Istanbul Gelisim Univ J Soc Sci 2024:11(2);559-574
DOI: 10.17336/igusbd.1318161

ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA

Innovation, Global Competitiveness and Human Development Index: EU Cluster Case*

İnovasyon, Küresel Rekabet Edebilirlik ve İnsani Gelişme Endeksi: AB Küme Örneği

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Abstract

This study investigates the effects of innovation on global competitiveness within the framework of the EU13 and EU15 countries. Using a Pooled Driscoll and Kraay regression analysis that takes into account unit and time effects, the research illuminates the relationship between the Human Development Index (HDI), which represents Global Competitiveness, Research Expenditure, the Number of Researchers, the Number of Patents, and the Human Capital Index. The findings reveal that while the number of researchers and research expenditure lack a statistically significant effect on HDI in both groups, a significant positive correlation was found between HDI and both the number of patents and human capital. More specifically, for EU13 countries, an increase in the number of patents and human capital leads to respective increases of 0.005 and 0.04 in the HDI, while for EU15 countries, these figures stand at 0.0008 and 0.03 respectively. The study concludes that investment strategies aimed at enhancing human capital and increasing the number of patent applications can notably improve global competitiveness. For EU13 countries, in particular, greater effort in the mentioned areas is needed to narrow the gap with their EU15 counterparts. In addition, despite the indirect impact on competitiveness, it is recommended for EU13 countries to boost their R&D investments and foster technological transfer to enhance their innovation capabilities. The findings from this study underscore the pivotal role of innovation in achieving global competitiveness and suggest a need for stronger collaboration within the European Union, particularly in scientific and technological fields, to facilitate knowledge and skill exchange.

Keywords

Innovation, Global Competitiveness, Human Development Index, EU13, Panel Data

*This study was prepared by using the data obtained during the doctoral thesis titled “Comparative analysis of the impact of innovation on global competitiveness: An application on EU countries under an innovative perspective”. Istanbul Gelişim University, Institute of Graduate Studies. 2022. Supervisor: Assoc. Prof. Dr. Kemal ERKİŞİ.

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Geliş/Received: 21.06.2023
Kabul/Accepted: 26.07.2023

Melike Çetin, “Innovation, Global Competitiveness and Human Development Index: EU Cluster Case”, Istanbul Gelisim University Journal of Social Sciences, 11 (2), October 2024, pp. 559-574.

Öz

Bu çalışma, EU13 ve EU15 ülkeleri çerçevesinde inovasyonun küresel rekabet üzerindeki etkilerini araştırmaktadır. Birim ve zaman etkilerini dikkate alarak Pooled Driscoll ve Kraay regresyon analizi kullanan araştırma Küresel Rekabet Gücünü temsil eden İnsan Gelişim İndeksi (HDI), Araştırma Harcamaları, Araştırmacı Sayısı, Patent Sayısı ve İnsan Sermayesi İndeksi arasındaki ilişkiyi aydınlatmaktadır. Bulgular, araştırmacı sayısı ve araştırma harcamalarının her iki grupta da HDI üzerinde istatistiksel olarak anlamlı bir etkisi olmadığını, ancak patent sayısı ve insan sermayesi ile HDI arasında anlamlı bir pozitif korelasyon olduğunu göstermiştir. Daha spesifik olarak, EU13 ülkeleri için, patent sayısındaki ve insan sermayesindeki bir artış, HDI'de sırasıyla 0.005 ve 0.04'lük bir artışa yol açarken, EU15 ülkeleri için bu rakamlar sırasıyla 0.0008 ve 0.03'tür. Çalışma, insan sermayesini artırmaya ve patent başvuru sayısını çoğaltmaya yönelik yatırım stratejilerinin küresel rekabeti önemli ölçüde iyileştirebileceği sonucuna ulaşmaktadır. Özellikle EU13 ülkeleri için, bahsedilen alanlarda daha fazla çaba sarf edilmesi, EU15 muadilleriyle aradaki farkı daraltma ihtiyacını ortaya koymaktadır. Ayrıca, rekabet üzerindeki dolaylı etkisine rağmen, EU13 ülkelerinin Ar-Ge yatırımlarını artırmaları ve inovasyon yeteneklerini artırmak için teknolojik transferi teşvik etmeleri önerilmektedir. Bu çalışmanın bulguları, küresel rekabeti elde etmede inovasyonun hayati rolünü vurgulamakta ve bilgi ve beceri alışverişini kolaylaştırmak için Avrupa Birliği içinde, özellikle bilimsel ve teknolojik alanlarda, daha güçlü bir işbirliği ihtiyacını öne çıkarmaktadır.

