INTERNATIONAL JOURNAL OF SOCIAL SCIENCES
20th September 2019. Vol.78. No.1

ISSN 2305-4557 www.Tijoss.com

THE RELATIONSHIP BETWEEN "INNOVATION, SCIENCE AND TECHNOLOGY" AND "ECONOMIC DEVELOPMENT": CANONICAL CORRELATION ANALYSIS FOR THE EU COUNTRIES

Assist. Prof. Dr. Ayşen Altun Ada
Department of Banking and Finance, Dumlupinar University, Kutahya, Turkey
aysenaltun@dpu.edu.tr

Lecturer, Bahar Çelik
Department of Marketing, Dumlupinar University, Kutahya, Turkey
bahar.celik@dpu.edu.tr

ABSTRACT

Today; innovation, science and technology constitute the essential force of economic development. The aim of this study is to investigate the relationship between the selected indicators of innovation, science and technology that belong to the EU countries and economic development. To this aim, the canonical correlation analysis technique was employed in order to determine the relationship between two variable sets. It was determined that there exists a high and statistically significant correlation between the variable sets

Keywords: european union, innovation, science and technology, economic development, canonical correlation.

1. INTRODUCTION

Countries that competed to become industrial societies in the 20th Century now vie for becoming information societies. This is an obligation, because countries that do not invest in research and development, use technology and science, and make inventions cannot compete in the global market. Countries that remain imitators rather than becoming inventors cannot retain their development dynamisms. In other words, the competition between nations today is not one of products, but one of scientific and technological effectiveness.

The fact that countries' economic policies and development plans are devised in this direction proves that innovation, science and technology are important factors that influence countries' economies and societies' qualities of life. While innovation is the concretization of new ideas and inventions by way of commercial activities; technology is the sum of information and skills that could be used to effectively and efficiently realize an industrial process, which covers research and development, production, marketing, selling and after-sale services. Science, on the other hand, produces laws without limits that are based on

ISSN 2305-4557 www.Tijoss.com

practical realities that are never static. While science paves the way for technological developments, which in return facilitate scientific development. Economic development, on the other hand, can be defined as a concept whose boundaries are not fixed yet which demonstrates itself through various indicators. It includes the rise of investments and living standards.

In this study, the relevant literature will be reviewed, then the opinions and policies prevalent in the EU regarding innovation, science and technology will be addressed. After the statistical data and the method employed in the study are introduced, analysis results and interpretation of these results will be presented.

2. LITERATURE REVIEW

Economic dynamism and technological development are so intertwined that it is nearly impossible to differentiate their influences over each other. After the Industrial Revolution of the 18th Century, science and technology got intertwined and started to coalesce. Then, in time, technological advancement became the most important parameter of economic development. Today, the term innovation in the globalized economy has become the keyword for competition and economic development (Fan et al., 2009 & Dickson, 1992). This term is also of crucial importance for sustainability, because innovative ideas and inventions influence not only the present time but also the future generations by enabling the efficient and effective utilization of resources.

One of the greatest contributors to the concept of innovation was Schumpeter (1928, 1939). He endowed the economic theory with the influences of technological development, innovation and invention on economic development with solid and detailed proofs. He emphasized that firms can increase their revenues through innovation, which brings about economic development. According to Schumpeter, economic development is achieved when the economic current leaves its course and jumps to a higher point of equilibrium. One of the forces behind this jump is innovations in the economic life.

Brynjolfsson and Hitt (1996) demonstrated that there exists a positive correlation between the investments made in information economics in the USA firms and the economic performance indicators for the period of 1987-1991. Loo and Soete (1999) suggested that numerous studies have been conducted in the recent fifty years on innovation, technology and economic development; however, these studies fail to fully demonstrate the relationship between economic development and technology. In their study, they found that technology has a limited impact upon growth, yet consumer welfare is enhanced through increased product differentiation. Bassanini, Scarpetta and Visco (2000) observed that the most visible change was that of the USA among the OECD countries in terms of productivity rise, and they related this finding to the utilization of scientific technology. They also suggested that technology-friendly conditions should be provided and relevant policies should be developed in order to ensure that technology becomes the driving force of productivity and growth. According to Pohjola (2000), it is not easy to measure the influence of rapidly changing information technologies on productivity. He examined the impacts of information technologies upon economic growth by using the data of 39 countries for the period of 1980-1995, and concluded that information technologies were influential over economic growth not for all the 39 countries. After he limited the data set to 23 developed OECD countries, he found that information technologies have a positive strong impact on economic growth. Lopez (2000) examined the concepts of competition, innovation and development. The conclusion was that innovation influences employment, economic growth, government policies and business strategies. This influence is not always positive. Technological

