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# The Impact of Intellectual Property Payments and R&D on Economic Growth: A Panel Analysis on Highly Industrialized Countries

*Fikri Mülkiyet Hakları ve R&D'nin Ekonomik Büyüme Üzerine Etkisi: Yüksek Endüstrileşmiş Ülkeler Üzerine Panel Analizi*

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**ABSTRACT**

*Research and development (R&D) activities play a crucial role in facilitating economic growth. Numerous studies suggest that R&D activities have a positive influence on economic growth. However, according to endogenous growth models, the impact of research and development on growth is expected to diminish over time due to the principle of diminishing returns. This scenario implies that the significance of research and development activities in relation to economic growth warrants further examination. A robust connection exists between research and development and intellectual property rights. The safeguarding of intellectual property and information is vital for technological advancement. The evolution of information, technology, and patent systems heavily relies on investment in intellectual property. Considering these factors, a study was conducted to analyze the effects of R&D and intellectual property investments on economic growth within nine highly industrialized nations. This analysis utilized annual panel data spanning from 2004 to 2023. The findings of the study indicate that both research and development efforts, as well as expenditures on intellectual property, contribute positively to economic growth in these highly industrialized countries.*

***Anahtar Kelimeler:***

*Ekonomik Büyüme,*

*Araştırma ve Geliştirme,*

*Fikri Mülkiyet Ödemeleri,*

*Panel Veri Analizi*

***Jel Kodları:***

*O11, O32, O34, O40*

**ÖZET**

*Araştırma ve geliştirme faaliyetleri ekonomik büyümenin önemli bir parçası olarak kabul edilmektedir. Birçok araştırma, Araştırma ve geliştirme faaliyetlerinin ekonomik büyümeye etkisinin olumlu olduğunu belirtmektedir. Fakat içsel büyüme modellerinin öngördüğü şekilde azalan verimler kanunu gereği araştırma ve geliştirme faaliyetlerinin büyümeye etkisinin zamanla azalması gerekmektedir. Bu durum araştırma ve geliştirme faaliyetlerinin ekonomik büyümeye etkisinin yeniden ele alınması gerektiğini göstermektedir. Araştırma ve geliştirme faaliyetleri ile fikri mülkiyet arasında güçlü bir ilişki bulunmaktadır. Fikri mülkiyet hakları, bilginin korunması teknolojinin gelişmesi için hayatidir. Bilgi, teknoloji ve patent yapısının gelişmesi ise fikri mülkiyet harcamaların gelişime bağlıdır. Bahsedilen gerekçeler ışığında araştırma ve geliştirme ile birlikte fikri mülkiyet harcamalarının ekonomik büyüme üzerine etkileri 9 yüksek endüstrileşmiş ülke için ele alınmıştır. 2004-2023 dönemi yıllık veriler ile panel veri analizi gerçekleştirilmiştir. Çalışma sonucunda araştırma ve geliştirme faaliyetleri ile fikri mülkiyet harcamalarının yüksek endüstrileşmiş ülkelerdeki ekonomik büyümeyi desteklediği sonucuna ulaşılmıştır.*

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## 1. INTRODUCTION

While research and development (R&D) activities are vital components of endogenous economic growth models, they are affected by the law of diminishing returns (Solow, 1956). This indicates that although R&D expenditures positively influence economic growth (EG), the benefits derived from these expenditures tend to diminish over time. It is anticipated that advancements in technology, specialization, and information technology may help alleviate these diminishing returns. Growiec (2022) argues that to counteract the diminishing returns associated with R&D spending, there should be corresponding support through additional R&D investment. Similarly, Iwaisako (2023) emphasizes that in order to sustain the favorable impact of R&D on EG, an increase in R&D investments should be prioritized in sectors with a strong emphasis on research activities. These studies advocate for policy interventions to ensure that the returns on R&D expenditures continue to contribute positively to EG. Empirical research suggests that the influence of R&D spending on EG is more pronounced in developed countries; however, evidence shows that there is a convergence trend between developed and developing nations. In scenarios where diminishing returns occur, resources tend to shift towards areas with higher returns. As a result, R&D efforts in developed countries may redirect to more productive and effective sectors. This shift could lead to a reduced impact of R&D on EG in countries that lose their research capabilities. Several studies support this notion. For instance, Celli et al. (2024) found that the convergence rate between countries investing relatively less in R&D and those investing more is consistent among EU nations, reinforcing the idea that developed countries may not achieve adequate efficiency due to diminishing returns. Similar findings were reported by Gumus & Celikay (2015), where a comparative analysis of developed and developing countries revealed that R&D's effect on EG is more significant in developing nations. These discussions highlight the necessity of reevaluating the relationship between R&D and EG in developed countries, taking into account the implications of diminishing returns.

