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## AN ANALYSIS FOR THE MACROECONOMIC DETERMINANTS OF INNOVATION CAPABILITY OF COUNTRIES

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### ABSTRACT

Today, technological innovations are one of the most important factors in achieving sustainable economic growth for countries in the long term. In order for technological innovations to be produced competitively, countries need to develop and strengthen their innovation climate and innovation capabilities. The main purpose of this study is to analyse the macroeconomic determinants of innovation capability for the 141 countries around the world for the 2019 data. In the study, according to the estimated model results, all explanatory variables in the model affect the dependent variable in the same direction. The signs of the coefficients of the explanatory variables are in line with the economic expectation. According to the empirical results, explanatory variables - business dynamism, financial system, research development and commercialization - contribute to the development of the innovation ability of countries. According to these results, it is of great importance to implement policies that will improve the innovation climate in order to develop innovations, which are the main source of economic development and sustainable economic growth. Countries must effectively design all phases of the science, technology and innovation value chain. Countries should develop their innovation policies and strategies to provide high added value. The continuity of innovation production should be ensured by establishing an effective innovation ecosystem with the actors and factors affecting the innovation production capability of countries. Countries should strengthen the allocation of resources to research and development to strengthen the science, technology and innovation value chain. The number of researchers in the research sector should be supported. Cooperation between university and industry is strengthened. Innovation and entrepreneurship need to be supported. Technology and innovation-based transformation of the country's economy is important for sustainable economic growth. In this process, it is especially important to develop individual entrepreneurship and innovation culture. At the enterprise level, it is necessary to support the transformation of enterprises into an innovative structure. The development of technological innovations should be integrated as an important strategy at the center of development and industrialization policies. Increasing the sustainability and global competitiveness of the country's economy with macroeconomic policies that support innovation is important for increasing social welfare.

**Keywords:** Innovation, capability, macroeconomy

## ÜLKELERİN İNOVASYON KABİLİYETİNİN MAKROEKONOMİK BELİRLEYİCİLERİ İÇİN BİR ANALİZ

### Öz

Günümüzde teknolojik yenilikler, uzun vadede ülkeler için sürdürülebilir ekonomik büyüme sağlamada en önemli faktörlerden biridir. Teknolojik yeniliklerin rekabetçi bir şekilde üretilebilmesi için ülkelerin inovasyon iklimini ve inovasyon yeteneklerini geliştirmeleri ve güçlendirmeleri gerekmektedir. Bu çalışmanın temel amacı, dünyadaki 141 ülkenin 2019 verileri için inovasyon kabiliyetinin makroekonomik belirleyicilerini analiz etmektir. Araştırmada tahmin edilen model sonuçlarına göre modeldeki tüm açıklayıcı değişkenler bağımlı değişkeni aynı yönde etkilemektedir. Açıklayıcı değişkenlerin katsayılarının işaretleri ekonomik beklentiyle uyumludur. Ampirik sonuçlara göre açıklayıcı değişkenler - iş dinamizmi, finansal sistem, araştırma geliştirme ve ticarileştirme - ülkelerin inovasyon yeteneklerinin gelişmesine katkıda bulunmaktadır. Bu sonuçlara göre, ekonomik kalkınmanın ve sürdürülebilir ekonomik büyümenin temel kaynağı olan yeniliklerin geliştirilmesi için inovasyon iklimini iyileştirecek politikaların uygulanması büyük önem arz etmektedir. Ülkeler bilim, teknoloji ve inovasyon değer zincirinin tüm aşamaları etkinlikle tasarlamalıdır. Ülkeler, yüksek katma değer sağlayacak şekilde inovasyon politika ve stratejilerini geliştirmelidir. Ülkelerin inovasyon üretim kabiliyetini etkileyen aktörler ve faktörlerle etkin bir inovasyon ekosistemi kurularak inovasyon üretiminin sürekliliği sağlanmalıdır. Ülkeler bilim, teknoloji ve inovasyon değer zincirinin güçlendirmek için, araştırma geliştirmeye kaynak tahsisini güçlendirmelidir. Araştırma sektöründe araştırmacı sayısı desteklenmelidir. Üniversite ve sanayi arasındaki işbirliği güçlendirilmelidir. Yenilikçilik ve girişimciliğin desteklenmesi gerekmektedir. Ülke ekonomisinin teknoloji ve yenilik temelli dönüşümü sürdürülebilir ekonomik büyüme açısından önem arz etmektedir. Bu süreçte özellikle bireysel girişimciliğin ve yenilikçilik kültürünün geliştirilmesi önem arz etmektedir. İşletme düzeyinde ise işletmelerin yenilikçi bir yapıya dönüşmelerinin desteklenmesi gerekmektedir. Kalkınma ve sanayileşme politikalarının merkezinde teknolojik yeniliklerin geliştirilmesi önemli bir strateji olarak entegre edilmelidir. Yeniliği destekleyen makroekonomik politikalarla ülke ekonomisinin sürdürülebilirlik küresel rekabet gücünün artırılması toplumsal refahın artırılması için önem arz etmektedir.