ISSN 2305-4557 www.Tijoss.com

innovation may sometimes negatively affect employment. According to Pradhan (2002), information technologies are of great importance especially for developing countries as a tool of socioeconomic development. However, since these technologies are developed by industrialized countries, simply imitating them does not make the desired contributions. Therefore, developing countries need to develop or purchase information technologies in line with their peculiar socioeconomic, cultural and structural characteristics. Howells (2005) suggests that innovation is important for regional development for two main reasons. First, innovation is linked with economic growth performance; second, big differences between regions emerge as a result of innovative activities. Metcalfe (2011) maintains that economies and firms need to make long-term innovation efforts in order to be able gain competitive advantage over and get ahead of their rivals.

3. THE IMPORTANCE THE EU ATTACHES ON INNOVATION, SCIENCE AND TECHNOLOGY

The European Union is an integrated body that attaches great importance to “Innovation, Science and Technology”. The EU policies increasingly include regional innovation initiatives or international entrepreneurship activities. It is seen that technology and innovation policies in the EU countries are not in the hands of national public institutions anymore. Efforts of the EU imply that innovative cultural zones as well as progressive policies that involve both cooperative and competitive visions have been embraced, rather than centralist and dominant public policies (Kuhlmanna and Edler, 2003).

Europe 2020 is the growth strategy of the EU in the next decade. A vision is determined for the European social market economy in the 21st Century. Innovation, science and technology are important aspects of the growth strategy of the EU for 2020. In the decision taken by the European Commission, the target is stated as establishing communication via ERA (A Reinforced European Research Area) and thus creating an open market sphere originating from national markets. This way, every organization will be able to access desired information and a European economy with high levels of employment, productivity and social welfare will be ensured in today’s rapidly changing world. R&D efforts will be given special importance (Eurostat).

The President of the European Commission, J. M. Barroso, stated that the EU should become a smart, sustainable and inclusive economy in the changing world. These three priorities will enable the EU and its members to achieve high levels of employment, productivity and social welfare. In this respect, the Union has five concrete objectives to be achieved by 2020: Employment, innovation, education, social inclusion and climate/energy. It is frequently emphasized that innovation, science and technology are of great importance to be able to achieve these objectives (Eurostat).

4. DATA

The data used in the study were those of the year 2010 for 27 EU countries; however, the data of 2009 were used for some countries and variables whose 2010 data could not be accessed. All the data were obtained from EUROSTAT. Canonical correlation analysis was performed on the variables in the data sets of “Innovation, Science and Technology” (U) and “Economic Development Indicators” (V). The following variables constituted the set of “Innovation, Science and Technology”: x1:Share of total R&D expenditures in GDP, x2: Turnover from innovation (%of total turnover) , x3:Research and development personnel (head count - % of the labour force), x4:Human resources in science and technology as a share of labour force, x5:European high-technology patents (per million inhabitants) and x6: Doctorate students in science and technology fields (% of the population aged 20-

ISSN 2305-4557 www.Tijoss.com

29). On the other hand, the following variables formed the other data set, "Economic Development Indicators": y1: Share of public investments in GDP, y2: Share of private investments in GDP, y3: Share of household investments in GDP, y4:Dispersion of regional GDP per inhabitant (% of the national GDP per inhabitant) and y5: Share of net national income in GDP[1]. In this study, the data matrix at the dimension (6+5)x27=11x27 was analyzed and relationships between the indicators were examined.

5. METHODOLOGY AND EMPIRICAL RESULTS

Canonical correlation analysis is a technique which is used to examine the nature of the relationship between two variable sets, each of which includes multiple variables. For the analysis developed by Hotelling (1936), firstly, the variable pair constituted by the linear combinations of the variables with the highest correlation is determined. Then, the pair formed by the linear combinations of the variables, which are nor correlated with the above pair and which have the highest correlation, is determined and included in the analysis. The pairs formed by the linear combinations of all variables are called canonical variables, and the correlation among them is called canonical correlation. Canonical correlations explain the extent of dependence between the variables of the two sets. The biggest purpose and benefit of the technique is moving from a large set of interrelated variables to a smaller set of canonical variables (Kachigian, 1991; Hair et al.,1998; Sharma, 1996).