Anahtar Kelimeler

İnovasyon, Küresel Rekabet Edebilirlik, İnsani Gelişme Endeksi, EU13, Panel Veri

Introduction

There are many factors that determine a country's global competitiveness, and efforts to identify these factors often focus on technological advancement and innovation. Technological advancement and innovation are crucial for a country to gain and maintain competitive advantage. Any economy acknowledges that these two factors are the foundation of economic growth and development. However, the concept of global competitiveness has gained a more complex dimension in recent debates. The question of how to measure the competitive performance a country will achieve through innovation and technological advancement has increasingly gained a broader meaning. Traditionally, countries' competitiveness was evaluated based on inputs based on cost and productivity, or later on structure and capabilities. However, these approaches lack the ability to measure competition in terms of welfare increase and hence growth and development. Therefore, indices have been developed that include a number of variables. These indices rank countries based on their performance and take into account not only gross national product, but also welfare. The ultimate goal of an economy should be to provide high and increasing incomes for individuals, expand employment opportunities, and improve living conditions. The European Union Commission has stated that competition is an economy's ability to provide its population with high living standards and high employment rates on a sustainable basis. From this perspective, a new understanding has developed and has added a new dimension to the measurement of global competitiveness. These measurements are made with multi-variable indices and these indices include variables related to welfare and quality of life. This study aims to reveal whether there is an effect of the basic innovation factors on global competitiveness, and if so, which factors are effective. The empirical test carried out for this purpose was carried out over two different groups of countries that are members of the European Union, AB15 and AB13. AB15 and AB13 refer to two different groups of countries that are members of the European Union (EU). AB15 covers 15 countries that joined the EU by 1995. These are Belgium, Germany, France, Italy, Luxembourg, the Netherlands, Denmark, Ireland, the United Kingdom, Greece, Portugal, Spain, Austria, Finland, and Sweden. These countries are generally considered older members and are more economically advanced. On the other hand, the term AB13 generally represents countries that joined the EU in 2004 and later. Among these countries are Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria, Romania, and Croatia. These countries are generally less economically developed and are generally located in Eastern Europe. As these

countries have joined the EU more recently, they are generally considered to be a result of the EU's expansion. Therefore, the difference between AB15 and AB13 is based on the dates of accession of member countries to the EU, their levels of economic development, and their geographical locations. The research reveals whether the relationship between innovation and global competition makes a difference between these two groups and whether the process has different effects on the relationship.

Literature Review Economic Theories and the Development of Innovation

It begins with the classical economists, Smith, Ricardo, and Malthus (Smith, 2007-originally published in 1776; Ricardo, 2014- originally published in 1817; Galor, 2011; Madsen & Strulik, 2020) who argue that division of labor, capital accumulation, and technological innovations contribute to economic growth. Marx, on the other hand, views the impact of technology on economic growth in the context of class relations, where capital accumulation and specialization may increase efficiency but eventually lead to a blocked system (Gera & Singh, 2019). Also, Schumpeter, known for his innovation debate, argues that economic growth depends on the power of the entrepreneur and their ability to create monopolistic profits. He introduces the concept of "creative destruction," where the old is destroyed, and the new is created (Schumpeter, 1934). The neo-classical school builds upon Schumpeter's ideas, but the main criticism is that it cannot explain how technological progress comes about (Werker & Athreye, 2004). The Evolutionary Approach argues that the analysis of technological change should be focused on the micro-level rather than the macro-level, and the process of technology use and innovation creation of companies are different. All classic approaches provide the various perspectives on the relationship between economic growth and innovation (Dosi & Nelson, 2018).

Subsequently, the concept of innovation has been undergoing a transformation within growth theories. Initially, Solow introduced technological development to his growth model as an external factor, but this approach received criticism for neglecting the importance of human capital (Solow, 1956). Consequently, he was frontier who developed endogenous growth model. Robert E. Lucas proposed one such model, which emphasized the relationship between human capital and economic growth. According to Lucas, growth occurs due to the quality of human capital, which could be improved through formal education or learning by doing (Lucas, 1988). Barro's public expenditure model inferred the relationship between the size of the state, savings, and growth rates. Effective state policies, such as focusing incentives in areas with a positive impact, technology transfers, and intensive research and development (R&D) activities, were emphasized to promote economic growth (Barro, 1990). Another endogenous growth model is Romer's model, which is based on the concept of "learning by doing." Romer claimed that knowledge is a capital good with increasing returns and is crucial for technological progress (Romer, 1986). Aghion and Howitt built on Schumpeter's theory of creative destruction and suggested that the growth rate in the economy depends on the amount of R&D activities. They provided an analysis showing this relationship in successive periods (Aghion & Howitt, 1992).

Competitiveness Theories and Global Competitiveness Indexes

Competitiveness refers to the policies and institutions that determine a country's productivity level and its ability to produce goods and services in line with international market conditions, according to the World Economic Forum and the OECD (WEF, 2008). Michael E. Porter's Diamond Model, developed in 1990, was the first theory proposed to explain competitiveness. Porter's model emphasizes the productivity and capacity of firms operating within a country's sectors as determinants of competitiveness, rather than focusing solely on the country itself. The model comprises four determinants of competitiveness - "input (factor) conditions", "demand conditions", "firm strategy and competitive structure", and "existence of related and supporting industries" - with the state and luck factors placed outside the model (Porter, 1990). However, the model was criticized by Dunning, who claimed that multinational companies, whose production is often outside national borders,

are not adequately addressed in the model (Dunning, 1992). Rugman and D'Cruz also proposed the double diamond model to account for small trading economies and argued that the single diamond model does not give accurate results for these small economies. (Rugman & D'Cruz, 1993). Moon et al. on the other hand, they criticized the external placement of multinational companies in the model and tried again by including these companies in the model (Moon et al., 1998).

Competitiveness is necessary for countries to achieve sustainable economic growth and prosperity. Although Michael Porter's Diamond Model was widely accepted to explain the competitiveness of developed countries, it failed to explain the complexity of competitiveness in underdeveloped countries. Cho took up this issue again and developed a new model called the Nine Factor Model. This model identifies two types of determinants for competitiveness: physical factors and human factors. Physical factors include resources from nature, the business environment, supporting industries, and domestic demand. Meanwhile, human factors consist of workers, economic policymakers and bureaucrats, entrepreneurs, and expert managers and engineers. The Nine Factor Model comprises four physical factors that determine a country's competitiveness and four human factors that enhance competitiveness by creating these physical factors, along with a chance factor that is externally influenced. The applicability of this model can better capture the dynamics of competitiveness in small economies, which are often ignored by previous models (Cho, 1998).