Intellectual Property Rights (IPR) and Intellectual Property Payments (IPP) are important for technology development and technology transfer between countries. The ideas developed by researchers are protected by a patent. The development of the patent structure in countries depends on the development of IPR. The development of IPR requires an increase in spending on intellectual property. The expenditures made by countries for this purpose cause researchers to increase innovation in science and technology (Kim et al., 2012: 359; Falvey et al., 2006: 701; Kwan & Lai, 2003: 854). In this sense, IPP and R&D are an inseparable whole and it is very important to consider them together. This study aims to contribute to the literature by examining the effects of IPP and R&D on EG together.

Investment is the foundation of macroeconomic growth. R&D activities are essential for the development of investments. The development of R&D takes place in the IPR and IPP timeline. It is important to consider the mentioned elements together in terms of the integrity of the subject. The literature has focused more on R&D and economic growth. This study emphasizes the importance of the issue by adding the IPP variable.

In the second part of the study, the theoretical structure of the subject is explained. The third part is a summary of the literature. This is followed by the results section. In this section, first the data and hypothesis, second the econometric method to be applied and third the empirical results will be shared. The last part presents the results and conclusions.

## 2. THEORETICAL BACKGROUND

According to the endogenous growth theory, EG is an internal process and arises under the influence of factors such as innovation, technology and intellectual property (Romer, 1990). As firms finance creativity and innovation, EG is stimulated. Spending on intellectual property is one of the most important elements of this process. Neoclassical growth theory, while examining the relationships between factors of production, suggests that technological progress and innovation are external (Solow, 1956). In an economy with strong IPR, the promotion of innovation and technological development accelerates EG.

IPR is an important positive economic externality that reflects the innovation and creativity of a society. IPR is a structure that ensures access to and control over works and the economic benefits they derive from those works. IPR has a structure that fundamentally affects many factors that support EG. Some of these are innovation, technological development, the growth of the knowledge economy, international competition, and social effects in the economic development process (Chang, 2001: 288).

IPR play a central role in promoting innovation and creativity. Property rights such as patents, copyrights and trademarks protect innovations developed by an individual or a firm. This protection encourages entrepreneurs and investors to take risks because they know they can protect the value they create. In this context, the introduction of new products and services to the market allows the firm to gain a competitive advantage (Singh et al., 2019: 3). This situation ensures the promotion of innovation through IPR.

IPR are a structure that has a direct impact on technological development and the flow of knowledge. Strong intellectual property protection mechanisms allow companies to invest more in R&D activities. Firms try to maximize the commercial potential of this knowledge by protecting their knowledge and innovations. This creates a foundation for future technological development (Ghafele & Gibert, 2012: 3). This refers to the provision of technological development and knowledge flows through IPR.

In the 21st century, the knowledge economy has been transformed into a structure based on knowledge and technology. In this context, the role of IPR has a great impact on the development of the knowledge economy. IPRs contribute to the implementation of knowledge-based business models by ensuring the protection of knowledge products. With the new products and services developed, enterprises that have a competitive advantage in the knowledge economy contribute to EG. This situation illustrates the strong relationship between IPRs and the knowledge economy. In the context of the knowledge economy, the value of knowledge and intellectual property increases (Dinopoulos & Segerstrom, 2010: 15).

IPR is an important factor that increases competition in the international market. Countries with a strong IPR system become more competitive in global markets. This increases the ability to attract foreign investment and promotes technology transfer. IPRs are considered as a factor that supports innovation in countries around the world (Hammami, 2019: 861; Pouris & Pouris, 2011: 3). In this regard, it is accepted that the IPR increases in developed countries carry out a technology transfer to developing countries.

