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Relationship Between Knowledge Economy Performance Indicators And Selected Macroeconomic Variables: an Application for OECD Countries

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Abstract
Information has been the most important source of social wealth throughout the history. Societies that have access to more superior knowledge and could utilize this knowledge aright via an effective political, economic and social organization surpassed others and achieved a higher level of welfare. The present study aimed to determine the correlation between knowledge economy performance indicators and selected macroeconomic variables. The data set compiled for 34 OECD countries was analyzed with canonical correlation analysis. The analyses demonstrated that there was a significant and strong relationship between the datasets.
Key words: *Knowledge Economy, Information and Communication Technologies (ICT), Canonical Correlation Analysis.*

Bilgi Ekonomisi Performans Göstergeleri ve Seçilmiş Makroekonomik Değişkenler Arasındaki İlişki: OECD Ülkeleri İçin Bir Uygulama

Özet
Bilgi, tarih boyunca toplumların zenginliğinin en önemli kaynağı olmuştur. Daha fazla ve daha nitelikli bilgiye sahip olan ve bilgiyi etkin bir siyasal, ekonomik ve sosyal örgütlenme ile doğru biçimde kullanabilen toplumlar diğerlerinin önüne geçerek daha yüksek bir refah seviyesine erişmiştir. Bu çalışmada bilgi ekonomisi performans göstergeleri ve seçilmiş makro ekonomik değişkenler arasındaki ilişki tespit edilmeye çalışılmıştır. Bu amaçla ele alınan OECD üyesi 34 ülke için derlenen veri seti kanonik korelasyon analizi ile değerlendirilmiştir. Yapılan analizler sonucunda değişken setleri arasında anlamlı ve güçlü bir ilişki olduğu görülmüştür.
Anahtar Kelimeler: *Bilgi Ekonomisi, Bilgi ve İletişim Teknolojileri (BİT), Kanonik Korelasyon Analizi.*

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1. INTRODUCTION

Knowledge and innovation played a significant role in progress and development since the beginning of human history. The share of knowledge in the foundation of the industrial revolution, which started in the 18th Century and reduced the agricultural population on earth during two centuries and transformed humans into producers of goods and services, could not be denied. However, along with the globalization that gained momentum during the 1980's and the technological revolution, knowledge and innovation became an indispensable part of the economy. Since that period, a shift from capital intensive production to information intensive production was experienced and developed country economies were transformed from an industrial production based economic structure into a service based production structure.

Along with globalization and the technological revolution, information became the key to competition. Formal knowledge is considered as both a personal and economic resource and although it is yet far away from negating the conventional production factors totally, it rendered production factors easily accessible[1]. Today, industries, which are at the center of the economy, are closely interested in the production and distribution of knowledge and information. Knowledge is reshaping the economic growth and operation models in the world.

The objective of the present study is to determine the degree and the direction of the effects of commonly used knowledge economy performance indicators on selected macroeconomic indicators in OECD countries, including Turkey.

2. KNOWLEDGE ECONOMY AND ITS INDICATORS

As the role of knowledge and technology in economic growth was recognized completely, the term "*knowledge-based economy*" emerged. Human knowledge christened in economics as human capital and technological knowledge have always been significant in economic development. The focus of conventional *"production functions"* are on labor, capital, materials and energy and the effects of knowledge and technology on production are peripheral. New analytical approaches are developed to include knowledge directly in production functions. Investments in knowledge could improve the efficiency of other production factors and transform these factors into new products and processes. Knowledge investments tend to increase (as opposed to decrease) the returns and thus, they are crucial for economic growth in the long term[2]. A knowledge-based economy means that knowledge production, exchange, distribution and utilization are primarily driven by economic growth, more employment and creation of wealth[3].