**Anahtar Kelimeler:** Yenilik, yetenek, makroekonomi

INTRODUCTION

Today, increasing competition requires businesses and countries to be more competitive. In order to be successful in global competition, countries have to manage their scarce resources more effectively. In this context, it is of great importance for countries to improve the skills of their human resources, which is the most important resource they have. The fact that a country's human resources are more innovative and more productive than its competitors will contribute to the increase of sustainable competitiveness of businesses and countries. On the other hand, technological innovations are one of the most important factors for countries to achieve sustainable economic growth in the long run. Countries should develop policies and make investments to develop and strengthen the innovation climate and innovation capabilities so that technological innovations can be produced competitively. In this context, the main purpose of this study is to analyse the macroeconomic determinants of innovation capability for the 141 countries around the world for the 2019 data.

The original aspect of the study according to the literature is that it is the first study to examine the innovation capabilities of countries for these countries by using these variables and this data source. In this context, the study aims to make original contributions to the literature in these respects.

LITERATURE REVIEW

In the economics literature, important scientific studies have been carried out for nearly a century regarding the critical role of technological change in achieving sustainable economic growth for countries in the long term. Figure.1. shows theoretical literature structure on technological change and economic growth from Smith to endogenous growth theory.

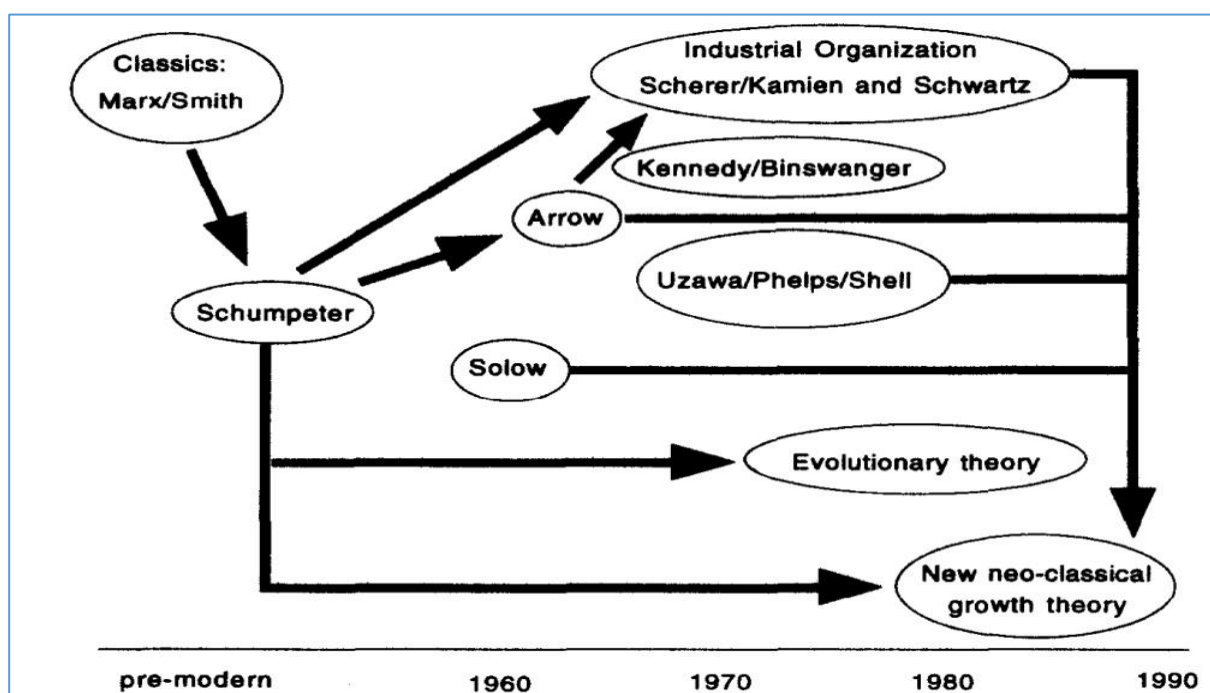


Figure.1. Theoretical Literature Structure on Technological Change and Economic Growth (Verspagen, B. ,1992)