The emergence of competitiveness theories has led to a renewed focus on measuring global competitiveness, resulting in the development of various measurement methods that support these theories (Kırankabeş, 2006). Given the complexity of factors and variables affecting global competitiveness, measuring the impact of each of them is thought to yield more accurate results in determining a country's competitiveness. As a result, multi-factor indices have been created to measure global competitiveness directly and support Porter's Diamond Model (Erkekoğlu & Ariç, 2013). Currently, two such indices are calculated, including the global competitiveness index published annually by the World Economic Forum since 1979, which was revised in 2007 to consider all macro variables in a country, and again in 2018 to reflect changes in the 4.0 industry (WEF, 2018). The second index is the global competitiveness index developed by the International Management Development Institute, which publishes an annual World Competitiveness Yearbook Report (IMD, 2017). However, both indices have been criticized for their methodologies because countries have different rankings depending on the index used to measure global competitiveness (Jones & Klenow, 2016). The methodologies of these indices have recently given economists an innovative perspective, as they take into account a country's level of development and GDP per capita. The previous view that measures competitiveness only in terms of costs or quality is considered to be flawed or incomplete. Global competitiveness should not be measured only through these concepts, but also the increase in welfare of a country, the development of people, and competition based on growth and development (Aiginger, Bärenthaler & Vogel 2013). Therefore, various indices that measure competitiveness and include a wide range of variables, such as the human development index, have been covered. These indices rank countries based on performance and consider welfare and quality of life factors, going beyond gross national product. The ultimate goal of an economy should be to provide high and increasing incomes, increase employment opportunities, and improve living conditions. This new perspective has brought new insights into the measurement of global competitiveness (Charles & Klenow, 2016; Önsel et al., 2008).

The Relationship of Global Competitiveness Measurement and Human Development Index

The Human Development Index is focused on the level of human development in relation to competitiveness. A country's ability to provide high-quality education services, expand its health services infrastructure, and ensure accessibility to public services, particularly health and education, can also positively impact its competitiveness. The Human Development Index includes four sub-indicators: life expectancy at birth, adult literacy status, schooling rate, and GDP per capita calculated according to the purchasing power index. The improvement in people's living standards directly affects a country's competitiveness (UNDP,2015b). Conversely, increasing competitiveness can lead

to an increase in the accessibility of basic needs such as health, education, and public services in a country. Economic growth alone is not sufficient for countries; they also need to increase their level of development. A country with high economic income but low living standards for its people will have its competitiveness negatively affected. A country that cannot improve its living standards as much as its economic income will not provide a sustainable level of welfare in the long run (Telleria, 2021).

The measurement of competitiveness has traditionally relied on variables such as employment rates, GDP per capita, foreign trade indicators, and labor productivity. However, with the introduction of multi-factor expanded indexes, new perspectives have emerged as an alternative to traditional measurement methods. Traditional methods of measuring competitiveness that use variables such as employment rates, GDP per capita, foreign trade indicators, and labor productivity can effectively work only in a small number of countries, such as Sweden, Denmark, Luxembourg, Austria, and the Netherlands. The effectiveness of these traditional methods in these countries can be attributed to a number of factors, including homogeneity, the size of the economy, economic structure, and the adoption of innovation and technology. These countries often lead in technology and innovation, factors that significantly contribute to competitiveness. However, these factors might not be sufficiently represented in traditional measures for larger, more diverse nations. In countries where there is considerable diversity in the performance of different regions or sectors, these traditional methods might not capture the full picture.

Therefore, there has been a growing discussion that competitiveness does not solely rely on economic indicators and should be re-evaluated by taking into account new factors. This discourse has led to the evaluation and measurement of competitiveness under an innovative perspective, which includes different variables. The innovative perspective emphasizes that improving living conditions and increasing the quality of life will boost competitiveness. (Ketels, 2006; Onsel, 2008; Ulengin et al., 2011). In this context, the Human Development Index has gained importance in evaluating competitiveness. The HDI measures a country's level of human development, which includes factors such as education, health, and accessibility to public services. These indicators have a positive impact on a country's competitiveness. Conversely, low living standards despite high economic income can negatively impact a country's competitiveness, and a country must aim to increase its level of development to sustain welfare in the long run (Aiginger et al., 2006; 2015).

As mentioned previously, it is not sufficient to evaluate competitiveness solely based on costs and productivity. Rather, the measurement of result-oriented competitiveness, which takes into account the ultimate goal of an economy, is crucial. This goal is to ensure high and increasing incomes, employment opportunities, and improved living conditions for individuals in the country. The European Commission refers to this concept as results-oriented competitiveness, defined as the economy's ability to sustainably provide its population with high and rising living standards and employment rates. Result-oriented competitiveness is based on the notion that the economic performance requires a multi-dimensional assessment. Instead of focusing solely on the size and growth rate of an economy, this assessment should examine how an economy performs on a broad range of social and economic indicators. These indicators include factors such as quality of life, employment rates, access to education and health services, and even environmental sustainability. Result-oriented competitiveness emphasizes that economic development should be used for the general welfare of society and for improving individuals' living standards. This perspective acknowledges that not only the growth of an economy is important, but also the improvement in the overall quality of individuals' lives is essential (Aiginger et all, 2013; Cassiers, 2007; EU Commission, 2001; 2007). Therefore, it is important to move beyond narrow assessments and consider the broader impact of competitiveness on the welfare and well-being of individuals.

Emprical Literature

The empirical literature has been examined from three different perspectives. First, empirical studies on the relationship between innovation and global competitiveness, second, empirical studies on the Human Development Index and Competitiveness Relationship, and finally, empirical studies on the difference or gap between EU Union Countries.