1 Peter F. Drucker, Kapitalist Ötesi Toplum, (İstanbul: İnkılap Kitabevi, 1993), s.65.

2 OECD, " The Knowledge-Based Economy", 1996, pp. 9-11.

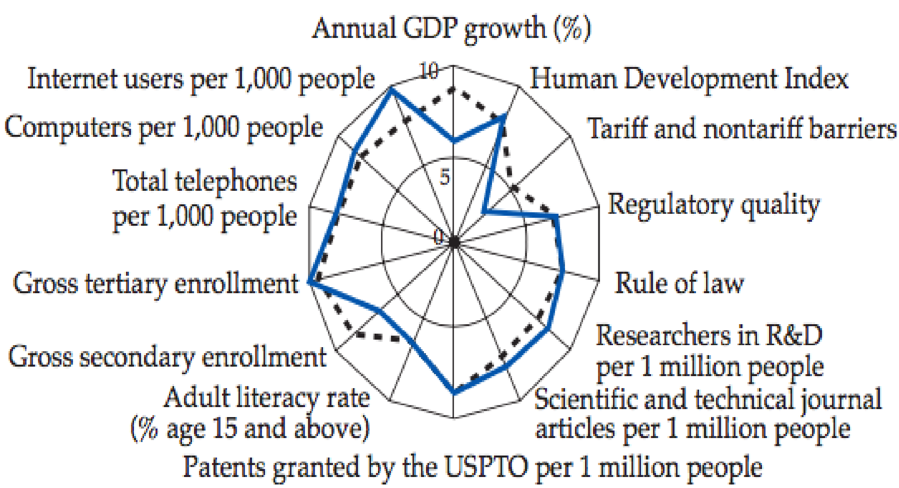
3 Abdul B. Kamara, Lobna Bousrih and Magidu Nyende, December 2007, Economic Research Working Paper, No: 88, African Development Bank, "Growing a Knowledge Based Economy: Evidence from Public Expenditure and Education in Africa", p. 4.

The requirements for a successful transition to a knowledge economy are long-term educational investments, an improved information infrastructure, advanced innovation capability and an economic environment that favors market transactions. As the World Bank pinned; these factors are the pillars of the knowledge economy (KE), and form the framework of the knowledge economy in ensemble[4]. These four pillars of the KE framework could be summarized as follows:

- Effective economic policies and organizations created by an economic motivation and the institutional framework that facilitate efficient allocation of resources and promote creativity and incentives for the efficient creation, distribution, and use of existing knowledge;
- Efficient creation and utilization of the knowledge by an educated and skilled labor force, which continuously improves and adapts their abilities;
- Corporations, research centers, universities, consultant firms, and other institutions functioning within an innovative system within the knowledge revolution, perusing the growing supply of global knowledge, via assimilation and adaptation of the available knowledge for local needs;
- Efficient communication, distribution and processing of knowledge are aimed via a modern and appropriate information.

The "basic scorecard" formed based on the above mentioned four pillars and include several variables is used to establish the knowledge economy index for nations.

Figure 1: *The KAM (Knowledge Assessment Methodology) Basic Scorecard*



Resource: The World Bank, The KAM (Knowledge Assessment Methodology)

4 Joonghae Suh and Drek H. C. Chen, Korea as a Knowledge Economy, (Washington DC: Korea Development Institute and World Bank Institute, 2007), p. 3.

In evaluating the status of a country with respect to the knowledge economy, a similar scorecard is created for each country and its rank within other countries is established. In the most recent Knowledge Economy Index published in 2012 and scored 146 nations, the world's most advanced knowledge economy was Sweden. Sweden is particularly strong in the pillars of innovation and Information and Communication Technology (ICT) ranking second. However, it was the 6th in the education pillar, falling from the 3rd position in 2000 (The World Bank, KAM Index 2012).

In addition to the index mentioned above that assesses the status of nations based on the knowledge economy, there are other performance indicators, which have critical significance in the process of transition into knowledge economy. These include several indicators such as R&D activities and expenditures, science and technology and human resources as the source of information production, scientific publications and patents, developments in information and communication industry as the output of investments in knowledge. Studies that are conducted under the light of these indicators demonstrate the knowledge economy performances of nations and determine which variables affect the macroeconomic indicators or dependent onto them. The variables used in the studies could be different. This is due the facts that the variable sets for knowledge economies of the countries are only emerging recently, there are problems with the data sets for developing countries and not every variable is suitable for analysis. The variables used in the analyses conducted in the present study were determined based on the most frequently used variables in the literature.

3. LITERATURE

The important role of knowledge in economy is not a novelty. Adam Smith wrote about a new cast of specialists of a speculative nature, who contributed to the production of knowledge, which was economically beneficial. According to Friedrich List, the infrastructure and institutions played a significant role in the creation and dissemination of knowledge, and thus resulted in the development of productive forces. Schumpeter considered innovation as a major impetus of economy, and his followers such as Galbraith, Goodwin and Hirschman followed the same idea. Furthermore, new growth theories are developed to explain the factors that promote economic growth in the long term by economists such as Romer and Grossman[5].

