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AN EMPIRICAL ANALYSE OF THE CORRELATION BETWEEN INNOVATION PERFORMANCE AND ECONOMIC DEVELOPMENT

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Abstract:
This study aims to highlight the correlation between innovation performance and economic development, based on the main theories in the field. We analyzed specific indicators worldwide for the year 2013 namely Gross Domestic Product per capita in current US$ (GDP/capita), as dependent variable, and innovation performance score calculated by WEF (INOV), as independent variable. Different types of models were empirically tested with the IBM® SPSS® Statistics Version 21 software. The results demonstrate that there is a significant correlation between variables, which is best described by the cubic model.

Key words: innovation performance, economic development, correlation, regression equation

JEL classification: O11, C29, B23

1. INTRODUCTION

Most of the authors in the field, as well as the Organization for Economic Co-Operation and Development (OECD), agree that today, the development of innovative capabilities is very important in respect to competitiveness growth and addressing global challenges, as innovation, based on research and development, is a "*sine qua non* of growth" (OECD, 2007; Năstase, Chaşovschi, Popescu, Scutariu, 2010; Iacovoiu, 2015).

Starting from this idea and given the theories and studies in the field, this paper aims to highlight if there is a relationship between innovation performance, calculated by the World Economic Forum (WEF), and economic development.

2. LITERATURE REVIEW

Since 2005, the Global Competitiveness Index (GCI) calculated by WEF, based on the key drivers of economic development, is a comprehensive tool that emphasizes the critical factors for productivity and competitiveness growth, as presented in the figure no.1.

According to this model (figure no.1), the factors are divided into three subindexes which group the twelve pillars of economic development. Whereas the key drivers are different according to the level of development, the model used by WEF attributes a superior weights to the pillars that are "more significant for an economy given its own stage of development" (WEF, 2013), as shown in the table no.1.

Thus, the twelfth pillar ("Innovation") is mostly significant (30%) for the economies that are in stage three of development, respectively the "innovation-drive" stage. In order to maintain and increase their competitiveness, companies in these countries must use their innovative capabilities to develop new products. As compared to these companies, firms in the economies that are in a lower stage of development can still make use of technologies acquired through "scientific and technological transfer", to facilitate the increase of production efficiency and the quality of their products (Iacovoiu, 2015).

Therefore, the increase of productivity can rely on innovation transfer only in the early stages of development, because, as a country improves its technologies, maintaining and increasing competitiveness requires to build and develop the own innovative capabilities (Akçomak and Bas, 2008; Becker, 2009). As such, only innovation can sustain the development of the economies "that have reached the high-tech frontier" (Romer, 1987).

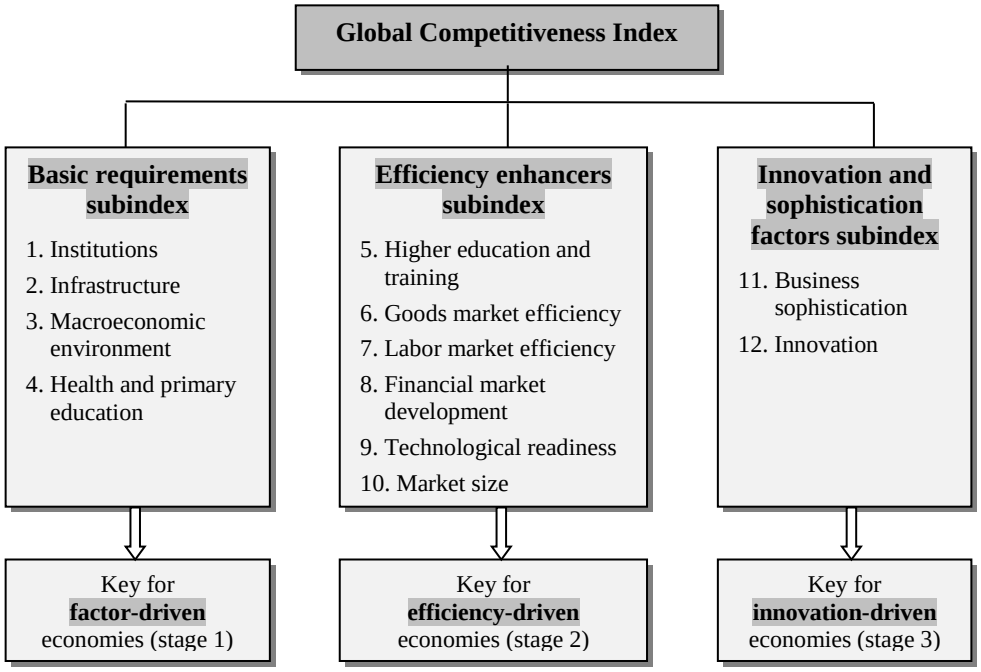

Figure no.1. Key drivers for economic development

Source: WEF (2013), *The Global Competitiveness Report 2013-2014: Full Data Edition*, Geneva, p.9