The Relationship Between Innovation and Global Competitiveness

Szymańska (2013) conducted a study among Switzerland, Sweden, the United States, Germany, the United Kingdom, France, China, India, Russia, the Czech Republic, and Poland between 2007 and 2011. They compare the level and structure of R&D expenditures, high-tech industries, key national R&D priorities supported by major public programs, total entrepreneurial activity levels, global competitiveness index, and global innovation index rankings.

In another study, Saray and Hark (2015) utilized dynamic panel methods to investigate the determinants of the competitiveness of high-tech products in OECD countries for the period of 2004-2013. In the research, technology-based products were categorized according to Foders's (1995) high, medium, and low technology classification, and Balassa's (1965) Revealed Comparative Advantage index was used. The findings revealed that the level of productivity and efficiency was the most significant determinant of competitiveness in high-tech products among OECD countries.

Fonseca and Lima (2015) investigates the possible correlation between sustainability, innovation, and competitiveness at the country level, an aspect less explored in literature. Utilizing internationally recognized rankings - The World Economic Forum's Sustainability-adjusted global competitiveness index, the Global Innovation Index by Cornell University, INSEAD, and WIPO, and the IMD World Competitiveness Yearbook - the study carried out a correlation analysis. The results, based on Pearson correlation coefficient, indicate a high correlation (all coefficients are greater than 0.73), suggesting a substantial relationship between social sustainability, innovation, and competitiveness at the country level.

Terzic (2017) conducted a study demonstrating the significance of innovation on economic growth and competitiveness in the economies of Estonia, Czech Republic, Slovenia, Hungary, Slovakia, Latvia, Lithuania, Bulgaria, Poland, and Romania, affiliated with the European Union. In his study, Terzic applied various tests to both primary and secondary data to determine the connection between innovation, competitiveness, and growth variables. The findings revealed a positive correlation between innovation performance and research expenditures, GDP per capita, innovation index, research systems, firm investments, and entrepreneurship. This suggests that future economic growth of these economies is dependent on improved conditions for entrepreneurship and research systems, and a higher degree of innovation performance.

Distanont and Khongmalai (2020) examined the role of innovation in providing competitive advantage for small and medium-sized enterprises at both micro and macro level. Explanatory and confirmatory factor analysis and structural equation modeling methods were used in the study where they preferred the frozen food industry for research. The findings of the research show that innovation at micro level increases competitive advantage through external factors and entrepreneurs, especially SME entrepreneurs, should be ready for economic changes and have the ability to adapt to them easily. At the macro level, it argues that countries need to improve their business environments in order to achieve sustainable development and create competitive advantage, and that innovation can be a powerful strategic tool to achieve these goals.

Human Development Index and Competitiveness Relationship

LaVan and Murphy (2007) investigated the relationship between national culture, human development, and job and growth competitiveness in Southeast Asia. The findings showed that human development and power distance positively affect entrepreneurial activity in cultural and national settings, and there is a need for public policy and regulatory guidelines to promote entrepreneurial activity in emerging economies.

Davies and Quinlivan (2009) examined the effect of trade on the social development of countries in their studies. In the study, using panel data analysis and generalized moments estimator methods, it has been shown that there is a significantly positive relationship between the increase in trade and the improvements in social welfare represented by the Human Development Index.

Ülengin et al. (2011) evaluated 45 countries using data envelopment and neural network analysis and investigated the effects of a country's competitiveness on human development. In their study,

they have shown that the competitiveness of a country, measured by the Human Development Index, is valid for its ability to transform a better life for its people.

Jawaid and Waheed (2017) analyzed the impact of bulk and fragmented trade on human development in Pakistan, taking the period from 1980 to 2013 in their study. In the study using cointegration and causality analysis, both a long-term positive relationship was found between trade and human development and it was shown that international trade has a causal effect on Pakistan's human development.

Reyes and Useche (2019) analyzed the performance and relationship between competitiveness, real GDP growth and human development with a sample representing 20 countries in the Latin America and Caribbean region. Examining the relationships between these three variables using correlation analysis, they revealed that declining conditions in competitiveness and economic growth indicators have been experienced since 2009. As a result of the research, Chile was the most competitive country and Venezuela was the weakest country. Also, Chile has been shown to have the highest level of human development index, while Nicaragua has the lowest level. According to the findings, there is an inverse relationship between the competitiveness of the Dominican Republic and its economic growth, while an inverse relationship has been found between the competitiveness and human development level of Jamaica and Venezuela.

Difference Between EU Union Countries

Granados and Sanz (2008) conducted a study to examine convergence in technology and income among EU regions during the period of 1990-2002 and their relationship with each other. The study found that there was convergence in all R&D indicators and patents across regions in the 1990s, which led to real convergence in per capita income levels. Moreover, a strong correlation was identified between the distribution of technology indicators and the regional income distribution in Europe, confirming the hypothesis of the research that convergence in commercial R&D leads to convergence in patents, which in turn leads to convergence in per capita income.

Similarly, Archibugi and Filippetti (2011) investigated the convergence in innovative efforts among EU members and the impact of the economic recession on it. The study utilized macro and micro scale data for the period of 2004-2008 and demonstrated that EU members had converged in their innovative potential during this period. However, the economic crisis in 2008 had a negative impact on innovative investment in almost all EU countries, particularly those that experienced increased segregation, leading to the danger of increasing inequality in innovative talents, which could ultimately result in differences in income and welfare.