In their study, Boskin and Lau (2000) analyzed post-Second World War data for G-7 countries using econometric methods and found that an advancement in technology is the most significant source of economic growth. Pohjola (2000) investigated the effects of the investments in information technology on economic growth in a study conducted with the data from 29 countries in the 1980-95 period using a precise economic growth model. The results indicated that physical capital was a key factor in economic growth for both developed and developing countries based on the full data for 39 countries. However, in a sample of 23 developed OECD nations,

5 OECD, " The Knowledge-Based Economy", 1996, s.9.

information technology investments demonstrated a strong influence on economic growth. Jin and Cho (2015) found that ICT capacity had statistically verified effects on economic development.

Yamak and Koçak (2007) investigated the possible effects of information technology investment expenditures on economic growth for the 1993-2005 period in 50 countries. Generally, the effect of information technology investment expenditures on economic growth in developed and developing countries was negative and insignificant. However, it was observed that information technology investment expenditures had a spillover effect on the growth in G-8 countries.

Billon et al. (2010) concluded in their study that income level of the nations was a significant factor in the development of information and communication technologies in 142 developed and developing countries. O'Mahony and Vecchi (2005) aimed to determine the effect of ICT on real production level increase in the United States and the United Kingdom. The effect was positive in both countries and more so in the United States.

In a study, Dewan and Kraemer (2000) estimated an inter-country production function that correlated IT and non-IT inputs to GDP output. Returns on IT capital investments are estimated to be positive and significant for investigated developed countries. However, it was just the opposite for the developing countries, where returns from non-IT capital were quite considerable. In an empirical study by Wong (2002) aimed to determine whether Asian countries were slow to adapt ICT when compared to other countries, although they had a higher share of global ICT production. The study found positive response to the hypothetical question and based on their current level of development (per capita GDP) and competitiveness (world competitiveness index), they had rather low rates of adaptation to ICT products.

An analysis of GDP data for Nordic Countries by Amiri (2013) confirmed that these countries had some of the highest Internet adoption rates in the world and some of the highest per capita GDP levels globally. And the above mentioned study demonstrated that Internet adoption is a direct factor on GDP growth in a given economy.

The analysis by Colecchia and Schreyer (2001) utilized a newly compiled database using System of National Accounts 1993 (SNA93) on investment in ICT equipment and software. Their article demonstrated that, the United States was not alone in benefiting from the positive effects of ICT capital investment and on economic growth and to experience an acceleration of these effects, despite differences between countries. ICT distribution is dependent on suitable infrastructure conditions and not necessarily on the presence of an ICT production industry.

The factors determining the distribution of the internet across countries were scrutinized by Kiiski and Pohjola (2002). It was determined that GDP per capita and the cost of internet access explained the observed computer hosts per capita growth in OECD countries. Education was significant for both developed and developing countries. In the study covering OECD countries, Hargittai (1999) interpreted the differences in internet connectivity among OECD countries. The empirical analyses conducted in this study demonstrated that the most effective predictors of internet connectivity of a country were economic wealth and telecommunications policies. It was found that there was a strong relationship between regulation and lower internet penetration and higher internet access changes. In a separate study, the impacts on the internet and cellular phone penetration levels were examined in several countries. It was demonstrated that internet access was strongly dependent on the institutional environment in the particular country. However, mobile phone networks, which are less site-dependent and are easily re-deployable, were less dependent on institutional features. Beilock and Dimitrova (2003) developed a model to explain the differences in internet usage rates (IURs) between global nations measured as users per capita. It was found that the most important determinant was per capita income. Openness of a society and the infrastructure were found to be the other important determinants and telephone and personal computer densities were utilized as as proxies.

European ICT activities were analyzed by Koski, Rouvinen and Yla-Anttila (2002). Their study was concentrated on the ICT production sector in EU countries. An obvious and increasing concentration tendency in ICT-related production and R&D was determined in Europe. According to Falk (2007) both ratios of business R&D expenditures to GDP and the share of R&D investment in high-tech industries had positive and significant effects on per capita GDP and long-term GDP per hour worked.

According to Powell and Snellman (2004), the key component of knowledge economy is a greater dependence on intellectual competencies, not on physical inputs or natural resources. The study provided evidence of an upward surge in information production and demonstrated that this increase was due to the emergence of new industries.