The relationship between R&D and EG is also a very important topic in the economic literature. Researchers have identified many direct and indirect effects between R&D and EG in the past. The first of the direct effects of R&D on EG is that R&D enables the development of innovative products and services. The existence of innovative products and services is a factor that positively affects demand in both domestic and foreign markets. The stimulation of effective demand in the country has a positive effect on total supply. Innovative products and services offered to foreign markets will make countries superior in international competition and will support EG by providing foreign exchange inflows to the country.

High R&D expenditures allow firms to increase their productivity. Studies show that R&D expenditures directly lead to increased productivity (Alam & Alvi, 2024: 3). Innovative processes improve production methods and optimize the use of resources. In this context, success in innovative processes leads to lower costs and higher profit margins. R&D helps companies increase their competitiveness and expand their market share. Innovative products and services exceed customer expectations and allow companies to be more dominant in the marketplace. Therefore, successful R&D studies contribute to EG by increasing companies' revenues. In addition, R&D investment has the potential to directly increase employment. Companies that develop new products and technologies usually need more workers. This leads to an increase in employment in the labor market. Increased employment also contributes to EG by increasing consumer spending.

R&D facilitates the transformation of knowledge and technology and supports its diffusion within the industry. Transforming the results of scientific research into practical applications accelerates the innovation process. For example, companies that collaborate with universities and research institutions can increase their competitiveness by acquiring the latest technologies and knowledge from external sources. This knowledge transfer contributes to EG by supporting the development of other firms in the sector (Wang et al. 2022: 525).

Developed countries are mobilized to develop R&D investments and global collaborations are established. This situation triggers EG by increasing international trade and foreign investment. Internationalization can strengthen the position of firms in the global market by enabling them to differentiate themselves.

Public policies can have an indirect effect on EG by encouraging R&D processes. Governments can encourage the private sector to focus on R&D by using tools such as tax incentives, grants and funding. These policies create a foundation that supports long-term EG (Cohen et al., 2002).

There are important links between intellectual property and R&D. The first is related to innovation management. Increasing R&D spending has a direct impact on the success of innovation processes. However, spending on R&D alone can reduce the competitiveness of the company if the products and services derived at the end of the process are not protected by intellectual property rights. Therefore, R&D and intellectual property strategies must work in harmony in the innovation management process. The second relates to market strategy. Intellectual property protection shapes a product's market entry strategies. If a company has strong intellectual property rights for the product or service it develops in the R&D process, it will have an advantage in entering the market. In addition, intellectual property protection can increase investor interest and create additional financing opportunities. The third is risk management. R&D projects usually involve high risks. Effective management of intellectual property rights helps to minimize these risks. Patents and other intellectual property tools provide significant protection to firms in highly competitive sectors, allowing them to implement R&D investments more securely (Manap et al., 2016).

## 3. LITERATURE

The association of knowledge and technology with the concept of EG is based on Arrow's (1962) "learning by doing" model. The basic idea is that individuals develop their educational experiences while working. It is very important to consider this concept as an internal factor and it is believed that it will contribute significantly to EG. Later, Christensen et al. (1973) studied the effect of technology using many input factors on a generalized functional form, and the effect of technological change attracted attention in economic literature. In this model, technology was considered to be external. Romer (1986) emphasized the important role of knowledge and human capital in EG. Since increasing knowledge is the basic building block of human capital, the concept of human capital was evaluated as internal. Thus, human capital was no different from other internal factors. Lucas (1988) emphasized the important role of both knowledge and human capital in EG. Romer (1990) added significant richness to the literature with a growth model in which Romer accepted all the concepts of technology, innovation, and knowledge as internal. These studies are seminal in explaining the fundamental roles of information, technology, and human factors in EG. Researchers have tested the validity of these situations in different countries and different periods.