Table no.1. Weight for the main drivers of economic development

Stages of development	GDP per capita (US$)	Weight for basic requirements subindex	Weight for efficiency enhancers subindex	Weight for innovation and sophistication factors
Stage 1 (Factor-driven)	<2,000	60%	35%	5%
Transition from stage 1 to stage 2	2,000–2,999	40–60%	35–50%	5–10%
Stage 2 (Efficiency-driven)	3,000–8,999	40%	50%	10%
Transition from stage 2 to stage 3	9,000–17,000	20–40%	50%	10–30%
Stage 3 (Innovation-driven)	>17,000	20%	50%	30%

Source: WEF (2013), *The Global Competitiveness Report 2013-2014: Full Data Edition*, Geneva, p.10

On the other hand, some economists criticized the endogenous growth theories as most of the models empirically tested have failed „to explain conditional convergence" (Sachs and Warner, 1997) as well as the significant differences between the income in developed countries compared to developing ones (Parente, 2001).

Moreover, Professor Paul Robin Krugman (2013), who is one of the most influential economic thinkers in the USA, underlined the fact that too much of these models involve "making assumptions about how unmeasurable things affected other unmeasurable things" (Krugman, 2013). According to him, endogenous growth theory is very difficult to empirically verify.

3. DATA AND METHODOLOGY

The relationship between innovation performance and economic development was analyzed using Gross Domestic Product per capita in current US$ (GDP/capita) and innovation performance calculated by WEF as the twelfth pillar of competitiveness (INOV). The indicators values for a number of 141 countries in the year 2013 are presented in Appendix.

As presented in "The Global Competitiveness Report" published by WEF, the *INOV* value is calculated based on the following parameters, focused on "technological innovation": "Quality of scientific research institutions"; "Company spending on R&D"; "Capacity for innovation"; "Availability of scientists and engineers"; "Government procurement of advanced tech products"; "PCT patents, applications/million population"; "University-industry collaboration in R&D" (WEF, 2013).

Based on the theories in the field, we tested the correlation between the GDP per capita and INOV using the IBM® SPSS® Statistics software, starting from the following relation:

$$GDP/capita = f(INOV) \quad (1)$$

The following steps were performed to highlight the regression equation which describes the correlation between the GDP per capita and INOV:

- Creating the scatter plots;
- Graphing the fitting line for the Linear, Logarithmic, Inverse, Quadratic, Cubic, Power, Compound, S-curve, Logistic, Growth, and Exponential models;
- Calculating the F and R square indicators;
- Determining the regression equation.

There were only considered models for which the value of significance probability (Sig.) is under .05 (5%). The model with the higher coefficient of determination value (R Square) describes in the best way the relationship between variables.

4. RESULTS AND DISCUSSIONS

The values of F and R Square and of the parameters of the regression equation for the Linear, Logarithmic, Inverse, Quadratic, Cubic, Power, Compound, S-curve, Logistic, Growth, and Exponential models are synthesized below (table no.2).

Table no 2. Values of F and R Square and of the regression equation parameters (Dependent Variable: GDP/capita; Independent variable: INOV)

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.612	206.842	1	131	.000	-54797.174	20824.970		
Logarithmic	.574	176.153	1	131	.000	-73881.614	74971.756		
Inverse	.508	135.397	1	131	.000	92170.172	-246757.885		
Quadratic	.623	107.373	2	130	.000	-13211.443	-1754.699	2889.062	
Cubic	.677	90.103	3	129	.000	319943.095	-280947.258	78013.130	-6470.218
Power	.494	127.968	1	131	.000	28.102	4.575		
Compound	.497	129.432	1	131	.000	102.502	3.433		
S-curve	.467	114.794	1	131	.000	13.618	-15.551		
Logistic	.497	129.432	1	131	.000	.010	.291		
Growth	.497	129.432	1	131	.000	4.630	1.234		
Exponential	.497	129.432	1	131	.000	102.502	1.234		

Source: Own calculation based on data in Appendix

Consistent with the presented analysis, the cubic model describes the best the correlation between the two variables, as 67.7% of the variation in the GDP/capita is determined by INOV. As

underlined above (table no.2), the value of F square for all other analyzed models is lower than 67.7%, respectively from 49.4% (Power model) to 61.2% (Linear model).

The cubic regression equation is:

$$GDP/capita = 319943.095 - 280947.258(INOV) + 78013.13(INOV)^2 - 6470.218\ (INOV)^3 \quad (2)$$

Figure no.2 shows the fitting line which describes the spread of data points for the cubic model.