Using the data obtained from 71 developed and developing countries, Pick and Azari (2008) analyzed the impact of socioeconomic, governmental, and accessibility factors on ICT usage, expenditure, and infrastructure. It was found that technological elements were highly correlated with scientific publications, followed by foreign direct investment, % of females in the labor force, and variables related to education in developed countries. On the other hand, technology components were strongly correlated with foreign direct investment, the priority of Information technologies for the state, and education variables.

Oort et al. (2009), in a study they conducted with municipal governments in Holland, analyzed the increase in employment with respect to the knowledge economy indicators. They concluded that the density of knowledge workers and innovativeness had strong effects on employment increase.

Erkekoğlu and Arıç (2013) studied on six variables calculated by the World Bank for the information society in twenty APEC countries and Turkey. The findings of their study demonstrated that Turkey, China, Mexico, Malaysia, Peru, Russian Federation and Thailand were in the same cluster.

In a study by Taşçı (2013) investigated the effects of ICT on Turkish economy, employment and added value within the context of OECD World Imput-Output Studies. Findings demonstrated that ICT sector reflected a rapid development process, penetrated into other sectors rapidly and was able to create employment even during crisis periods.

According to the OECD (2013) report, data for European Union and the United States demonstrated that knowledge-based capital (KBC) investments had a 20% - 27% share of the average labor productivity growth. The determinants of competitive success for corporations are also transformed by knowledge-based capital.

4. METHODOLOGY

4.1. Canonical Variates and the Canonical Correlation

Canonical correlation analysis (CCA) is a multivariate statistical technique that aims to determine the relationship between two variable sets $(X_1, X_2, \ldots\ldots X_p;\ Y_1, Y_2, \ldots\ldots Y_q)$ that contain two or more variables. H. Hotelling first developed the method and provided the scientific community with the example of relating arithmetic speed and arithmetic power to reading speed and reading power. The technique could also be used to correlate governmental policy variables with economic goal variables and university "performance" variables with pre-university "achievement" variables[6].

In canonical correlation analysis, linear combinations with maximum correlation and unit variances are obtained for each variable set. Afterwards, a second linear combination pair with maximum correlation and unit variances is obtained independent of the previously found pair. And this process is conducted until new linear combination pairs are equal to the number of variables in the set with the lower number of variables[7].

$$W_1 = a_{11}X_1 + a_{12}X_2 + \ldots + a_{1p}X_p \qquad (1)$$

$$V_1 = b_{11}Y_1 + b_{12}Y_2 + \ldots + b_{1q}Y_q \qquad (2)$$

Equation 1 and Equation 2 express the W_1 and V_1 variables that are the linear combinations of and Y variables. When it is assumed that the correlation between

6 Richard A. Johnson and Dean W. Wichern, Applied Multivariate Statistical Analysis (New Jersey: Upper Saddle River Prentice-Hall Inc., 1998), p. 587.

7 Hüseyin Tatlıdil, Uygulamalı Çok Değişkenli İstatistik Analiz, (Ankara: Ziraat Matbaacılık A.Ş. 2002), s. 217.

W_1 and V_1 variables is C_1, the objective of the CCA is to predict $a_{11}, a_{12}, \ldots, a_{1p}$ and $b_{11}, b_{12}, \ldots, b_{1q}$ coefficients so that C_1 value would be maximum. Equations 1 and 2 depict canonical equations, W_1 and V_1 canonical variates, and C_1 depicts the canonical coefficient[8].

After calculating W_1 and V_1 canonical variates, the other canonical variate set and V_2 is calculated:

$$W_2 = a_{21}X_1 + a_{22}X_2 + \ldots + a_{2p}\ X_p$$
$$V_2 = b_{21}Y_1 + b_{22}Y_2 + \ldots + b_{2q}\ Y_q$$

the correlation coefficient between these two variables C_2 is defined independent from W_1 and V_1 canonical variates. In other words, canonical variate sets are obtained independent from each other. This procedure is performed until the correlation coefficient C_m between the m canonical variate set is maximum.

$$W_m = a_{m1}X_1 + a_{m2}X_2 + \ldots + a_{mp}\ X_p$$
$$V_m = b_{m1}Y_1 + b_{m2}Y_2 + \ldots + b_{mq}\ Y_q$$

In brief, the aim of canonical correlation is to define the m count canonical variate sets $(W_1,V_1), (W_2,V_2),\ldots,(W_m,V_m)$ until corresponding correlation coefficients $C_1, C_2, \ldots, C_m$ are maximum:

$$Cor(V_j,V_k) = 0 \quad \text{for all} \quad j \neq k$$
$$Cor(W_j,W_k) = 0 \quad \text{for all} \quad j \neq k$$
$$Cor(W_j,V_k) = 0 \quad \text{for all} \quad j \neq k$$

Thus, CCA could be considered as a maximization problem that should be solved with certain limitations.