Foddi and Usa (2013) conducted a study on knowledge production and dissemination in the subregions of 29 EU countries based on the "Innovation Union" initiative and Europe's 2020 strategy. The study evaluated the effectiveness of the initiative on a regional basis and analyzed the efficiency of European regions in utilizing internal and external inputs for new knowledge and ideas production. The analysis, using the data envelopment method and Malmquist productivity index, revealed that the most productive regions are located in the central or economically strategic regions of Europe. The Malmquist productivity analysis further showed that productivity dynamics, both in magnitude and intrinsic characteristics, vary significantly across regions. These findings suggest significant disparities between the center and periphery of Europe, and between the rich, industrialized countries that joined the EU first and the relatively poorer countries that have joined more recently.

Barrios, Flores, and Martínez (2019) applied a new methodology developed by Phillips and Sul in 2007 to analyze the innovation activity convergence process in European regions from 2002 to 2012. The study aimed to detect convergence or endogenous identification of groupings of regions. According to their findings, seven innovation convergence clubs were identified based on the club convergence hypothesis, which explains the convergence process of European regions during the analyzed period.

Research Objective, Methodology and Data Method

The method for the analysis is the panel regression method. Panel regression analysis is defined as bringing together cross-sectional observations of units such as individuals, households, firms and

countries over a certain time period and estimating economic relations with the help of panel data models. Panel data is a method that combines both data sets, allowing the simultaneous use of time series data, which includes the change of variables according to different units of time, and cross-section data collected from different units at a certain point in time. In panel data, there are N units and T number of observations corresponding to each unit. In general, the panel data model;

$$Y_{it} = \alpha_{it} + \beta_{it} X_{it} + u_{it}$$

$$i=1,.....,N;\ t=1,.....,T \qquad (1)$$

In the model, the index i represents the unit dimension forming the horizontal section such as individuals, households, firms and countries, and the index t represents the time series dimension. α_{it} represents the constant coefficient, β_{it} represents the slope coefficient of the explanatory variable, and uit represents the error term.

Data Set

In the study, global competitiveness and innovation indicators were taken as independent variables. The human development index (HDI) is included in the model as a variable representing global competitiveness under an innovative perspective. Variables representing innovation are research expenditures, number of researchers, number of patents and human capital, which are mentioned as basic indicators in the literature. The variables represented in this model are the ratio of research expenditures in Euro currency to the gross national product (RDEXPGDP), the ratio of people with higher education (ISCED) and/or people working in science and technology to the population (RDEMPEN), the ratio of the number of applications for triple patents (Triadic Patent Family) to the population. (PATN) and per capita human capital index (HCI) based on years of education and return to education.

The sample group of the study is the countries with full membership to the European Union. The European Union is an economic and political union consisting of 28 members by 2020. After 2020, England, which is in the EU15 group, left the union by deciding to leave. However, as this study covers past data, England was included in the analysis. The analysis will be made comparatively based on the EU15 and EU13 groupings of the full member states of the European Union. Data sets belonging to the sample group were obtained from UNDP, EUROSTAT, WIPO and Penn World Table.10 databases. These data sources are widely used in the literature and therefore the data series are considered reliable.

The main problem of this study is to determine how much the innovation indicators affect the global competitiveness through the sample countries and to make a comparison over the variables represented by the two country groups, as mentioned above. The variables were included in the model by taking their natural logarithms. The purpose of taking the logarithm in panel data analysis is often related to dealing with skewness in the data and normalizing the distribution. Logarithm transformation help to stabilize variance and make the data more tractable for analysis. The time dimension that can be reached in order to make a healthy estimation in econometric application is between 2000 and 2019, and the interval of the time series is in the frequency of years.

Table 1: Dependent and independent variables and data sources in the model

Variables	Proxy Variables	Symbol	Source
Global competitiveness	Human Development Index	HDI	UNDP
Research expenditures	Ratio of research expenditures to gross national product (EUR)	RDEXPGDP	EUROSTAT
Researcher number	Proportion of people with tertiary education (ISCED) and/or people working in science and technology to the population	RDEMPEN	EUROSTAT
Patent application number	The ratio of the number of Triadic Patent Family applications to the population	PATN	WIPO
Human Capital Index	Human capital index per capita based on duration of education and return to education	HCI	Penn World Table 10

Table 2: EU15 and EU13 club distribution in EU member countries

EU15 Countries	EU13 Countries
Germany, Austria, Belgium, Denmark, Finland, France, Netherlands, UK, Ireland, Spain, Sweden, Italy, Luxembourg, Portugal, Greece	Bulgaria, Czech Republic, Estonia, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovakia, Slovenia

Econometric Models

There are two different models in the study. The first model was created for EU15 countries, and the second model was created for EU13 countries.

Model 1: $\ln HDI_{it} = \alpha + \beta_1 \ln RDEXPGDP_{it} + \beta_2 \ln RDEMPEN_{it} + \beta_3 \ln PATN_{it} + \beta_4 \ln HCI_{it} + u_{it} + \mu_i + \lambda_t$

i=15 N (EU15) t=20 T (2000-2019) (2)

Model 2: $\ln HDI_{it} = \alpha + \beta_1 \ln RDEXPGDP_{it} + \beta_2 \ln RDEMPEN_{it} + \beta_3 \ln PATN_{it} + \beta_4 \ln HCI_{it} + u_{it} + \mu_i + \lambda_t$

i=13 N (EU13) t=20 T (2000-2019) (3)

Results and Discussion Multiple Correlation Test

Multiple correlation is the situation where there is a high level of correlation between at least two of the variables in the model. Whether the variables in the model have multiple correlations with each other is decided by looking at the VIF value. The average VIF value found is 2.10 for the first model and 1.88 for the second model. According to these results, there is no multicollinearity problem in either model. Tab. 3 below shows us the VIF value between the variables.

