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HOW DOES THE GLOBAL INNOVATION INDEX SCORE AFFECT INCOME? A POLICY FOR INNOVATIVENESS

KÜRESEL YENİLİKÇİLİK ENDEKS PUANI GELİRİ NASIL ETKİLER? YENİLİKÇİLİK İÇİN BİR POLİTİKA

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Abstract

It is well known that innovation is essential for competition, and countries must pursue several policies and take steps to be regarded as innovative. This study aims to investigate the association between national income and the variables that form the Global Innovation Index (GII), an indicator of nations' innovativeness, and to provide a road map for developing countries. First, The Ordinary Least Square (OLS) method was used to analyze the effect of the main pillars of the GII score on the country's income. Then Two-Stage Least Square was applied to determine whether the factors that were not significant on the OLS have essential instrumental variables. As a result, it has been determined that all the main factors that make up the GII score are statistically significant at different levels of importance on the country's income. However, only the creative output factor was inversely related to income among these factors.

This study assists developing countries in both reconsidering their innovation policies and identifying deficiencies for improving their innovation levels. Focusing on the crucial factors for countries will allow them to contribute to their economic progress more swiftly and efficiently.

Keywords: Global Innovation Index, country's income, comparative innovativeness factors, competitive strategic management

JEL Classification: O32, O38

Öz

Yeniliğin rekabet için önemli olduğu bilinmektedir ve ülkelerin yenilikçi sayılabilmesi için birtakım politikaları izlemesi ve adımları atması gerekmektedir. Bu çalışmanın amacı, ülkelerin gelirleri ile yenilikçiliğinin bir göstergesi olan Küresel İnovasyon Endeksi'ni (GII) oluşturan faktörlerin ülke geliri ile ilişkisini incelemek ve gelişmekte olan ülkeler için bir yol haritası çizmektir. Öncelikle, GII puanını oluşturan ana faktörlerinin ülke geliri üzerindeki etkisini analiz etmek için Basit Doğrusal Regresyon (OLS) yöntemi kullanılmıştır. Daha sonra OLS üzerinde anlamlı olmayan faktörlerin, önemli araç değişkenlere sahip olup

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olmadığını belirlemek için İki Aşamalı En Küçük Kareler (2SLS) yöntemi uygulanmıştır. Sonuç olarak, GII puanını oluşturan tüm ana faktörlerin ülke geliri üzerinde istatistiksel olarak farklı önem seviyelerinde anlamlı olduğu saptanmıştır. Ancak bu faktörlerden sadece yaratıcı çıktı faktörünün gelir ile ters yönde ilişkili olduğu ortaya çıkmıştır.

Bu çalışma, hem gelişmekte olan ülkelere yenilik politikalarını yeniden gözden geçirmeye, hem de yenilikçilik düzeylerini iyileştirmeye yönelik eksikliklerini belirlemede yardımcı olmaktadır. Ülkeler için çok önemli olan faktörlere odaklanma ise onların ekonomik büyümesine daha hızlı ve etkin bir şekilde katkıda bulunmasını sağlayacaktır.

Anahtar Kelimeler: Küresel İnovasyon Endeksi, ülke geliri, karşılaştırmalı yenilikçilik faktörleri, rekabetçi stratejik yönetim

JEL Sınıflandırması: O32, O38.

1. Introduction

The economic development level of countries can be associated with their incomes, and it might be claimed that a country's competitive power is proportional to its economic power. Growth is widely acknowledged as the most effective means of improving the quality of life-sustaining factors such as education, nutrition, health, and survival, as well as eradicating poverty (World Economic Forum, 2019). Hence, countries have strongly emphasized continuing to grow and constantly improving their welfare levels. The Global Competitiveness Index 4.0 (GCI), which assesses countries' global competitiveness indexes, considers several policies and factors determining their productivity levels. Besides, a study (H. Lee & Park, 2005) that compared Asian countries' productivity in terms of R&D revealed Singapore had the highest score in productivity (99.38%) due to the technology balance taken in 1999. The reason for the R&D efficiency of the countries is the healthy and well-functioning innovation strategies (Hu, Yang, & Chen, 2014a) because the competition policy of governments also affects their economic growth. According to WEF (2019), low competitiveness diminishes economic dynamism, promotes capital sharing, and widens the pay difference. China has the world's second-largest economy, with a population of 1.38 billion and a nominal gross domestic product (GDP) of $10,983 trillion (Heikkila, Berardo, Weible, & Yi, 2019) may be the effect of the current political order. According to GCI data for 2019, Singapore is the most competitive country, with 84.8 points out of 141 countries, followed by the USA (83.7), Hong Kong SAR (83.1), and the Netherlands (82.4), respectively.