8 Subhash Sharma, Applied Multivariate Techniques, (New York: John Wiley & Sons, Inc., 1996, p. 397-398.

4.2.Statistical and Practical Significance for the Canonical Correlations

Initially, statistical significance of canonical variates and canonical correlations should be tested and then the results should be interpreted. The null hypothesis and the alternative hypothesis used for this purpose are as follows:

$$H_0 : C_1 = C_2 = \ldots = C_m = 0$$
$$H_1 : C_1 \neq C_2 \neq \ldots \neq C_m \neq 0$$

Although there are several techniques to test the above mentioned hypotheses, Wilks' Lambda Approach is the most commonly used method. Wilks' Lambda (Λ) statistic used here is expressed as follows:

$$\Lambda = \prod_{i=1}^{m}(1 - C_i^2)$$

Significance of this statistic is tested by the following B statistic with $p \times k$ degrees of freedom and a χ^2 distribution:

$$B = -\left[n - 1 - \frac{1}{2}\ (p + k + 1) \right] \ln \Lambda \qquad (6)$$

where n depicts the sample size; p is the number of variables in the first set; k is the number of variables in the second set; C_i is the canonical correlations; and m is the number of canonical correlations (k=min(p, k)). To assess the significance of the calculated B statistic, $\chi^2_{(p \times k;\, \alpha)}$ critical value is used. If it is determined that the B test statistics was significant, in other words the null hypothesis was rejected, the largest canonical correlation is excluded from the test and the test is repeated with the remaining canonical correlations[9]. The process is repeated until an insignificant B_i value is obtained.

When the sample size is large, small canonical correlations could be statistically significant. Furthermore, a large canonical correlation does not necessarily mean a strong correlation between the variable sets. Canonical correlation maximizes the correlation between linear combinations of the variable sets, but it does not mean that the amount of variance observed in one variable set is accounted for by oth-

9 Kazım Özdamar, Paket Programlar ile İstatistiksel Veri Analizi, (Eskişehir: Kaan Kitabevi, 2004), s. 430.

er variable sets. A redundancy measure (RM) was proposed by Stewart and Love (1968)[10] to identify how much of the variance in one set of variables is accounted for by the other set of variables. Redundancy measures could be calculated for each canonical correlation[11].

5. DATA AND VARIABLES

Data sets used in the study were compiled from "The Global Information Technology Report 2015" published by World Economic Forum and the World Bank data. In the present study conducted to analyze the correlation between knowledge economy performance indicators and selected macroeconomic variable sets 2013 data were utilized and 34 OECD countries were included in the analysis. Sample size should be at least 10 times the data based on data attainability. Related variables were determined based on the World Bank Criteria for Transition to Knowledge Economy. Variables used in the study are presented in Table 1 followed by detailed explanations.

Table 1: *Knowledge Economy Performance Indicators for OECD Countries and Macroeconomic Variables*

Performance Indicator	Macroeconomic Variables
Education expenditure (%)	GDP growth (annual %)
Regulatory quality (%)	PCT ICT patent application
Internet users (%)	(per million population)
Fixed broadband internet subscriptions	Ict good exports (% of total goods export)
(per 100 population)	Uneployment rate (%)
Share of workforce employed in	GDP per capita (current US $)
knowledge intensive activities (%)	
R&D expenditure (% of GDP)	
Secure internet server (per 1 million people)	

Education expenditure (EE): Total general (local, regional and central) government expenditure on education (current, capital, and transfers), expressed as a percentage of GDP.

Regulatory Quality (RQ): Captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

10 Douglas Stewart and William Love, "A general canonical correlation index", Psychological Bulletin, Vol 70 (3, Pt.1), 1968, pp. 160-163.

11 Sharma, a.g.e., p. 404-405.

Internet Users (IU): This refers to the proportion of individuals who used the Internet in the last 12 months (Percentage of individuals using the Internet).