In exploring the link between research and development (R&D) activities and economic growth (EG), Inekwe (2015) carried out a study involving 88 developing nations. The countries were classified into two categories: high-income and low-income. The findings revealed that R&D expenditures in high-income countries have a beneficial impact on economic growth, whereas the impact in low-income countries was found to be negligible. Gumus & Celikay (2015) assessed 52 countries, comprising both developed and developing nations. Their study concluded that R&D spending positively affects EG in both categories; however, it is noteworthy that the coefficient for developing countries was higher compared to that for developed countries, indicating that the relationship between R&D and EG is more favorable for developing nations, with substantial results. Dogan & Yildiz (2016) concluded that R&D expenditures lead to improvements in financial indicators in capital markets. One of the significant outcomes from the research by Sokolov-Mladenović et al. (2016) highlights that the effect of R&D investment on EG is more than twice as substantial. Additionally, the study noted a negative correlation between rising fertility rates in EU countries and EG. In a separate study by Nair et al. (2020) focusing on OECD countries, it was demonstrated that R&D expenditure is a key component of sustainable EG in these nations. They also stressed the importance of infrastructure investments in the information and communication technology sector in supporting the R&D domain. Olaye et al. (2020) conducted a study in Africa, concluding that innovation driven by R&D expenditures is fundamental to achieve sustainable growth in African nations. Furthermore, Ahmet & Zheng (2023) examined the effects of patenting and R&D spending on EG across 36 OECD countries, utilizing both linear and nonlinear analytical methods. Their findings indicated that positive fluctuations in R&D investments contribute to EG during periods of economic expansion, while negative fluctuations during downturns can adversely affect growth. Iwaisako (2023) investigated the influence of R&D expenditures on EG and emphasized that for optimal economic growth, the allocation of R&D funds or subsidies should be directed towards industries with higher research intensity. Celli et al. (2024) analyzed the link between R&D spending and growth in EU nations, finding a positive influence of R&D on EG. Notably, the study observed that countries investing heavily in R&D do not necessarily gain more benefits than those investing less, suggesting a convergence trend among EU countries. Khezri et al. (2024) examined 46 nations and concluded that, despite low R&D spending, macroeconomic factors still positively impact growth. These findings illustrate that R&D significantly influences EG in developing countries.

Several studies have also looked at the combined effects of R&D and intellectual property rights (IPR) or intellectual property policies (IPP) on EG. Park (1999) conducted research on 60 nations, finding a positive influence of R&D on EG, though the impact of IPR was statistically insignificant. Schneider (2005) studied 47 developed and developing countries and concluded that both R&D and IPR positively affect EG. Xu & Cao (2019) focused on the role of IPR in sustainable EG in China and found that, while IPR had a positive effect on EG, the influence of R&D was not statistically significant. In a study of 12 European countries, Aricioglu & Ucan (2015) found a positive impact of IPR, yet R&D was not statistically significant. Liu (2016) examined 92 countries and determined that both IPR and R&D positively affect EG, with R&D having a more substantial impact than IPR. Ambrammal (2023) surveyed 129 countries and categorized the results by income levels, demonstrating that R&D has a strong positive effect on sustainable EG, independent of income groupings. The effect of IPR on EG was observed to be U-shaped. Lastly, Cheng et al. (2024) conducted research on 107 countries, confirming that both R&D and IPR positively influence EG, with the authors indicating that IPR enhances EG by increasing the stock of knowledge capital through R&D endeavors.

## 4. EMPIRICAL ANALYSIS

This section will be divided into 3 parts. The first part discusses the data and the hypothesis. The second part introduces the panel data analysis to be used. The third part presents the results of the analysis.

### 4.1. Data and hypothesis

This study examines the impact of IPP and R&D variables on EG. The study was conducted on 9 highly industrialized countries (United States, Germany, China, France, United Kingdom, Italy, Japan, Canada, Russian Federation). A panel with the variables listed in Table 1 was constructed for the data period 2004-2023. The reason for choosing this data period is to study the effects of the specified variables on EG in developed countries over the last twenty years. The study used panel data analysis. The analyses were implemented in the Stata package program.

**Table 1.** Variables, Descriptions and Sources

| Variables | Explanations | Source |
|---|---|---|
| *Economic growth* | GDP (constant 2015 US$) | World Bank |
| *İnvestment* | Gross capital formation (% of GDP) | World Bank |
| *Employment* | Employment to population ratio, 15+, total (%) | World Bank |
| *Trade* | Export plus import (% of GDP) | World Bank |
| *Inflation* | Inflation, GDP deflatör (annual %) | World Bank |
| *Intellectual Property Payments* | Charges for the use of intellectual property, payments (BoP, current US$) | World Bank |
| *Research and Development* | Patent applications | World Bank |