In contrast, Switzerland and Japan (83.3) are in the same rank (World Economic Forum, 2019). Economic wellbeing – people's control over created commodities and services – may be measured in historical contexts using measurements of GDP, which is the appropriate starting point for any historical analysis of wellbeing. GDP is a crucial metric for assessing a country's economic success, which is a key determinant of people's financial well-being (Bolt, Timmer, and van Zanden 2014). GDP is an indicator of a country's economic power (GDP), calculated by dividing this figure by population. Hence, the higher the GDP, the higher the GDP per capita (Harvie, Slater, Philp, & Wheatley, 2009).

Some wealthy countries do not owe their wealth to natural resources. In contrast, others with abundant natural resources are not highly economically developed, although there is a positive correlation between a country's diversity of natural resources and its income level (Bravo-Ortega & de Gregorio, 2011). For instance, when comparing Botswana to Sierra Leone, both diamond exporters, it can be seen that Botswana has contributed impressively to its economic growth by independently managing its rents and revenues from natural resources since 1966. It was even recorded that it had the world's GDP per capita growth rate until 1998, despite a downward trend after 1990. On the other hand, Sierra Leone struggled to control the country's diamond trade and, according to the World Bank, was the poorest country in the world in 1998 (Gylfason & Zoega, 2006).

Jorgenson and Vu (2013) suggest that economic growth is the result of two processes: one is reproducing existing technologies by investing more money and employing more workers, and the other is an innovation brought about by technological changes. That is the reason behind state-funded project announcements that are pretty frequent in social and printed media. Increased project supports and collaborations with other countries indicate how much governments recognize the importance of innovative projects.

Innovativeness is the degree of adaptation to a new idea within the social system in which an individual or unit is present (Rogers, 1983). The earliest adopters of the innovation are classified as pioneers, and the last to adapt are classified as laggards. The widely recognized GII (Global Innovation Index) score is considered in the classification of countries' innovation, and countries with the highest GII scores are considered pioneers in innovation. Seven main factors of support determine this score port: These are Institutions (Political Environment, Regulatory Environment, Business Environment), Human Capital & Research (Education, Tertiary Education, Research & Development), Infrastructure (Information and Communication Technologies-ICTs, General Infrastructure, Ecological Sustainability), Market Sophistication (Credit, Investment, Trade Competition and Market Scale), Business Sophistication (Knowledge Workers, Innovation Linkage, Knowledge Absorption), Knowledge & Technology Outputs (Knowledge Creation, Knowledge Impact, Knowledge Diffusion), and Creative Outputs (Intangible Assets, Creative Goods and Services, Online Creativity). Sub-factors explaining each support factor are given in parentheses.

These factors determine the effect of the countries' steps on the innovation path. This study aims to examine the effects of these factors, which constitute the global innovation index of nations, on the countries' income. Countries that build their innovation policies on the factors that have the most significant effect on income will be able to take a faster and more effective step on this path and compete with developed countries in the long run.

2. Literature Review

Apart from the income that countries will obtain by operating their assets, their level of creation and use of information and technology will also contribute to the economy of nations. The literature claims that global capital is more equitably distributed, particularly in the 21st century, when knowledge is crucial (Piketty, 2014). This situation demonstrates that the country's economy may be boosted without relying only on natural resources.