Fixed broadband internet subscriptions (FBIS): This refers to total fixed (wired) broadband Internet subscriptions to high-speed access to the public Internet (Per 100 Population).

Share of workforce employed in knowledge intensive activities (SWE): Knowledge-intensive jobs correspond to the International Labour Organization (ILO) aggregate category "Managers, professionals, and technicians.

R&D expenditure (RDE): Expenditures for R&D are current and capital expenditures (both public and private) on creative work undertaken systemically to increase knowledge, including knowledge of humanity, culture and society and the use of knowledge for new applications.

Secure internet server (SIS): Secure Internet servers are servers using encryption technology in internet transactions (Per million people).

GDP growth (GDPG): Annual percentage growth rate of GDP at market prices based on constant local currency.

PCT ICT patent application (PAP): Number of applications for information and communication technology–related patents filed under the Patent Cooperation Treaty (PCT) per million population.

Ict good exports (ICTGE) :Information and communication technology goods exports include telecommunications, audio and video, computer and related equipment; electronic components; and other information and communication technology goods. Software is excluded.

Unemployment rate (UR): Unemployment refers to the share of the labor force that is without work but available for and seeking employment.

GDP per capita (GDPPC): GDP per capita is gross domestic product divided by midyear population.

6. EMPIRICAL FINDINGS

In this section, canonical correlation between the data sets defined as the knowledge economy performance indicators and selected macroeconomic variables was determined. For this purpose, knowledge economy performance indicator variables were accepted as the first set and selected macroeconomic variables were accepted as the second set. With the expectation to obtain significant correlations among the variables inherent to sets, correlations within the sets were considered worthy of investigation with SPSS software.

Table 2: *Correlation between the Knowledge Economy Performance Indicators and Selected Macroeconomic Variables*

	Performance Indicators							Macroeconomic Variables				
	EE	RQ	IU	FBIS	SWE	RDE	SIS	GDPG	PAP	ICTGE	UR	GDPPC
EE	1.00											
RQ	0.48**	1.00										
IU	0.50**	0.80**	1.00									
FBIS	0.50**	0.60**	0.81**	1.00								
SWE	0.49**	0.70**	0.71**	0.65**	1.00							
RDE	0.35*	0.37*	0.54**	0.57**	0.31	1.00						
SIS	0.48**	0.61**	0.82**	0.76**	0.60**	0.43*	1.00					
GDPG								1.00				
PAP								0.07	1.00			
ICTGE								0.14	0.14	1.00		
UR								-0.59**	-0.35*	-0.17	1.00	
GDPPC								0.04	0.33	-0.41*	-0.36*	1.00

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

As the findings in Table 2 are scrutinized, statistically significant and positive correlations are observed among the variables in performance indicators set. Especially, the significant and strong correlations between the internet server (SIS) and internet users (IU) variables and the regulatory quality (RQ) and internet users (IU) variables are noticeable. However, statistically significant yet negative correlations are observed among the variables within the set of macroeconomic variables. A negative correlation between the unemployment rate (UR) variable and GDP per capita (GDPPC) is determined.

Table 3: *Correlation between the Knowledge Economy Performance Indicators and Macroeconomic Variable Sets*

	GDPG	PAP	ICTGE	UR	GDPPC
EE	-0.0755	0.2118	-0.2625	-0.2203	0.2978
RQ	0.1364	0.4096*	-0.2743	-0.4229*	0.6918**
IU	0.0822	0.5007**	-0.1298	-0.4096*	0.7030**
FBIS	-0.1056	0.4575**	-0.2190	-0.2599	0.6690**
SWE	-0.0792	0.1862	-0.3752*	-0.2079	0.7332**
RDE	0.0167	0.8391**	0.1235	-0.3923*	0.3126
SIS	0.1611	0.3915**	-0.1486	-0.4904**	0.7029

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

The calculated correlations between the Performance Indicators and Macroeconomic Variable sets are presented in Table 3: In Table 3, it is possible to observe that there are statistically significant, positive and strong correlations between the R&D expenditure (RDE) and PCT ICT patent application (PAP), and share of workforce employed in knowledge intensive activities (SWE) and GDP per capita (GDPPC) variables. In addition, statistically significant and negative correlations are observed between the secure internet server (SIS) and unemployment rate (UR), and regulatory quality (RQ) and again unemployment rate (UR) variables.