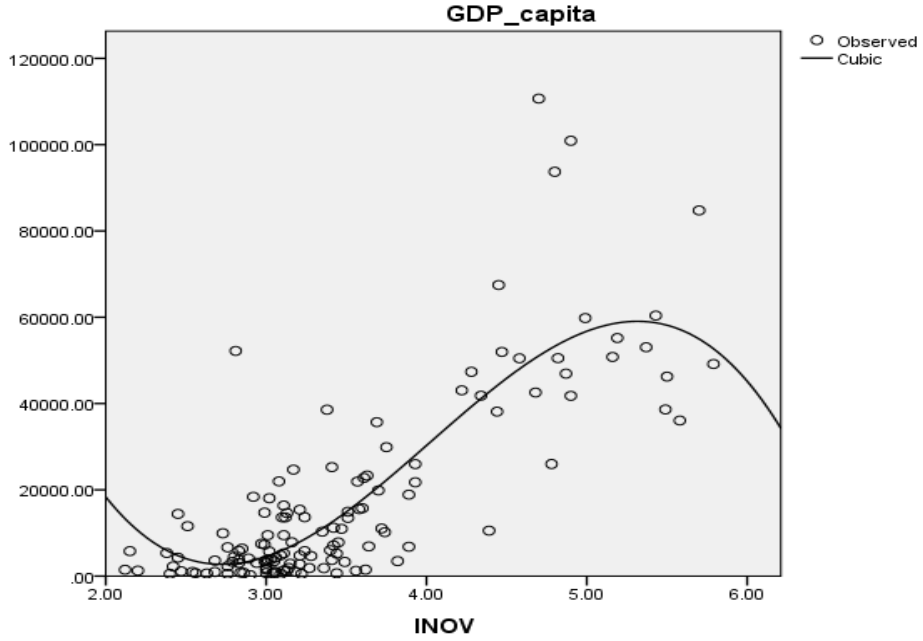

Figure no 2. The Fitting Line of the Cubic Model

Source: Data in Table no.2

Therefore, the cubic model reveals a relatively strong correlation between innovation performance (INOV), as independent variable, and economic development given by the GDP/capita, as dependent one. This statement is in line with most of the theories in the field that underline the importance of innovative capabilities for productivity and competitiveness growth, especially in those countries that are in the superior stages of economic development.

5. CONCLUSION

The results of the analyses presented above demonstrate that there is a significant correlation between innovation performance score calculated by WEF (INOV), as independent variable, and the economic development, given by the level of GDP/capita. This correlation is best described by the cubic model, as 67.7% of the variation in the GDP/capita was determined by the variation of INOV.

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APPENDIX

GDP/capita and INOV score (2013)

No.	COUNTRY	GDP/capita[1] (current US$)	INOV Score[2]
1	Luxembourg	110,664.80	4.7
2	Norway	100,898.40	4.9
3	Qatar	93,714.10	4.8
4	Switzerland	84,748.40	5.7
5	Australia	67,463.00	4.45
6	Sweden	60,380.90	5.43
7	Denmark	59,818.60	4.99
8	Singapore	55,182.50	5.19
9	United States of America	53,042.00	5.37
10	Kuwait	52,197.30	2.81
11	Canada	51,964.30	4.47
12	Netherlands	50,792.50	5.16
13	Austria	50,510.70	4.82
14	Ireland	50,478.40	4.58
15	Finland	49,150.60	5.79
16	Iceland	47,349.50	4.28
17	Belgium	46,929.60	4.87
18	Germany	46,251.40	5.5
19	United Arab Emirates	43,048.90	4.22
20	France	42,560.40	4.68
21	New Zealand	41,824.30	4.34
22	United Kingdom	41,781.10	4.9
23	Japan	38,633.70	5.49
24	Brunei Darussalam	38,563.30	3.38
25	Hong Kong (China)	38,123.50	4.44