From a macroeconomic perspective, human capital accumulation improves labor productivity, facilitates technological innovations, and increases returns to money (Son, 2010). The fast development of science, the diffusion of information and communication technologies, and the conversion of human capital and its intellectual component into the leading resource of tangible and intangible production provided the change to the information economy and, in some countries, to the knowledge economy (Podra, Litvin, Zhyvko, Kopytko, & Kukharska, 2020). Quality of human capital signifies knowledge creation; institutional support and human capital affect knowledge impact; human capital and institutional support demand knowledge diffusion (Kwan & Chiu, 2015).

Comprehending the efficacious channels of technology diffusion is vital for policymakers in the face of expanding globalization. Several factors influence the possibility of technology transfer. One of them is the social capability of an economy (Abramovitz, 1986), which requires various efforts and capabilities to improve education, infrastructures, and, more commonly, technological abilities (Teixeira & Fortuna, 2010).

The competition mechanisms, investment, and innovation drive human capital formation and development. The public and private investment magnitude relies on investors' returns, the economic state, the education sector, and country policies that specify the priorities for the investment allocation(Forrester, Ustinova, Kosyakova, Ronzhina, & Suraeva, 2016).

Implying that being developed with productivity and renewal adaptations was associated with growth, Benhabib and Spiegel (1994) identified a positive and significant correlation between the productivity growth rate and the stock of human capital in their study. They believe that the growth will be driven by the capital stock of human capital rather than the human capital accumulation rate (Amsler & Bolsmann, 2012). A study concluded that if a country spends more on R&D, then it has more significant growth levels of Total Factor Productivity (Habib, Abbas, & Noman, 2019).

According to Rogers, innovativeness is the degree to which a person or other unit of adoption embraces new ideas substantially sooner than other members of a social system (Rogers, 1983). Additionally, a country's innovativeness is heavily influenced by four factors: GDP per capita, educational attainment, number of engineers and scientists, and the percentage of manufacturing and service industries in total GDP (Chol Lee, 1990).

On the other hand, it compared countries to the GII, which rates countries according to their performance. Alparslan, Yastıoğlu, and Taş (2018) stated that among 142 countries, Turkey ranked 74th in 2012, 68th in 2013, 54th in 2014, 58th in 2015, and 42nd in 2016. In terms of innovation performance, Turkey appears to be steadily improving. However, when Turkey is compared to OECD and European countries, this growth does not appear to be sufficient (Alparslan, Yastıoğlu, & Taş, 2018). The underlying reason for mentioning the Turkish data is not apparent.

Hajek, Henriques, and Hajkova (2014) evaluated potential relationships between regional innovation system components and investigated possible associations between regional innovation systems components and economic growth using Self Organizing Map (SOM), a self-organizing artificial neural network technique. As a result, it is found that knowledge-intensive regions affect innovation. It has been determined that the economic growth of European regions is related to the country's innovation and entrepreneurial activity level. On the other hand, companies in countries that follow technology from afar follow an investment-based strategy (Acemoglu, Aghion, & Zilibotti, 2006).

Many countries invest in R&D studies to achieve long-term and consistent growth (Hu, Yang, & Chen, 2014b). Such studies are carried out in universities and technoparks, including the R&D departments that companies establish within their structure and private R&D departments.

A European industrial R&D investment review revealed that 2,500 companies are the world's largest investment holders in total. Following the United Kingdom's exit from the European Union, it was discovered that the world accounted for roughly 90% of R&D based on business. Out of these 2500 companies, 421 (20.9%) were established in Europe and 124 of which in Germany, 775 (38.5%) in the USA, 309 (12.7%) in Japan, 536 (13.1%) in China, the remaining 459 in other countries (Grassano, N., Hernandez Guevara, H., Tuebke, A., Amoroso, S., Dosso, M., Georgakaki, A. and Pasimeni, 2020). It is striking that America is the pioneer in this field, and Europe is the second. The same report revealed that most investments were made in information and communication technologies in 2018. When the R&D factor affecting the GII score of the countries is examined in general, it is seen that Norway (64.6) and Sweden (64.6) take the first place. They are followed by Switzerland (62), Denmark (61.5), Estonia (61.2), the United Kingdom (60.3), Spain (60.1), and Japan (60), respectively. With 54.73 points, the USA ranks 24th.