Table 4: *Canonical Correlations between the Knowledge Economy Performance Indicators and Macroeconomic Variable Sets*

Canonical Correlations	Wilk's Lambda	Chi-Square	df	Sig.
0.906	0.035	88.469	35.000	0.000
0.822	0.198	42.944	24.000	0.010
0.487	0.611	13.062	15.000	0.598
0.425	0.800	5.900	8.000	0.658
0.151	0.977	0.609	3.000	0.894

Canonical correlation coefficients, calculated for the mentioned variable sets and the values calculated in regard to the Wilk's Lambda approach are presented in Table 4: Primarily, it is necessary to evaluate the significances of the calculated canonical correlation coefficients statistically. For this purpose, once the test statistics provided with respect to Wilk's Lambda approach are scrutinized, it is observed that the first two canonical correlation coefficients at the significant level of 0.05 are statistically significant.

Table 5: *Redundancy Analysis*

Proportion of Explained Variance of Performance Indicator Set				Proportion of Explained Variance of Macroeconomic Variable Set			
by its own canonical variable		by opposite canonical variable		by its own canonical variable		by opposite canonical variable	
CV1-1	0.400	CV1-1	0.328	CV2-1	0.317	CV2-1	0.260
CV1-2	0.261	CV1-2	0.177	CV2-2	0.209	CV2-2	0.141
CV1-3	0.071	CV1-3	0.017	CV2-3	0.272	CV2-3	0.065
CV1-4	0.068	CV1-4	0.012	CV2-4	0.106	CV2-4	0.019
CV1-5	0.075	CV1-5	0.002	CV2-5	0.096	CV2-5	0.002

In order to interpret the calculated canonical correlation coefficients, it is recommended to evaluate the practical significances along with the statistical significances. For this purpose, the results of the redundancy analysis conducted for the canonical correlations are presented in Table 5: As Table 5 is studied, it is observed that the CV1-1 canonical variable could explain the 40 % of the total variance of the variables within the performance indicators set and the CV2-1 canonical variable could explain the 31.7 % of the total variance of the variables within the macroeconomic variable set. Besides, while the CV1-1 canonical variable explained the 32.8 % of the total variance of the variables within the macroeconomic variable set, CV2-1 canonical variable could explain 26 % of the total variance of the variables within the performance indicators set. Similar interpretations could be made for the CV1-2 and CV2-2 canonical variables. In summary, it is clearly understood that the first and second correlation coefficients are significant both statistically and practically. Therefore, it is decided that an evaluation for the obtained first and second canonical variable pair is necessary.

Table 6: *Canonical and Cross Loadings for Performance Indicator Set*

	Canonical Loadings					Cross Loadings				
	CV1-1	**CV1-2**	**CV1-3**	**CV1-4**	**CV1-5**	**CV1-1**	**CV1-2**	**CV1-3**	**CV1-4**	**CV1-5**
EE	-0.32	0.209	0.352	-0.616	0.376	-0.29	0.172	0.171	-0.262	0.057
RQ	-0.631	0.552	-0.013	-0.234	-0.355	-0.571	0.454	-0.006	-0.099	-0.053
IU	-0.713	0.500	0.011	0.147	0.116	-0.645	0.411	0.005	0.063	0.017
FBIS	-0.631	0.498	0.407	0.123	0.214	-0.572	0.409	0.198	0.052	0.032
SWE	-0.396	0.776	0.293	-0.018	0.062	-0.359	0.638	0.142	-0.008	0.009
RDE	-0.909	-0.230	0.281	0.048	0.149	-0.824	-0.189	0.137	0.020	0.022
SIS	-0.64	0.571	-0.201	-0.067	0.419	-0.580	0.470	-0.098	-0.029	0.063

It is possible to observe the canonical loadings and cross loadings, calculated between the canonical variables derived by the canonical correlation analysis for performance indicators and macroeconomic variable sets and the the existing variables, in Table 6 and Table 7. The correlations between the CV1-1 variable derived for the performance indicators set and the RDE, IU and SIS variables are calculated respectively as -0.909, -0.713 and -0.640, and for the correlations between CV1-2 variable and the SWE, SIS and RQ variables are calculated respectively as 0.776, 0.571 and 0.552. According to the data in Table 6 it is possible to assert that, in defining the CV1-1 variable, starting form the most important variable, the order of importance is RDE, IU and SIS, and in defining the CV1-2 the order of importance is SWE, SIS and RQ.