Innovation capability includes not only countries at the macroeconomic level but also sectors and firms at the microeconomic level. The components in building innovation capability at firm level are given in Figure.2.

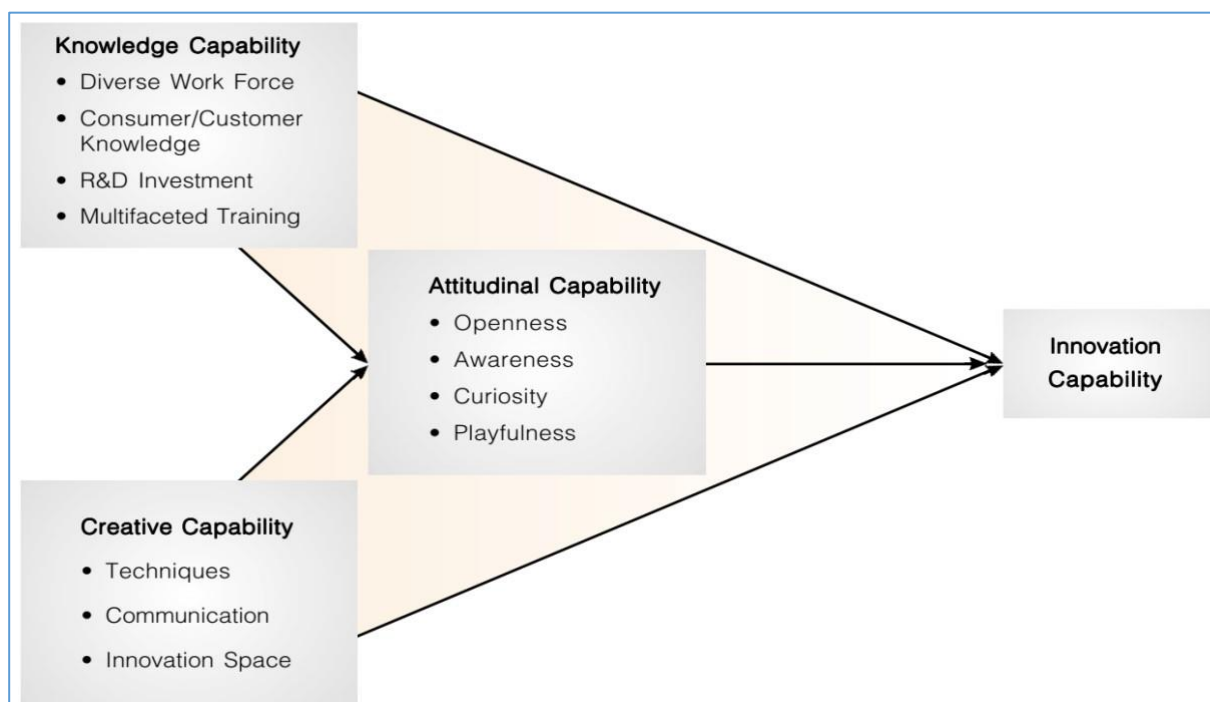


Figure.2. Building Innovation Capability (Parashar, M., & Singh, S. K., 2005)

There is an important literature on the sources, causes and economic consequences of technological change and technological innovations. The highlights of these studies are summarized in Table.1. At the national, sectoral, regional and firm level, many factors from micro and macro level, from education to human capital, from research development to infrastructure and international trade conditions, are effective in the development of innovation capability. (see Chen et al, 2020; Torun & Çetinoğlu, 2019 and 2020; Han et al 2021; Tekic & Tekic, 2021).

