistic	1.728093	Probability	0.178144
Obs*R-squared	6.470446	Probability	0.166662

Source: results obtained by using the Eviews programme

The p-value of the Obs*R-squared is higher than 0.05, and as a result the null hypothesis is accepted, meaning that the model is homoscedastic. This result indicates the desirable situation.
Finally, in order to have the certainty that the regression is good, the residual normality has to be detected. The ideal is that residual to be normally distributed.
H_o: Normal distribution (the residual (u) follows a normal distribution)
H_1: Not normal distribution (the residual (u) follows not normal distribution)
The testing is made through the histogram-normality test, by performing the Jarque-Bera Statistic that registers a p-value higher than 0.05. Consequently, the null hypothesis is accepted and the desirable situation is accomplished.
Finally, equation 2 is expressing the influence that each independent variable has on the national competitiveness in the EU.

$$COMP = 3.35255477 + 1.054443102*HR + 1.628281786*IASSETS \quad (2)$$

Overall, the equation fulfils all the main rules for a good regression, even though the number of inserted explanatory variables within the model is narrowed. Human resources and intellectual assets are the validated variables to explain the competitiveness index at the national level within the European Union.
The coefficients associated to "human resources" and "intellectual assets" variables show that the competitiveness index at the national level in the European Union is predicted to increase by 1.05 when „human resources" goes up by one, and increase by 1.63 when intellectual assets goes up by one, and is predicted to be 3.35 when all the variables are zero. Moreover, there are studies (Halpern, 2007) enforcing that capital accumulation, including human capital, is perceived as a driving force for economic growth. Similarly, studies conducted by Fagerberg indicate that "both R&D and patenting yield very statistically significant results, with the correlation between productivity and patenting being closer than that between productivity and R&D" (Clark, Guy, 1997, p. 15).

3.2. Connection between GCI and indicators of IUS

Behind the two dimensions of the Innovation Union Scoreboard that were validated as having a positive impact on the national competitiveness in the EU there are several indicators. According to the Innovation Union Scoreboard (Hollanders, Es-Sadki, 2014) the "human resources" dimension has three associated indicators, as follows: new doctorate graduates per 1000 population aged 25-34, percentage population aged 30-34 having completed tertiary education, and percentage youth aged 20-24 having attained at least upper secondary level education. Evoking the same source of

information, the "intellectual assets" dimension includes four indicators, namely: PCT patents applications per billion GDP, PCT patent applications in societal challenges per billion GDP, community trademarks per billion GDP, and community designs per billion GDP. The following step was to compose a regression including all the seven indicators in order to predict their impact on the national competitiveness index. By multiple testing, the final variant of the regression includes three out of the seven indicators, as presented in equation 3. The explanatory variables are represented by population aged 30-34 having completed tertiary education, PCT patents applications, and community trademarks.

$$COMP= C(1)+C(2)*POP\_T\_ED+C(3)*PCT\_PAT\_AP+C(4)*COM\_TRADEMARK \quad (3)$$

Applying the least square function the results are exposed in table 5.

Table 5. The results of the correlation between national competitiveness and the indicators of innovation

Dependent Variable: COMP
Method: Least Squares
Sample: 1 28
Included observations: 28

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.532799	0.151335	23.34428	0.0000
POP_T_ED	0.009238	0.004390	2.104238	0.0460
PCT_PAT_AP	0.477196	0.054386	8.774276	0.0000
COM_TRADEMARK	0.024985	0.012375	2.018949	0.0548
R-squared	0.849812	Mean dependent var		4.695357
Adjusted R-squared	0.831038	S.D. dependent var		0.499463
S.E. of regression	0.205304	Akaike info criterion		-0.197088
Sum squared resid	1.011592	Schwarz criterion		-0.006773
Log likelihood	6.759236	F-statistic		45.26653
Durbin-Watson stat	2.045743	Prob(F-statistic)		0.000000

Source: results obtained by using the Eviews programme

The stability of the model is tested through the Ramsey test and its results are exposed in table 6.