Eigenvalues and canonical correlations of the canonical correlation analysis performed between the sets of "Innovation, Science and Technology" and "Economic Development Indicators" are presented in Table 1.

[1] Source for access to the variables in the data set and their explanations; http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.

INTERNATIONAL JOURNAL OF SOCIAL SCIENCES
20th September 2019. Vol.78. No.1

ISSN 2305-4557 www.Tijoss.com

Table 1: Eigenvalues and Canonical Correlations

Function	Eigenvalue	Variance Extracted	Total Variance Extracted	Canonical Correlation	Wilks L.	p
1	2,418	49,119	49,119	0,841	0,051	0,001*
2	1,323	26,874	75,993	0,755	0,173	0,020*
3	0,803	16,307	92,3	0,667	0,402	0,108
4	0,373	7,579	99,88	0,521	0,724	0,374
5	0,006	0,12	100	0,077	0,994	0,943

*p<0.05

According to Table 1, the eigenvalue calculated for the pair of canonical correlation is an indicator of total variance. As eigenvalues increase, canonical correlation coefficients also go up. It is seen that the highest eigenvalue belongs to the first function. It is observed that eigenvalues gradually decrease in other pairs of canonical correlation. Significances of the canonical correlations between the pairs of canonical variables were tested through the Wilks Lamda statistics, and it was found that two pairs of canonical variables were significant at the level of 0.05. While the canonical correlation coefficient of the first pair of canonical variables was 0.841; the coefficient of the second one was found to be 0,755.

Table 2- Canonical Coefficients

U	Raw Canonical Correlation Coefficients		Standardized Canonical Correlation Coefficients		V	Raw Canonical Correlation Coefficients		Standardized Canonical Correlation Coefficients	
	1	2	1	2		1	2	1	2
x1	-1,077	-0,725	-1,024	-0,689	y1	-0,26	0,28	-0,29	0,312
x2	0,062	-0,055	0,264	-0,233	y2	-0,044	0,083	-0,096	0,181
x3	3,156	0,765	1,593	0,386	y3	-0,035	0,157	-0,055	0,246
x4	0,025	-0,008	0,207	-0,071	y4	-0,07	0,072	-0,61	0,629
x5	-0,008	-0,058	-0,115	-0,885	y5	-0,11	-0,11	-0,714	-0,713
x6	-0,043	2,195	-0,011	0,568					

The canonical functions, which belong to the first two pairs of canonical variables obtained through standardized canonical coefficients, will be the following:

*U1= -1.024*x1 + 0,264*x2 + 1.593*x3 + 0,207*x4 – 0,115*x5 – 0.011*x6*

In the formation of the canonical variable U1, the contribution of the variable x3 is the highest (1,593). It is seen that the variable that contributed the least to the variable U1 is x6, which had a negative contribution.

*U2= -0,689*x1 - 0,233*x2 + 0,386*x3 - 0,071*x4 – 0,885*x5 + 0.568*x6*

In the formation of the canonical variable U2, the contribution of the variable x5 is the highest (0,885). It is seen that the variable that contributed the least to the variable U2 is x4.

*V1= - 0,290*y1 - 0,096*y2 - 0,055*y3 - 0,610*y4 – 0.714*y5*

In the formation of the canonical variable V1, the contribution of the variable y5 is the highest

ISSN 2305-4557 www.Tijoss.com

*V2= 0,312*y1 + 0,181*y2 + 0,246*y3 + 0,629*y4 – 0.713*y5*

In the formation of the canonical variable V2, the contribution of the variable y5 is the highest (0,713). It is seen that the variable that contributed the least to the variable V2 is y2.

Although standardized canonical coefficients are generally preferred over non-standardized ones; big differences might be seen in these coefficients especially in small samples and when there is multicollinearity in the data set. Therefore, it is (0,714). It is seen that the variable that contributed

the least to the variable V1 is y3.

more suitable to use the correlations between the canonical variable and the original variables in that set. These correlation coefficients are called canonical loadings, which are used to determine the degree of the contribution that the relevant variable makes to its own canonical variable and therefore to the canonical correlation coefficient (Sharma,1996). The canonical loadings that belong to the first two pairs of canonical variables are presented in Table 3.