Table.1. Literature Review

Author(s)	Findings
Schumpeter (1934, 1942)	Schumpeter stated that entrepreneurs, inventions and innovations play an important role in the development of the capitalist system.
Solow and Swan (1956)	In Solow's growth model, long-run per capita growth depends on technological change. The source of technological change is exogenous.
Arrow (1962)	Arrow stated that technological development can be endogenous and spread with the process of learning by doing.
Uzawa (1965)	The study stated that technological progress can only be achieved by using some positive amount of scarce resources.
Nelson & Phelps (1966)	In the study, it was stated that investment in education and human resources is important for technological development and economic growth.
Romer (1986)	In the study, it was stated that knowledge is an input with increased marginal productivity and with the endogenous technological change, growth rates may not decrease but increase over time.

Lucas (1988)	In the study, it is emphasized that human capital accumulation through education has positive effects on technological development and economic growth.
Romer (1990)	In the study, it is stated that investments made in the research sector and human capital contribute to technological development and economic growth.
Aghion and Howitt (1990)	In the study, it was stated that competitive innovation production causes rapid obsolescence of innovations. Although this situation creates negative effects for innovations, it is stated that continuous innovation can also contribute to growth despite the possibility of obsolescence of the innovations.
Grosman and Helpman (1989, 1990, 1991)	In the studies, the effects of the process of production and spillovers of knowledge on technological change and growth have been revealed.
Parashar & Singh (2005).	In the study, it was stated that knowledge capability, creative capability and attitudinal capability are important in the development of innovation capability.
Saunila & Ukko, (2012).	In the study, it was stated that there is a relationship between innovation capability and firm performance at the firm level.
Zawislak et al (2012)	It was stated that among the factors affecting the innovation capability of companies, technology development, operations, management and transaction components are important.
Rajapathirana & Hui (2018)	It has been stated that in companies with high innovation capacity, the innovation capacity positively affects the performance of the companies.
Qi et al (2020)	In the study, it was stated that focusing on research and development, industrial structure, fiscal policy and incentives are important in the development of regional innovation capability.
Mi et al (2020)	In the study, it was stated that the strategic investments and institutional capacities of multinational companies are important on the development of their innovation capabilities.
Wang et al (2020)	In the study, it was stated that a good institutional environment, high level human capital research, supportive infrastructure are important on the development of national innovation capabilities.
Mendoza-Silva, (2021).	In the study, it was stated that social structures among employees are important in the development of innovation capability at the firm level.
Jeon et al (2021)	In the study, national innovation capability is defined as the innovation development capacity of the state in the field of science and technology that enables it to increase social and economic welfare.
Park et al (2021)	In the study, it was stated that determining the determinants of regional competitiveness and a correct strategic planning play an important role in the development of regional innovation capability.

## EMPRICAL ANALYSIS

### Data and Methodology

Table 2. shows data source and definition of the variables. Data for 141 countries around the world and for the year 2019. Data is obtained from WEF the Global Competitiveness Index 4.0 Dataset. Dependent variable is Innovation Capability. Independent variables are financial system, business dynamism, research development and commercialization. We also use different control variables such as GDP, Human Capital etc. but we report the most statistically suitable model estimation results.

Table 2. Data and Variables

Variable	Definition	Year	Country
Innovation Capability	It measures the level of incentives in a country for collaboration, connectivity, creativity, and diversity in different visions, the capacity to transform ideas into new products and services, the quantity and quality of formal research and development. (1-100 scale, 100 best)	2019	141
Financial system	The depth of the financial system, that is, the availability and stability of credit, equity, debt, insurance and other financial products, that is, the reduction of excessive risk-taking and opportunistic behavior of the financial system. (1-100 scale, top 100)	2019	141
Business Dynamism	Business dynamism defines a culture that includes the capacity of the private sector to produce and adopt new technologies, new ways of organizing business, easy entry and exit of companies, change, risk, new business models and administrative rules. (1-100 scale, top 100)	2019	141
Research Development	Research and development covers scientific publications, patent applications, R&D expenditures, research institutions prominence index. (1-100 scale, top 100)	2019	141
Commercialization	Commercialization covers buyer sophistication and trademark applications (1-100 scale, top 100).	2019	141

Source: WEF (2019) the Global Competitiveness Index 4.0 Dataset.

Estimated regression model is given in *Equation.1*. The estimator for the model is the Variance-covariance matrix of the estimators, vce (Robust) because of heteroscedasticity in the OLS estimator residuals based on the results Breusch-Pagan / Cook-Weisberg test for heteroscedasticity.