Table 6. Ramsey RESET Test

F-statistic	0.457257	Probability	0.505652
Log likelihood ratio	0.551199	Probability	0.457828

Source: results obtained by using the Eviews programme

As F statistic (0.457) registers a lower value than F critical (0.05; 3, 24) of 3.01, then the null hypothesis is accepted, meaning that the model is correctly specified as linear.
Further on, similar tests as in the case of the dimensions of innovation are applied, in order to determine whether the current regression is good or has some minuses. The value of R^2 indicates a good regression, namely 85% of the national competitiveness in UE may be explained through the influence of the variables included within the equation. Moreover, all the independent variables are individually significant, based on the corresponding p-values which are less than 0.05. Further on, to influence or to explain the dependent variable, the independent variables should be jointly significant. In this respect F-test is used and based on its p-value less than 0.05, the null hypothesis

is rejected. As a result, the four independent variables can jointly influence the dependent variable "COMP".
The results of the Breusch-Godfrey, White test, histogram-normality test are all encouraging and confirm that is no correlation between residuals, the model is homoscedastic, respectively the residuals follow a normal distribution.
Finally, equation 4 is expressing the influence that each independent variable, represented by indicators of the Innovation Union Scoreboard, has on the national competitiveness within the European Union.

$$COMP = 3.532798965 + 0.009238330553*POP\_T\_ED + 0.4771957769*PCT\_PAT\_AP + 0.02498496308*COM\_TRADEMARK \quad (4)$$

Overall, the applied tests confirm that the regression is good, even though the number of validated explanatory variables is limited. Population aged 30-34 having completed tertiary education, PCT patents applications, community trademarks, and free term are the variables that explain the competitiveness index at the national level within the European Union.
The coefficients associated to "PCT_pat_ap" and "com_trademarks" variables show that the competitiveness index at the national level in the European Union is predicted to increase by 0.48 when „PCT patent applications" goes up by one, and increase by 0.02 when community trademarks goes up by one. The value of the coefficient associated to "pop_t_ed" variable is extremely low, meaning that the population aged 30-34 having completed tertiary education has a positive impact on the national competitiveness in EU, but of low relevancy. Finally, the explained variable is predicted to be 3.53 when all the variables are zero.

4. CONCLUSIONS

The paper starts with an overall picture on the positive connection between national competitiveness in EU and innovation. Further on, the paper is focused on the development of the corresponding linear regression between national competitiveness in EU and innovation. The latter is represented, on one hand, by the dimensions of IUS, and on the other hand, by the indicators part of the validated dimensions of IUS. Various tests were applied on both regressions in order to verify their stability and correctness. The results of the applied tests are encouraging and the explanatory variables may be interpreted. Consequently, there is a positive impact of the two validated dimensions of innovation, namely human resources and intellectual assets, on national competitiveness in EU. Several indicators are part of the two validated dimensions, but only some of them are included within the second regression. Population aged 30-34 having completed tertiary education, PCT patents applications, and community trademarks are the indicators validated as having a positive impact on the national competitiveness in EU.
Overall, stakeholders involved in stimulating and implementing innovation at the national level in EU for increasing competitiveness should focus on two main directions, namely on developing human resources, by stimulating the population aged 30-34 to complete tertiary education, and on intellectual assets, by supporting patent applications and community trademarks.
Starting from the suggestions of Arnold et al. (2009) some recommendations for stimulating the most relevant determinants of innovation in order to increase the competitiveness at the national level in EU are the following:
- *developing the "human resources" dimension:*
  - Developing an integrated system of education and qualifications that stimulate population aged 30-34 to complete the tertiary level of education;
  - Modernize university curricula in accordance to the employment market needs;

- Developing financial supporting schemes, available through competition, mainly for the population at the tertiary education level;
- Establishing a system of flexible life-long learning so that population could reach the highest levels of education;

- *developing the "intellectual assets" dimension:*
  - Providing incentives for the national holders of patents or trademarks to innovate in strategically relevant areas of the corresponding country;
  - Developing a network between the holders of patents and trademarks and potential investors (Iosif, 2014).

The shortcomings of the paper came up due to the impossibility of validation of all the dimensions of innovation or indicators part of the validated dimensions as having impact on the national competitiveness in EU. Even though the regressions are stable and the influence of the explanatory variables on national competitiveness is confirmed, there are too few dimensions, respectively indicators part of IUS that are validated. Future research directions imply the duplication of the current research analyses at the regional level within the European Union and compare the results between national and regional level.

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