Table 3: Conanical Weights

U	*Conanicial weights*		*V*	*Conanicial weights*	
	1	*2*		*1*	*2*
x1	0,293	-0,751	y1	-0,254	0,520
x2	0,067	0,152	y2	-0,176	0,252
x3	0,751	-0,507	y3	0,210	-0,263
x4	0,516	-0,529	y4	-0,695	0,562
x5	0,164	-0,914	y5	-0,696	-0,705
x6	0,192	-0,234			

Table 3 demonstrates that the biggest loading value (0,751) in the canonical variable U1 belongs to the variable x3. It is seen that the biggest loading value (-0,914) in the canonical variable U2 belongs to the variable x5. On the other hand, the biggest factor loading value (0,696) in the canonical variable V1 belongs to the variable y5, whereas the biggest factor loading value (-0,705) in the canonical variable V2 belongs to the variable y5.

6. CONCLUSIONS

In terms of the results of the canonical correlation significance between the selected "Innovation, Science and Technology" and "Economic Development" Indicators of the EU countries, five different pairs of canonical variables were obtained.

The first two of them were found to be significant, and it was observed that they had high canonical correlation coefficients. The highest canonical correlation coefficient was found as 0,841, whereas the second highest was 0,755. In conclusion, within the framework of the variables determined for 27 EU countries, it was found that there exists a high and statistically significant correlation between economic development and innovation, science and technology.

7. REFERENCES

1. Bassanini, A. , Scarpetta, S. and Visco, I. (2000). Knowledge, Technology and Economic Growth: Recent Evidence from OECD Countries. National Bank of Belgium Working Papers-Research Series.

ISSN 2305-4557 www.Tijoss.com

2. Brynjolfsson, E. and Hitt, L. (1996). Paradox lost? Firm-Level Evidence on The Returns to Information Systems Spending, *Management Science*, 42: 541-558.

3. Dickson, D. (1992). Alternatif Teknoloji.Teknik Değişmenin Politik Boyutları (Trans. Nezih Erdoğan). Ayrıntı Pub. İstanbul.

4. Eurostat;http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/introduction. Retrieved 26 February 2013.

5. Fan, Q., Li, K. , Zeng, D. Z. , Dong, Y. and Peng, R. (2009). Innovation for Development and the Role of Goverment- A Perspective from the East Asia and Pasific Region. the World Bank. Washington. DC.

6. Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C. (1998). Multivariate Data Analysis, Prentice Hall, New Jersey.

7. Hotelling, H. (1936). The Most Predictable Criterion , *Journal of Educational Psychology*, 26, 139-142.

8. Howells, J. (2005). Innovation and Regional Economic Development: A Matter of Perspective? *Science Direct*, 34: 1220–1234.

9. Kachigian, S.K. (1991). Multivariate Statistical Analysis: A Conceptual Introduction. New York: Radius Press.

10. Kuhlmanna, S. and Edler, J. (2003). Scenarios of Technology and Innovation Policies in Europe: Investigating Future Governance. *Science Direct*, 70: 619-637.

11. Loo, I.D. and Soete, L. (1999). The Impact of Technology on Economic Growth: Some New Ideas and Empirical Considerations, MERIT Research Memoranda.

12. Lopez, M.R. (2000). Innovation, Competitiveness and Development, Searching for the Linkages to Economic Development, IKE Internal Seminar, Denmark.

13. Metcalfe, S. (2011). J.A. Schumpeter and the Theory of Economic Evolution (One Hundred Years beyond the Theory of Economic Development). Papers on Economic & Evolution, Vienna.

14. Pohjola, M. (2000), Information Technology and Economic Growth: A Cross-Country Analysis. UNU World Institute for Development Economics Research (UNU/WIDER), Working Papers, No: 173.

15. Pradhan, J. (2002). Information Technology in Nepal: What Role for the Government ? *The Electronic Journal on Information Systems in Developing Countries*, 8,3:1-11.

16. Schumpeter, J. (1928). The Instability of Capitalism. *The Economic Journal* , 38 (151) : 361-386.

ISSN 2305-4557 www.Tijoss.com

17. Schumpeter, J. (1939). Business Cycles. A Theoretical, Historical and Statistical Analysis of the Capitalist Process. New York Toronto London, McGraw-Hill Book Company.

18. Sharma, S. (1996). Applied Multivariate Techniques. John Wiley & Sons Inc. Canada.