26	Israel	36,050.70	5.58
27	Italy	35,685.60	3.69
28	Spain	29,882.10	3.75
29	Korea, Republic of	25,977.00	4.78
30	Saudi Arabia	25,961.80	3.93
31	Cyprus	25,249.00	3.41
32	Bahrain	24,689.10	3.17
33	Slovenia	23,295.30	3.63
34	Malta	22,775.00	3.61
35	Greece	21,965.90	3.08
36	Oman	21,929.00	3.57
37	Portugal	21,738.30	3.93
38	Czech Republic	19,858.30	3.7
39	Estonia	18,877.30	3.89
40	Trinidad and Tobago	18,372.90	2.92
41	Slovakia	18,049.20	3.02
42	Uruguay	16,350.70	3.11
43	Chile	15,732.30	3.6
44	Lithuania	15,529.70	3.58
45	Latvia	15,381.10	3.21
46	Barbados	14,917.10	3.51
47	Argentina	14,715.20	2.99
48	Russian Federation	14,611.70	3.13
49	Venezuela, Bolivarian Republic of	14,414.80	2.45
50	Poland	13,653.70	3.24
51	Kazakhstan	13,611.50	3.1
52	Croatia	13,597.90	3.12
53	Hungary	13,485.50	3.51
54	Gabon	11,571.10	2.51
55	Brazil	11,208.10	3.42
56	Panama	11,036.80	3.72
57	Turkey	10,971.70	3.47
58	Malaysia	10,538.10	4.39
59	Mexico	10,307.30	3.35
60	Costa Rica	10,184.60	3.74
61	Lebanon	9,928.00	2.73
62	Romania	9,490.80	3.01
63	Mauritius	9,477.80	3.11
64	Colombia	7,831.20	3.16
65	Azerbaijan	7,811.60	3.45
66	Belarus	7,575.50	-
67	Bulgaria	7,498.80	2.97
68	Botswana	7,315.00	2.99
69	Montenegro	7,106.90	3.42
70	South Africa	6,886.30	3.64
71	China	6,807.40	3.89
72	Peru	6,661.60	2.76
73	Serbia	6,353.80	2.85
74	Ecuador	6,002.90	3.4
75	Dominican Republic	5,879.00	2.83
76	Angola	5,783.40	2.15
77	Thailand	5,779.00	3.24
78	Namibia	5,693.10	3.02
79	Algeria	5,360.70	2.38
80	Jamaica	5,290.50	3.11
81	Jordan	5,213.40	3.44
82	Belize	4,893.90	-
83	TFYR of Macedonia	4,838.50	3.09
84	Iran, Islamic Republic of	4,763.30	3.21
85	Bosnia and Herzegovina	4,661.80	3.28

86	Albania	4,460.30	2.8
87	Fiji	4,375.40	-
88	Tunisia	4,316.70	3.06
89	Paraguay	4,264.70	2.45
90	Mongolia	4,056.40	2.89
91	Ukraine	3,900.50	3.03
92	El Salvador	3,826.10	3.01
93	Cabo Verde	3,767.10	2.83
94	Guyana	3,739.50	3.41
95	Georgia	3,596.90	2.68
96	Armenia	3,504.80	2.99
97	Guatemala	3,477.90	3.05
98	Indonesia	3,475.30	3.82
99	Egypt	3,314.50	2.79
100	Sri Lanka	3,279.90	3.49
101	Morocco	3,092.60	2.94
102	Swaziland	3,034.20	2.83
103	Nigeria	3,005.50	3
104	Bolivia, Plurinational State of	2,867.60	3.15
105	Philippines	2,765.10	3.21
106	Honduras	2,290.80	2.76
107	Moldova, Republic of	2,239.60	2.42
108	Viet Nam	1,910.50	3.14
109	Uzbekistan	1,878.00	-
110	Ghana	1,858.20	3.27
111	Nicaragua	1,851.10	3
112	Zambia	1,844.80	3.36
113	Sudan	1,753.40	-
114	Côte d'Ivoire	1,528.90	3
115	India	1,497.50	3.62
116	Yemen	1,473.10	2.12
117	Cameroon	1,328.60	3.11
118	Pakistan	1,275.30	3.13
119	Kyrgyzstan	1,263.40	2.2
120	Kenya	1,245.50	3.56
121	Lesotho	1,125.60	2.47
122	Senegal	1,046.60	3.18
123	Tajikistan	1,036.60	-
124	Cambodia	1,006.80	3.05
125	Bangladesh	957.8	2.54
126	Zimbabwe	953.4	2.68
127	Tanzania, United Republic of	912.7	3.06
128	Benin	804.7	2.84
129	Burkina Faso	760.9	2.86
130	Mali	715.1	3
131	Nepal	694.1	2.56
132	Uganda	657.4	3.04
133	Rwanda	638.7	3.44
134	Togo	636.4	-
135	Mozambique	605	2.63
136	Guinea	523.1	2.4
137	Ethiopia	505	2.76
138	Gambia	488.6	3.22
139	Madagascar	463	3.09
140	Niger	415.4	-
141	Malawi	226.5	2.9

Source: 1) The World Bank, Data, http://data.worldbank.org/indicator/NY.GDP.PCAP.CD, on-line, [Accessed on July 16, 2015]; 2) WEF (2013), The Global Competitiveness Report 2013-2014: Full Data Edition, p.22.