Table 3: Multiple correlation test VIF results

	EU15 Countries		EU13 Countries	
Variables	VIF	1/VIF	VIF	1/VIF
lnHCI	2.36	0.424454	2.69	0.371606
lnRDEMPEN	2.23	0.448983	2.43	0.411325
lnRDEXPGDP	2.10	0.475742	1.29	0.773831
lnPATN	1.72	0.580236	1.11	0.898522
Mean VIF	2.10		1.88	

Unit Root Test

In panel data analysis, unit root tests are used to determine whether the series are stationary or not. Under this section, the results of the Multivariate Extended Dickey-Fuller Test from the second generation second group are shared. It is more appropriate to use the Multivariate Extended Dickey-Fuller Test in case of T>N. In Table 4, unit root results for the variables in AB13 and AB15 models are given. Considering the critical values at the 5% significance level in the table, it is seen that the variables are stationary at the level.

Table 4: Multivariate Extended Dickey-Fuller test results

	EU15 Countries	EU13 Countries	
MADF Unit root test	Madf value (lag 2)	Madf value (lag 2)	Critical Value (%5)
lnHDI	1022.889	137.509	45.195
lnRDEXPGDP	488.127	114.414	45.195
lnRDEMPEN	173.857	74.949	45.195
lnPATN	239.087	172.108	45.195
lnHCI	366.374	1260.202	45.195

Unit and Time Effect

In panel data analysis, many units combine with the time dimension. Therefore, it is expected that each unit should be included in the model with its own characteristics. It is thought that the unit effect generally varies according to the units, but is constant over time. In the same way, differences in the time dimension can be reflected in the model from time to time. Therefore, the heterogeneity of the observations of the variables included in the model means that there may be unit and time effects. In this case, it would be more accurate to choose one of the fixed or random effects models. For this reason, the existence of unit and time effects in the models was investigated. When the statistical values of the F test, LM test and LR test in table 5 are examined, it is seen that the likelihood values (p) reject the H_0 hypothesis at the 5% significance level. According to the results of all three tests, the presence of unit effect is seen in both models.

Table 5: Unit effect results of F, LM and LR tests

	F test	p value	LM test	p value	LR test	p value
EU15 Countries	52,01***	0,000	320,20***	0,000	180,19***	0,000
EU13 Countries	32,98***	0,000	608,29***	0,000	224,11***	0,000

*** p<.01

When the statistical values of the F test are examined in Table 6, it is seen that the likelihood values (p) reject the H_0 hypothesis at the 5% significance level. According to the results of the F test, there is a time effect in both models. When the statistical values of the LM test are examined, the likelihood values (p) accept the H_0 hypothesis for EU15 countries at the 5% significance level; It is seen that it rejects the H_0 hypothesis for EU13 countries. According to the results of the LM test, there is a time effect in the first model, but there is no time effect in the second model. When the statistical values of the LR test are examined, it is seen that the probability values (p) reject the H_0 hypothesis at the 5% significance level. According to the results of all three tests, it can be accepted that there is a time effect in both models.

Table 6: Time effect results of F, LM, LR tests

	F test	p value	LM test	p value	LR test	p value
EU15 Countries	8,40***	0,000	0,000	1,000	81,41***	0,000
EU13 Countries	5,35***	0,000	71,18***	0,000	51,76***	0,000

*** p<.01

Driscoll and the Kraay Estimator

Econometric models of both country groups were estimated with the Driscoll and Kraay estimator, which was the most appropriate choice for the study, and a model including time and unit effects. First, dumy variables were determined to see the effect of time and unit effects on the constant coefficient, and then separate models were estimated for the EU13 and EU15 country groups. The findings are given in Table 7 below.

According to the results of the first Pooled Driscoll and Kraay regression analysis, which estimates the parameters of EU13 countries according to unit and time effects, no statistically significant relationship was found between the Human Development Index representing the Global Competitiveness Index and the Research Expenditure and the Number of Researchers representing Innovation. However, a positive correlation was found between the Human Development Index and the Number of Patents and Human Capital at the 1% significance level. The constant term in the model also has a negative relationship at the 1% significance level.

An increase in the Number of Patents, one of the independent variables, causes an increase of 0.0049337 on the Human Development Index, and an increase in the Human Capital Index causes an increase of 0.0386043. While the weakest effect was the effect created by the Patent Numbers with

0.0049337, the effect created by the Human Capital Index with 0.0386043 was the most affected. The coefficient of the constant term in the model causes the Human Development Index to decrease by 0.1141802 while other variables are constant.

Table 7: Driscoll and Kraay with time and unit effects model estimation findings for EU13 and EU15 countries

	EU15 Countries				EU13 Countries			
Dependent variable lnHDI	**Coefficient value**	**Standard error**	**t-stat value**	**p value**	**Coefficient value**	**Standard error**	**t-stat value**	**p value**
lnRDEXPGDP	0.0066809	0.0067884	0.98	0.342	-0.0034458	0.0035166	-0.98	0.346
lnRDEMPEN	0.0007096	0.0043273	0.16	0.872	-0.0114383	0.0087205	-1.31	0.214
lnPATN	0.0008095*	0.0004102	1.97	0.069	0.0049337***	0.0011865	4.16	0.001
lnHCI	0.0333974**	0.0133535	2.50	0.025	0.0386043**	0.0143567	2.69	0.020
Constant	-0.0770646***	0.0211793	-3.64	0.003	-0.1141802***	0.0062669	-18.22	0.000
R^2	0.9671				0.9762			
F test	53827.12				93928.14			
p value	0.0000				0.0000			

*** p<.01, ** p<.05, * p<.1

According to the results of the second regression analysis, which estimates the parameters of the EU15 countries according to unit and time effects, the relationship between the Human Development Index representing the Global Competitiveness Index and the Research Expenditures representing Innovation and the Number of Researchers was not found statistically significant. However, between the Human Development Index and other explanatory variables, the Patent Numbers likelihood values (p) were less than 1% significance level and positively; Human Capital Index likelihood values (p) were found to be less than 5% significance level and in a positive relationship. The likelihood values (p) of the constant term in the model are smaller than the 1% significance level and have a negative relationship.