Universities are expected to contribute to the economy in various ways because qualified workers perform tasks that require literacy and critical thinking efficiently indirectly, and an increased proportion of educated workers makes a country's economy more productive (Lestari Widarni & Bawono, 2021). For example, as is stated, the rate of R&D investment, the presence of R&D companies on the global scale, and the number of researchers and universities ranked in the top three in the QS rankings demonstrate a country's R&D power, which has a significant effect on the country's economy.

However, cooperation and the opportunities provided by the government play a crucial role, especially in creating technology at the university as an industrial requirement and its transfer to the industry.

Universities worldwide have begun competing for a place among ultra-elite (1-2%) universities. Universities employ global rivalry as a political instrument, and the fact that they are world-class reflects a country's efficiency, power, and prestige (Amsler & Bolsmann, 2012). In the universities where knowledge is produced, the emergence of new publications, the production of research, and access to other information undoubtedly facilitate information and communication technologies (ICTs). Indeed, this service, provided free of charge in many developed countries, provides an advantage to the country's citizens. In less developed countries, however, the situation is the polar opposite. According to a study, countries with limited access to ICTs have a common denominator of low income, low educational skills, low literacy, and a high GDP indicator as a measure of economic wealth. The study discovered that general economic power determines Internet access even in economically prosperous countries. (Hargittai, 1999). However, he also considers that GDP per capita is not the main factor in the spread of the Internet and that elements should be investigated at least at four levels (White, Gunasekaran, Shea, & Ariguzo, 2011).

Furthermore, while GDP per capita has been demonstrated effective in spreading ICTs, states' investment in ICTs also assures that these technologies are widely used. It has proven to be an essential factor in the widespread adoption of personal computers and the Internet (Quibria, Ahmed, Shamsun N. Tschang, Reyes-Macasaquit, & Mari-Len, 2002). Other factors influencing the spread of the Internet are vital telephone infrastructure, robust service sector employment, high political openness, and breadth of urban density (Crenshaw & Robison, 2006).

Innovation, research and development, and economic power have all been highlighted in previous studies. This study investigated whether all these different efforts, studies, and expenditures are related to the country's economy. This research contributes to the literature by comparing the significance levels of these aspects that reflect the countries' innovation studies.

2.1. GII Score

Global Innovation Index (GII) measures innovativeness. GII contains three sub-indices: overall GII, the Innovation Input Sub-Index, and the Innovation Output Sub-Index. GII score is calculated by estimating the mean of Input and Output indices, and these two sub-indices have their sub-indices. The input index comprises institutions, human capital and research, infrastructure, market sophistication, and business sophistication factors, which are the main pillars of the national economy that incorporate innovative shiftings. On the other hand, the output sub-index includes both the knowledge and technology outputs and creative outputs. The sub-indices are given in Appendix. The chart below shows the countries' GII scores in the year 2021.

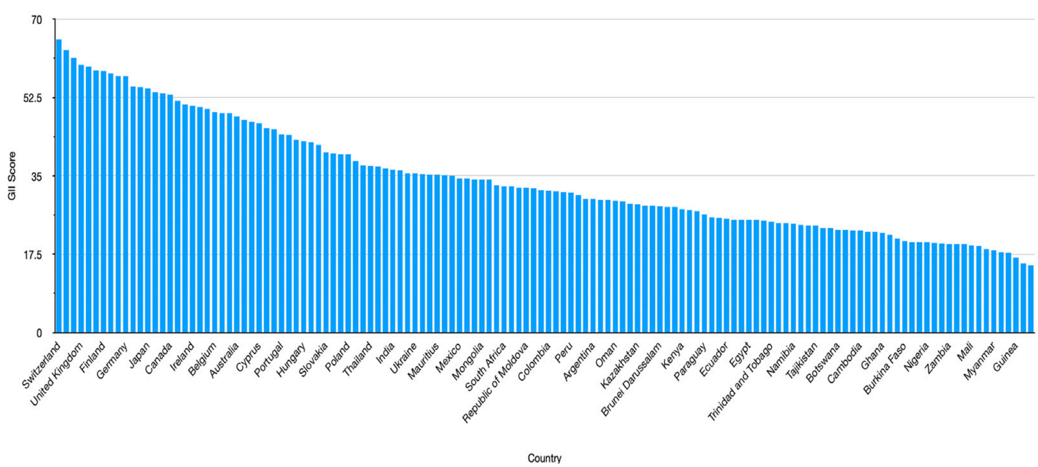

Figure 1: Countries vs. their GII scores ranking

The chart above reveals that the highest score belongs to Switzerland while the lowest belongs to Angola.