All seven variables used in the study were obtained from the World Bank's, World Development Indicators database. Since the econometric regression model was constructed using the Cobb-Douglas production model, EG was used as the dependent variable; capital, employment, and other variables were used as explanatory variables.

$$ln\ gdp_{i,t} = inv_{i,t} + emp_{i,t} + inf_{i,t} + trd_{i,t} + ln\ ıpp_{i,t} + ln\ rnd_{i,t} + u_{i,t} \tag{1}$$

Equation (1) represents the panel regression to be applied. The explanations of the variables, whose short names are written, are shown in Table 1. In equation (1), i represents the units; t represents the time operator; u represents the error terms. A panel data consisting of 9 units and 20 time series was used in the study. Although other variables were used as ratios and percentages, since the variables of *Economic Growth*, *Intellectual Property Payments* and *Research and Development* were at level value, the logarithm of these three variables was taken.

**Table 2.** Descriptive Statistics of Variables

| Variables | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| *Economic growth* | 178 | 28.86 | 0.830 | 27.61 | 30.71 |
| *İnvestment* | 175 | 24.12 | 7.291 | 14.96 | 46.66 |
| *Employment* | 178 | 57.37 | 6.192 | 42.83 | 71.23 |
| *Inflation* | 178 | 3.022 | 4.133 | -2.324 | 24.46 |
| *Trade* | 176 | 53.56 | 17.00 | 23.10 | 99.88 |
| *Intellectual Property Payments* | 178 | 23.21 | 0.717 | 20.77 | 24.83 |
| *Research and Development* | 156 | 10.68 | 1.627 | 8.307 | 14.17 |

Since data for some years in the series of the variables are missing in the data source, unbalanced panel data were used. Table 2 shows that the data for *Economic growth, Employment, Inflation,* and *Intellectual Property Payments* are complete in terms of observations, while the observations of other variables are missing. The highest standard deviation is found in the *Trade* variable. In addition, the difference between the minimum and maximum values also occurred in the *Trade* variable.

### 4.2. Econometric Method

Panel data analysis is a combination of time series and cross-sectional analysis. Thus, information can be obtained from both unit and time dimensions.

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 T_{it} + \beta_3 Z_{it} \dots\dots\dots \beta_k M_{k,it} + u_{it} \qquad (2)$$

Equation (2) shows a panel data linear regression. Y represents the dependent variable, and X,T,Z and M represents the independent variable. The i symbol represents the number of units, and t represents the time dimension.

$$\begin{aligned} &a)\ Y_{it} = \beta_0 + \beta_1 K_{it} + \lambda_i + \zeta_t + u_{it} \\ &b)\ Y_{it} = \beta_0 + \beta_1 K_{it} + \zeta_t + u_{it} \\ &c)\ Y_{it} = \beta_0 + \beta_1 K_{it} + \lambda_i + u_{it} \\ &d)\ Y_{it} = \beta_0 + \beta_1 K_{it} + u_{it} \end{aligned} \qquad (3)$$

Four different models are shown in equation (3). These models are models that incorporate unobservable effects specific to panel data in different ways. Unobservable effects can be unit or time related. In some panel data models, as shown in row a, unit and time effects are present together. These models are called "unit and time effect models". In some models there is only a time effect, as shown in row b. These models are called "time effect models". In some models, there is only a unit effect, as shown in row c. These models are called "unit effect models". In some models, there is neither a unit effect nor a time effect, as shown in row d. The models shown in row d are called the "classical model".

The presence of unit and time effects in the model can be determined using fixed effects and random effects estimators. There are two fixed effects estimation methods: Dummy Variable Least Squares and Within-Group estimators. In random effects there are Generalised Least Squares and Likelihood Ratio estimators. By selecting an estimator from the fixed effects and random effects estimators, the panel is first aligned by unit and the test results are obtained. Then the panel is adjusted for time and the test results are obtained again. This allows the unit and time effects in the panel to be determined.