An increase in the Number of Patents, one of the independent variables, causes an increase of 0.0008095 in the Human Development Index, and an increase in the Human Capital Index causes an increase of 0.0333974. While the weakest effect was the effect of Patent Numbers with 0.0008095, the most effect was Human Capital with 0.0333974. The coefficient of the constant term in the model causes the Human Development Index to decrease by 0.0770646 while other variables are constant.

Comparison of the Findings of Both Country Groups

Within the scope of this study, an attempt has been made to illustrate the comparative impact of innovation on global competitiveness through the analysis of data from EU13 and EU15 countries. The results obtained as a result of the comparison of the findings obtained from both country groups are briefly as follows:

Research Expenditure and Number of Researchers variables for EU13 and EU15 countries do not have a statistically significant effect on the Human Development Index. Therefore, it is not possible to compare the data of country groups.

The effect of an increase in the Number of Patents by EU13 countries on the Human Development Index (0.0049337) is greater than the effect (0.0008095) of an increase in the Number of Patents made by EU15 countries.

The effect (0.0386043) of an increase in Human Capital by EU13 countries on the Human Development Index is smaller than the effect (0.0333974) of an increase in Human Capital stock by EU15 countries.

The constant term gives us the value of the dependent variable Y if all the independent variables take a zero (0) value (X_i=0). When the fixed terms in the model are compared, the value (-0.1141802) of the EU13 countries when their innovation indicators are zero (0) is absolutely greater than the value (-0.0770646) that EU15 countries will take when their innovation indicators are zero.

Table 8: Comparison of Driscoll and Kraay with time and unit effects model estimation findings for EU15 and EU13 countries

	EU15 countries		**EU13 countries**	
Variables	Coefficient value	p values	Coefficient value	p value
lnRDEXPGDP	0.0066809	0.342	-0.0034458	0.346
lnRDEMPEN	0.0007096	0.872	-0.0114383	0.214
lnPATN	0.0008095*	0.069	0.0049337***	0.001
lnHCI	0.0333974**	0.025	0.0386043**	0.020
Sabit	-0.0770646***	0.003	-0.1141802***	0.000

*** p<.01, ** p<.05, * p<.1

Conclusion

With the rapid reflection of technological developments, both the concepts of innovation and global competition have become an indispensable target for economies in our world, where borders are gradually decreasing with the effect of globalization. Countries have focused on looking for ways to increase their capabilities in order to make innovative production and thus gain global competitiveness as a way to achieve sustainable growth and increase the wealth and welfare of the country. Especially after the year 2000, world economies allocate more resources to R&D activities, increase their infrastructure and superstructure investments, especially education and health, to strengthen their human capital, strengthen their institutions, use information and communication technology to reach information and create faster decision-making mechanisms. and even the development of effective innovation policies and strategies has put countries in an inevitable race for global competition. Although the leaders of this race are among the developed countries, developing countries are also increasing their power day by day. However, although countries are in a race among themselves, it would not be wrong to say that the world economy and welfare as a whole has increased when an assessment is made throughout the world. It is possible to see this progress with the help of indexes developed in specific areas. These global indices, created using multidimensional and multivariate calculations, enable us to understand progress in the relevant field and compare one country with another and the country's past and present period, or the progress made in global and regional impact.

As discussed in the relevant sections of the study, there are multiple indexes used to measure global competitiveness. In particular, the human development index, which is used as one of these indexes that measures global competitiveness, goes beyond the macroeconomic variables of countries under an innovative perspective and makes a competitiveness assessment based on living standards and welfare. Today, competition does not only mean that countries get a share from international markets. Because this makes competition a zero-sum game, where one country gains the others lose. However, this is not the case in reality, because even if a country has low competitiveness and rates, it will continue to produce, thereby increasing its revenues and subsequently enhancing its welfare. However, it is crucial that we do not fall into this misconception.The policy of lower wages to increase competition or the discourse that devaluation makes a nation more competitive is flawed. This creates a situation that completely reduces the welfare of the citizens of the country. An export strategy based on low wages or a cheap currency does not allow us to achieve a high and desirable standard of living. The welfare of a country is measured by the value of the goods and services it produces per unit of its labor, capital and natural resources. Thus, the efficiency of an economy emerges. Efficiency, on the other hand, is an element that determines both the ability of

a country to set prices against its competitors in foreign markets and its production potential. The real competitiveness then depends on the level of productivity achieved by the countries. Efficiency supports high wages, a strong currency, a strong capital structure and, of course, a high standard of living. Innovation is a very important driving force at this point. It is used for national economies to increase productivity, competitiveness and therefore high standard of living.