If it is looked at the top of the GII rank, then it can be seen that Switzerland has held the first rank since 2021. It is in the high-income group, and its innovation productivity is also high because it delivers better innovation outputs relative to its level of innovation investments. It is also good at the creative outcomes and level of infrastructure. Unlike Switzerland, Angola is the weakest country in the GII rank and the lower-middle-income group.

Figure 2 below displays the primary pillar performance of both countries. Switzerland's best performance is in knowledge and technology outputs, while its inadequate performance is in institutions, human capital, and research.

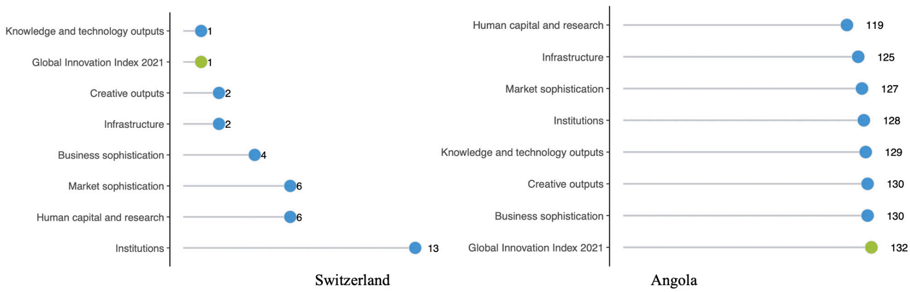

Figure 2: The main pillar ranking for Switzerland and Angola (World Intellectual Property Organization, 2021).

Compared to Switzerland, Angola performs well in human capital and research, among its other pillars score.

3. Method

3.1. Data

The study includes data between 2015 and 2020. The countries' incomes were obtained from the World Bank database. The differences in the sub-components used in calculating the GII score by years were subtracted, and the common sub-components in each year were analyzed. For example, while one component (item 1.3.3.) was additive in determining the innovation scores of the institutional environments of the countries in 2015, this component was not taken into account or calculated in other years. Similar situations were encountered in 2016 and 2018 as well. Therefore, sub-components that are not common for each year were not included in the analysis. Before analysis, missing values and outliers were removed, and the data were normalized. For removing outliers in the data set, the Mahalonabis Distance method was used.

3.2. Analysis

R studio (version: 2022.02.2+485 "Prairie Trillium") was used to analyze the models. The Ordinary Least Square (OLS) method was used to analyze the effect of the main pillars of GII on the country's income. Then Two-Stage Least Square was applied to determine whether the factors that were not significant on the OLS had meaningful instrumental variables.

The dependent variable Y_i in the multiple regression model, whose statistical equation (Eq.1) is given below, represents the countries' incomes and the variables X_{ij} represent the innovation index components that can affect the nations' revenues.

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \cdots + \beta_k X_{ki} + u_i \qquad i=1,\ldots,n \tag{1}$$

Market and business culture, which are among the factors determining GII, can be considered factors affecting each other bilaterally. In addition, human capital and research factor, knowledge and technology outputs, and creative output factors might affect business culture and, thus, indirectly affect the country's income. Because human capital, knowledge, and related R&D studies and the resulting technology values and business culture can indirectly affect the country's revenue. The innovation policies of the countries and the infrastructure they provide are the factors that can affect the country's income through market competence. For this reason, the 2SLS method was applied in this study.