Once the unit and time effects have been determined, it is necessary to determine whether the unit/time effects are correlated with the independent variables. This is done with the Hausman test. If there is a correlation, it is decided that the fixed effects estimator is consistent. If there is no correlation, it is decided that the random effects estimator is effective.

$$H = (\hat{\beta}_{fixed} - \hat{\beta}_{random})' \left[Avar(\hat{\beta}_{fixed}) - Avar(\hat{\beta}_{random})\right]^{-1} (\hat{\beta}_{fixed} - \hat{\beta}_{random}) \qquad (4)$$

Equation (4) shows the Hausman test methodology. The terms $Avar(\hat{\beta}_{fixed})$ and $Avar(\hat{\beta}_{random})$ represent the asymptotic variance and covariance matrices obtained from estimators, respectively (Tatoglu, 2020: 196). Once the model has been selected using the Hausman test, the final estimation results are subjected to a number of tests. In the presence of cross-sectional dependence, autocorrelation and heteroskedasticity in the model, the panel data analysis is completed by re-estimating with robust estimators that produce robust standard errors.

### 4.3. Findings

If the series are not distributed around their mean, it is recommended that the series' first be subjected to unit root analysis, as the changes in the series have a permanent effect and create a risk of spurious regression. However, when the time dimension is short, unit root analysis may not perform well (Afriyie et al, 2020: 660). Moreover, if one examines the studies in the literature that conduct panel data analysis and have a short time dimension similar to this study, it is seen that they apply the analysis without performing a unit root test (Matthess et al., 2023; Martínez-Alonso et al., 2023; Asad et al., 2023; Bersalli et al., 2020). Therefore, in this study, other tests were carried out without including unit root analysis.

**Table 3.** Determination of Unit and Time Effects

| Tests | | Unit | Time | Decision |
|---|---|---|---|---|
| FE | Stat. | 921.79 | 1.07 | Unit |
| | Prob. | (0.000) | (0.394) | |
| RE | Stat. | 814.15 | 0.00 | |
| | Prob. | (0.000) | (1.000) | |

In panel data applications, there may be unobservable effects or unobservable heterogeneity that can come from both unit and time or both elements. These effects can be detected with FE (fixed effect) and RE (random effect) tests. The tests applied to the unit-ordered data are then reapplied to the time-ordered data. As a result, it is determined whether the effects are caused by unit or time. According to Table 3, it has been determined that there are unit effects in the applied panel.

**Table 4.** Hausman Test Results

| Variables | Fixed | Random | Difference | Hausman |
|---|---|---|---|---|
| *İnvestment* | 0.0068 | 0.0064 | 0.0003 | 4.58 (0.598) Random Effect |
| *Employment* | -0.0085 | -0.0078 | -0.0007 | |
| *Inflation* | 0.0013 | 0.0013 | 0.0000 | |
| *Trade* | 0.0021 | 0.0020 | 0.0001 | |
| *Intellectual Property Payments* | 0.2346 | 0.2342 | 0.0003 | |
| *Research and Development* | 0.2314 | 0.2346 | 0.0031 | |

After determining the unit and/or time effects, the Hausman test (1978) is applied to determine the correlation of these effects with the independent variables. If there is no correlation between the unit effect and the independent variables, the random effects model is valid. This is because in the fixed effects estimator, the unit effects are dropped from the model. On the other hand, if there is no correlation, the random effects estimator creates an endogeneity problem. This is because in the random effects model, since the unit effect is summarized in the error terms in the model, the correlation between the independent variable and the unit effect violates the exogeneity assumption. Therefore, if there is a correlation, the fixed effects are consistent (Tatoglu, 2020: 199-200). According to the results of Table 4, it has been determined that the random effects are effective according to the Hausman test result.

**Table 5.** Diagnostic Tests

| | Tests | | Stat. (Prob.) |
|---|---|---|---|
| Multicollinearity | Mean VİF | | 2.20 |
| Normality | D'Agustino & Belanger D'Agustino | e: | 1.85 (0.395) |
| | | u: | 2.24 (0.325) |
| Heteroskedasticity | Brown ve Forsythe | W0 | 4.50 (0.000) |
| | | W10 | 4.50 (0.000) |
| | | W50 | 2.77 (0.006) |
| Autocorrelation | Modified Bhargava et al. Durbin–Watson | | 0.54 |
| | Baltagi–Wu LBI | | 0.72 |
| Cross-Sectional Dependence | Pesaran | | 4.47 (0.000) |
| | Friedman | | 34.9 (0.000) |