Table 7: *Canonical and Cross Loadings for Macroeconomic Variable Set*

	Canonical Loadings					Cross Loadings				
	CV2-1	CV2-2	CV2-3	CV2-4	CV2-5	CV2-1	CV2-2	CV2-3	CV2-4	CV2-5
GDPG	-0.178	-0.023	-0.888	-0.193	-0.377	-0.161	-0.019	-0.432	-0.082	-0.057
PAP	-0.935	-0.263	0.148	0.119	-0.146	-0.847	-0.216	.072	0.050	-0.022
ICTGE	-0.076	-0.532	-0.446	0.546	0.464	-0.069	-0.437	-0.217	0.232	0.070
UR	0.602	-0.11	0.592	0.422	-0.312	0.545	-0.09	0.288	0.180	-0.047
GDPPC	-0.560	0.824	0.052	0.048	-0.046	-0.508	0.678	0.025	0.020	-0.007

According to Table 7, the correlations between the CV2-1 variable, derived for the macroeconomic variables set, and PAP, UR and GDPPC variables are calculated respectively as -0.935, 0.602 and -0.560 and the correlations between the CV2-2 variable and GDPPC, ICTGE and PAP variables are respectively as 0.824, -0.532 and -0.263. Due to these findings, it could be interpreted that the order of importance in defining the CV2-1 variable is PAP, UR and GDPPC, and the CV2-2 variable is GDPPC, ICTGE and PAP. Therefore, the CV1-1 variable could be named as RDE, the CV1-2 variable as SWE, the CV2-1 variable as PAP and the CV2-2 variable as GDPPC. It is necessary to determine the linear combinations of the significant canonical correlations stand for, because canonical variates (CV) are the linear combinations of the original variables. The issue is concurrent with analysing principal components, latent factors and the discriminant factors in principal component analysis, factor analysis and discriminant analysis, respectively[12]. Thus, canonical variates could be named based on the similar properties of the variables that reflect the most important correlations between the significant structures defined with canonical correlation analysis.

7. CONCLUSION

In recent years, information and communication technologies became a general purpose technology utilized in all areas of social life. In this process, information and communication technologies became a high added value industry and started to be used in other industries as well. Developments such as creation of new knowledge, increasing the effectiveness of production factors, emergence of new professional and expertise areas were experienced. Several reports published in the world (Republic of Turkey Ministry of Development, 2015; World Economic Forum, 2009) focus on the contribution of knowledge to growth and employment. Targets set in this direction include investments in information technology, qualified human resources and employment, ensuring internet user security, development of internet entrepreneurship and e-commerce, reinforcement of broadband

12 Sharma, a.g.e., p. 404.

infrastructure and industrial competition. The results of the present study support the above mentioned reports.

In the present study, it was attempted to determine whether there was a correlation between knowledge economy performance indicators and selected macroeconomic variable sets of 34 OECD member countries. For this purpose, canonical correlation analysis, a multivariate statistical technique, was applied to collected data. Conducted analyses resulted in two statistically and practically significant canonical correlation coefficients and two canonical variate pairs between the sets. First and second canonical correlation coefficients were calculated as 0.906 and 0.822, respectively. The canonical variable CV1-1 was named as R&D expenditure (RDE), CV1-2 as share of workforce employed in knowledge intensive activities (SWE), CV2-1 as patent application (PAP), and CV2-2 was named as GDP per capita (GDPPC). The findings demonstrated a significant, strong and positive correlation between the knowledge economy performance indicators and macroeconomic variables. It was observed that the most significant variables that contributed to this correlation were R&D expenditure (RDE), share of workforce employed in knowledge intensive activities (SWE), patent application (PAP) and GDP per capita (GDPPC).

Creation of knowledge-based sectors and lines of work that utilize information and communication technologies (ICT) intensely and opportunities to access new markets create new employment possibilities. In fact, the empirical findings of the present study demonstrated a negative correlation between the variables of secure internet servers and regulatory quality and unemployment rate. Strong and positive correlations were identified between the variable of share of workforce employed in knowledge intensive activities and per capita income. Furthermore, a further negative correlation was identified between per capita income and unemployment rate in OECD countries.

To facilitate the transition to knowledge society, to increase per capita income and to reach desired rates of economic growth, increased efforts should be made to develop public policies towards the private sector considered as regulatory quality, R&D expenditures and improvement of qualified workforce performance indicators of knowledge economy.

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