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + u_i \quad \text{Equation.1.}$$

where  $i = 1, 2, \dots, N$ .

$Y_i$ : Innovation Capability

$X_{1i}$ : Business Dynamism

$X_{2i}$ : Financial system

$X_{3i}$ : Research Development

$X_{4i}$ : Commercialization

$u_i$ : Error term

expected signs for the coefficients is as follow

$$\beta_1 > 0; \beta_2 > 0; \beta_3 > 0; \beta_4 > 0$$

### Empirical Results

Table.3. shows the descriptive statistics for the variables. The mean of innovation capability is 42.98, the mean of business dynamism is 59.95, the mean of financial system is 62.44, the mean of research development is 36.30 and the mean of commercialization is 54.45.

**Table.3.** Descriptive Statistics for the Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Innovation Capability	141	42.98	17.06	18.00	86.80
Business Dynamism	141	59.95	11.41	14.10	84.20
Financial system	141	62.44	14.19	29.00	91.40
Research Development	141	36.30	22.70	13.50	100.00
Commercialization	141	54.45	16.70	11.80	84.90

Table.4. shows estimation results for equation 1 with the estimator of variance-covariance matrix, vce (robust). According to the estimated model results, all the explanatory variables in the model are statistically significant at the 0.01 significance level. According to the F test results, the estimated model is a statistically significant overall. As there is a heteroscedasticity problem in OLS estimation based on the results Breusch-Pagan / CookWeisberg test for heteroscedasticity. Variance-covariance matrix of the estimators, vce (Robust) is used. Rsquare result is good enough for the model fitting. Also, there is no multicollinearity problem in the model (VIF <5). According to the estimated model results, all explanatory variables in the model affect the dependent variable in the same direction. The signs of the coefficients of the explanatory variables are in line with the economic expectation.

**Table.4.** Estimation Results for Equation 1 (Dependent variable is Innovation Capability)  
(Estimator: Variance-covariance matrix of the estimators, vce (Robust))

<i>Explanatory variables</i>	Coef.	Robust Std. Err.	t	P> t	VIF
Business Dynamism	.11813	.0333949	3.54	0.001	3.24
Financial system	.129736	.0292189	4.44	0.000	3.45
Research Development	.500314	.0176295	28.38	0.000	2.70
Commercialization	.224821	.0208086	10.80	0.000	3.16
cons	-2.605663	1.329173	-1.96	0.052	

Number of obs = 141

F(4, 136) = 1320.57

Prob > F = 0.0000

R-squared = 0.9808

Root MSE = 2.3997

Breusch-Pagan / Cook-Weisberg Test For Heteroscedasticity:

$\chi^2$  (1) = 17.36; Prob > chi2 = 0.000

## DISCUSSION AND CONCLUSION

The main purpose of this study is to analyse the macroeconomic determinants of innovation capability for 141 countries around the world. In the study, according to the estimated model results, all explanatory variables in the model affect the dependent variable in the same direction. The signs of the coefficients of the explanatory variables are in line with the economic expectation. Developments that are explanatory variables - business dynamism, financial system, research development and commercialization - also contribute to the development of the innovation ability of countries. According to these results, it is of great importance to

implement policies that will improve the innovation climate in order to develop innovations, which are the main source of economic development and sustainable economic growth.

The following policies play a critical role for countries to improve their innovation capabilities. These policies include devoting more resources to research and development; invest more in human resources in research sector; make university-industry cooperation more effective; provide more funding and incentives to the research sector; to further support innovative entrepreneurship; At the macroeconomic and microeconomic level, it is necessary to develop policies that will further strengthen the innovation capabilities of enterprises.

The results of the study support the results in the literature. Focusing on research and development, attracting financing conditions, dynamism of the business world and commercialization of innovations are important in developing national innovation capability.

Since increasing the innovation capability of countries is an important field of scientific study, further scientific studies in the future may analyse the microeconomic and macroeconomic determinants of innovation capability according to country groups. With the development of more appropriate policies according to country groups, more contribution will be made to the development of these countries

#### **Ethical Text**

In this article, journal writing rules, publishing principles, research and publishing ethics rules, journal ethics rules are followed. Responsibility belongs to the author for any violations related to the article.

**Statement of Author's Contribution Rate:** The author's contribution rate in research is 100%.

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