According to the test results obtained, diagnostic tests should be applied to the model before running the estimator. In panel data analysis, robust estimators are applied in the presence of one or more diagnostic problems. The model is expected to have normal distribution characteristics. Therefore, the test proposed by D'Agostino, Belanger & D'Agostino (1986) was applied. The test tests the conformity of both the error terms and the errors due to unobserved units or times to the normal distribution. The basic hypothesis of the test is "normal distribution exists". According to the results presented in Table 5, the basic hypothesis could not be rejected. Accordingly, the unobserved errors resulting from random effects and the error terms of the model are normally distributed. The fact that the average of the applied Variance Inflation Factor (VIF) test is below 5 indicates the absence of a multicollinearity problem. According to Table 5, since the VIF value (2.20) is less than 5, it has been determined that there is no multicollinearity problem. For the heteroscedasticity problem, the Brown ve Forsythe (1974) test was applied. The basic hypothesis of the test is "there is no heteroscedasticity". According to Table 5, the basic hypothesis was rejected at the 1% significance level. Thus, it can be seen that there is a heteroscedasticity problem. The Durbin-Watson & Baltagi-Wu tests proposed by Bhargava, Franzini & Narendranathan (1982) were used to determine autocorrelation. The decision point of the test is that if the test statistic is below the value of "2", it can be said that there is autocorrelation. Since the test results are below 2, it has been decided that there is autocorrelation. The Pesaran and Friedman tests were applied for the existence of cross-sectional dependence. The basic hypothesis of the tests is "there is no cross-sectional dependence". According to the test results, the basic hypothesis could be rejected, and it was determined that there is a cross-sectional dependence problem. Finally, there is a problem of autocorrelation, cross-sectional dependence, and heteroskedasticity in the model. These problems are corrected with the estimator that produces robust standard errors.

**Table 6.** Results of the Driscoll-Kray Estimators (Dependent Variable: Economic Growth)

| **Variables** | **Coeff.** | **St. Dv** | **t stat.** | **Prob.** |
|---|---|---|---|---|
| *İnvestment* | 0.0064 | 0.0037 | 1.74 | 0.101 |
| *Employment* | -0.0078 | 0.0036 | -2.15 | 0.046 |
| *Inflation* | 0.0013 | 0.0021 | 0.64 | 0.530 |
| *Trade* | 0.0020 | 0.0010 | 1.86 | 0.080 |
| *Intellectual Property Payments* | 0.2342 | 0.0239 | 9.76 | 0.000 |
| *Research and Development* | 0.2346 | 0.0142 | 16.50 | 0.000 |
| Cons. | 21.103 | 0.3180 | 66.34 | 0.000 |

Table 6 shows the results obtained using the Driscoll ve Kraay estimators of the final model. *Investment* and *Employment* variables are the basic components of EG. Therefore, in the economic literature, increases in both variables are expected to have a positive impact on EG. In the estimation results, it is seen that the *Investment* variable is not statistically significant despite its positive coefficient. In the literature, it is mostly seen that the gross capital formation variable positively affects economic growth. Some examples of this positive relationship are Kesar et al. (2023); Pasara & Garidzirai (2020); Jermsittiparsert et al. (2019) studies.

The *Employment* variable is statistically significant but the coefficient sign is negative, contrary to expectations. However, in recent years, some researchers have focused on the concept of "jobless growth". This concept refers to the fact that there may be situations where economically growing economies do not create employment. Butkus et. al. (2024); Mathy (2024); Haider et al. (2023); Alfaro et al. (2023); Onaran (2008) studies provide empirical evidence that jobless growth can occur. In the main literature of the study, Inekwe (2015) found that employment negatively affects growth in developing countries and middle-income countries.

When the instrumental variables used were examined, it was determined that the *Inflation* variable had a positive sign but was not statistically significant. The positive coefficient sign in inflation is consistent with economic expectations. It shows that increases in inflation cause increases in economic growth. Purnomo & Wibowo (2024). Ioan et al. (2020); Thanh (2015) studies have conducted research on different country groups. As a result of the studies, it has been determined that increases in inflation positively affect economic growth.