The research we present here is carried out on EU member states, which are at the same level of development but differ in their economic and cultural conditions. Whether the main innovation indicators of the countries included in the analysis under two groups as EU13 and EU15 affect the global competitiveness and the factors that affect it are compared in the EU13 and EU15 country groups. According to the research findings, contrary to expectations, research expenditures and the number of researchers do not have a significant effect on competitiveness in both groups. Other human capital index and number of patents variables have a significant effect in both groups. Making investments that will increase the human capital index value and number of patent applications by the countries in both groups and developing strategies in this direction will increase their competitiveness. As a result of the comparison, it is noteworthy that there is a gap between the variables of both human capital and patent numbers between the EU13 and EU15 groups. The development of EU13 countries lags behind EU15 countries. In order to close the gap, EU13 countries should invest more in human capital compared to EU15 countries and turn to incentives and measures to increase patent applications. By supporting the countries in this country group more, the European Union can close the gap within the union and provide the balance over time.

To sum up, EU13 countries, in comparison to EU15 nations, need to devise strategies that foster technological transfers and enhance their innovation capacities. The role of innovation is pivotal in achieving global competitiveness, and an indicator of this effectiveness is the number of patent applications filed. Looking at our study's timeframe from 2007 to 2019, research expenditures and the count of researchers might not have a direct impact on competitiveness, yet they could potentially influence it indirectly. For this reason, EU13 countries ought to consistently escalate their investments in Research and Development, with particular emphasis on applied research. Additionally, a stronger push for collaboration in scientific and technological fields among EU nations is recommended, promoting the exchange of knowledge and skills.

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Özet

Bu çalışmanın amacı, Avrupa Birliği (AB) üye ülkeleri arasında inovasyon göstergelerinin küresel rekabet üzerindeki etkisini analiz etmektir. Panel regresyon yöntemi, panel veri modellerini kullanarak ekonomik ilişkilerin tahmin edilmesinde kullanılmaktadır.

Çalışmada, bağımsız değişkenler olarak küresel rekabet ve inovasyon göstergeleri kullanılmıştır. İnovasyon değişkenleri arasında gayri safi milli hasılaya oranla araştırma harcamaları, yüksek eğitim görmüş bireylerin veya bilim ve teknoloji alanında çalışanların nüfusa oranı, patent başvurularının nüfusa oranı ve eğitim süresine ve eğitime getirilen geri dönüşlere dayalı olarak hesaplanan kişi başına düşen insan sermayesi endeksi yer almaktadır.

Çalışma için AB üye ülkeleri için iki farklı model oluşturulmuştur: EU15 ve EU13 ülke grupları için ayrı ayrı modeller. Modellerde bağımlı değişken olarak HDI›nin doğal logaritması kullanılmış, bağımsız değişkenler olarak ise inovasyon göstergelerinin doğal logaritmaları kullanılmıştır. Modeller ayrıca hata terimlerini (uit), birim etkilerini (μi) ve zaman etkilerini (λt) içermekte olup, bağımlı değişkeni etkileyebilecek ek faktörleri hesaba katmaktadır. Çalışmada Driscoll ve Kraay tahmincisi kullanılarak EU13 ve EU15 ülke gruplarının parametrelerinin tahmin edilmesi amaçlanmıştır.

EU13 ülkeleri için, çalışmada küresel rekabeti temsil eden İnsani Gelişme Endeksi (HDI) ile Araştırma Harcamaları ve Araştırmacı Sayısı değişkenleri arasında istatistiksel olarak anlamlı bir ilişki bulunmamıştır. Bununla birlikte, HDI ile Patent Sayısı ve İnsan Sermayesi arasında pozitif bir ilişki bulunmuş ve bu ilişki %1 anlamlılık düzeyinde istatistiksel olarak anlamlı hale gelmiştir. Modeldeki sabit terim de %1 anlamlılık düzeyinde negatif bir ilişki göstermiştir.

Benzer şekilde, EU15 ülkeleri için HDI ile Araştırma Harcamaları veya Araştırmacı Sayısı arasında istatistiksel olarak anlamlı bir ilişki bulunmamıştır. Ancak, HDI ile Patent Sayısı arasında %1 anlamlılık düzeyinde pozitif bir ilişki ve İnsan Sermayesi ile %5 anlamlılık düzeyinde pozitif bir ilişki bulunmuştur. Modeldeki sabit terim de %1 anlamlılık düzeyinde negatif bir ilişki göstermiştir.

Her iki ülke grubunun bulguları karşılaştırıldığında, Patent Sayısı değişkeninin HDI üzerindeki etkisi EU13 ülkelerinde EU15 ülkelerine göre daha büyük bulunmuştur. Öte yandan, İnsan Sermayesi değişkeninin HDI üzerindeki etkisi EU15 ülkelerinde EU13 ülkelerine göre daha güçlü bulunmuştur. Modeldeki sabit terim, tüm inovasyon göstergeleri sıfır olduğunda, HDI değeri EU13 ülkeleri için EU15 ülkelerine göre daha yüksek olduğunu göstermiştir.

Sonuç olarak, bu çalışma, günümüz hızla değişen dünyasında inovasyon ve küresel rekabetin ekonomiler için önemini vurgulamaktadır. İnsani Gelişme Endeksi, sadece makroekonomik değişkenleri değil, yaşam standartlarını ve refahı da dikkate alan küresel rekabetin bir ölçüsü olarak kullanılmaktadır. Araştırma bulguları, insan sermayesine yapılan yatırımların ve patent başvurularının rekabetçiliği artırabileceğini göstermektedir. Ayrıca, EU13 ve EU15 grupları arasındaki karşılaştırma, insan sermayesi ve patent sayıları açısından EU13 ülkelerinin geride kaldığını ortaya koymaktadır. Bu farkın kapatılması için, EU13 ülkelerinin insan sermayesine daha fazla yatırım yapması ve patent başvurularını artırmak için stratejiler geliştirmesi önerilmektedir. Bu süreçte, AB'nin desteğiyle birlikte, birliğin içinde dengeyi sağlamak mümkün olabilir.