The *Trade* variable was positively signed and statistically significant. It can be interpreted that the increasing trade volume in industrialized countries supports economic growth. In economic expectations, the *trade* is expected to have a positive effect on economic growth, but it is also possible for this effect to be negative. Since foreign trade revenues will be positive at the point where exports exceed imports, the trade variable is also expected to have a positive effect on economic growth. Khezri et al. (2024); Audi et al. (2022); Banday et al. (2021); Iyoha & Okim (2017); Liu (2016); Brueckner & Lederman (2015); Kılavuz & Topcu (2012) are studies indicating a positive relationship between trade and EG. The findings of this study are consistent with the literature.

The IPP variable positively affects economic growth and is significant according to the 1% significance level. The increase in Intellectual property payments in the country group supports economic growth. The IPP variable is high in terms of coefficient. This shows that industrialized countries attach great importance to the issue of Intellectual property. IPP is not a frequently used variable in the literature. The IPR variable has been used more in the literature. The positive relationship between Intellectual property and economic growth found in the studies of Cheng (2024); Ambrammal (2023); Xu & Cao (2019); Liu (2016); Aricioglu & Ucan (2015); Schneider (2005) is consistent with the results of this study.

The R&D variable positively affects economic growth. The increase in the number of patents in industrialized countries supports economic growth. In fact, it is seen that the R&D variable is quite strong compared to other variables as a coefficient. This situation shows that research and development activities are of great importance in developed countries. The vast majority of studies in the literature have found a positive relationship between

R&D and economic growth. The results obtained in this study are also consistent with the literature and economic expectations. The positive relationship between R&D and economic growth found by Alam & Alvi (2024); Khezri et al. (2024); Ahmet & Zheng (2023); Wang et al. (2022); Olaoye et al. (2021); Nair et al. (2020); Liu (2016); Sokolov-Mladenović et al. (2016); Gumus & Celikay (2015) is consistent with the findings of this study.

## 5. CONCLUSION

This study examines the impact of *Intellectual Property Payment* and *Research and Development* activities on EG in highly industrialized countries. The article used annual data for the period 2004-2023 for 9 highly industrialized countries. The econometric method used was panel data analysis (fixed-random effects). The results show that *Intellectual Property Payment* and *Research and Development* variables have a positive impact on EG dynamics.

Increasing R&D activities enables the development of new technologies and products, which indirectly increases labor productivity. In this process, the competitive advantage provided by high-tech products is a critical element for EG. Particularly in knowledge-based economies, the innovations generated by R&D play an important role in transforming industry and increasing competitiveness in the global marketplace.

Since increasing R&D activities will cause both quantitative increases in investment and employment and productivity in macroeconomic terms, it acts as the locomotive of economic growth. In addition, exports of R&D products support both foreign trade and balance the balance of payments in countries. For this reason, the development steps taken by highly industrialized countries towards industrialization form the basis of long-term economic growth. It is recommended that R&D activities continue to be supported as a policy.

Effective protection of intellectual property rights and commercialization of innovations are essential for encouraging R&D investments. Intellectual property ensures the protection of the values created by researchers and entrepreneurs, reduces the risks in this process and encourages innovation. The study has shown that strengthening intellectual property systems creates a sustainable growth environment for economic actors both locally and internationally. For this reason, in order to establish R&D activities on solid foundations, protection of intellectual property rights at a level higher than the current situation should always be included in long-term policies.

As a result, the positive impact of R&D and intellectual property rights on EG is central to countries' long-term strategies. Policymakers can increase the sustainability of EG by developing regulations that encourage R&D investment and protect intellectual property rights. In this context, the creation of a strong innovation ecosystem will enhance not only national economic development but also global competitiveness. Future research can support the design of policies and strategies by examining these interactions in more detail.

This study conducted research on 9 highly industrialized countries. The data period is limited to 2004-2023. These features indicate the limitations of the study. Although studies have been conducted in the literature according to different income and development levels, panel data with longer data sets and a wider number of countries should be created in future studies. The development of database infrastructures may allow the subject to be reconsidered with longer data sets in the coming years. In addition, since the subject of the effects of intellectual property rights on economic growth together with R&D activities does not have sufficient depth in the literature, it should be addressed more comprehensively in future studies.

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This paper complies with Research and Publication Ethics, has no conflict of interest to declare, and has received no financial support.

**AUTHORS' CONTRIBUTIONS:**

The entire research is written by the author.

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