In the first stage of the 2SLS technic, all variables are estimated by the OLS method (Eq. 2).

$$x_i = \alpha + \beta_1 z_1 + \beta_2 z_2 + \cdots + \beta_k z_k \tag{2}$$

Values in this regression model are estimated and labeled ($\acute{x}_{r1}$). In the second step, the variable in the equation (Eq. 3) is calculated by using the estimated values in (Eq. 2) with the OLS method (Hoffmann, 2022).

$$y = \alpha_r + \beta_{r1} \acute{x}_{r1} \tag{3}$$

This way, the coefficients of the variables contaminated with the error terms in the OLS model have been estimated more accurately, and the residual values correctly reflect the measurement error.

4. Results

4.1. Descriptive Statistics

There was 720 sample in the dataset. Table 1 shows the descriptive statistics of the variables to be analyzed. The income range is pretty broad and is valued in dollars. The mean value of revenues of the countries according to five years is $6.62*10^{11}$, the lowest income value is $1.70*10^{9}$, while the highest is $2.14*10^{13}$.

The min value among the main pillars is 0, and the max value 100. The smallest mean value in the central pillar is knowledge and technology output, while the highest belongs to the institutional environment. The first quartal of market sophistication is 29.5, and the third quartal is 51.7.

Table 1: Descriptive Statistics of the Variable

Statistics	Income	INS	HUM	INFR	MAR	KNW	BUS	CRT
Min	1.70E+09	6.5	0	0	0	2	8.6	0.4
1st Qu	2.57E+10	27.32	24.88	26.6	29.5	15.68	23.7	18.88
Median	9.04E+10	48.75	36.95	41.7	43	22.6	30.3	28.05
Mean	6.62E+11	47.72	39.85	39.15	39.56	26.16	33.29	29.48
3rd Qu	3.75E+11	64.4	54.23	52.75	51.7	33.9	40.62	39.2
Max	2.14E+13	95.1	93.4	99	100	74.9	68.8	69.5

Pillars Code: INS: Instıtutıons, HUM: Human Capital and Research, INFR: Infrastructure, MAR: Market Sophistication, KNW: Knowledge and Technology Outputs, BUS: Business Sophistication, CRT: Creative Outputs

Business sophistication has the smallest max value (68.8) among the others, whereas market sophistication has the highest. The second smallest mean among pillars is creative outputs, with 29.48, and the median is 28.5.

4.2. Analysis Result

The β coefficients of the independent variables estimated by (OLS) and the coefficient estimates are shown in Table 2 below.

Table 2: Results of Multiple Regression (OLS) Analysis

Variables	Estimate	Std. Error	t value	Pr(>|t|)	Sig.	VIF
(Intercept)	-0.03	0.01	-2.63	0.01	**	
INS	-0.04	0.02	-2.12	0.03	*	2.15
HUM	-0.01	0.03	-0.20	0.84		2.34
INFR	0.07	0.03	2.48	0.01	*	2.42
MAR	0.02	0.02	0.92	0.36		1.76
KNW	0.25	0.04	6.04	0.00	***	5.04
BUS	0.01	0.04	0.20	0.84		4.68
CRT	-0.10	0.04	-2.72	0.01	**	3.71

*Significance codes: 0 '***' 0.001 '**' 0.01 '*'.*

Variables Code: INS: Institutions, HUM: Human Capital and Research, INFR: Infrastructure, MAR: Market Sophistication, BUS: Business Sophistication, KNW: Knowledge And Technology Outputs, CRT: Creative Outputs

It is seen from Table 2 that BUS, MAR, and HUM variables are statistically insignificant, but other variables affect the dependent variable Income at different significance levels.

There is no multicollinearity problem between the variables (VIF values <10), but when the correlations between the variables are examined (Table 3), it is seen that these variables are significantly related to KNW.

Table 3: Pearson Correlation Coefficient Matrix of the Variables

	Income	INS	HUM	INFR	MAR	KNW	BUS	CRT
Income	1							
INS	0.14	1						
HUM	0.24	0.09	1					
INFR	0.27	0.62	0.33	1				
MAR	0.15	0.61	0.05	0.49	1			
KNW	0.38	0.48	0.67	0.63	0.40	1		
BUS	0.32	0.46	0.64	0.66	0.39	0.86	1	
CRT	0.25	0.50	0.58	0.67	0.45	0.80	0.80	1

From this point of view, the variables HUM, BUS, and MAR might be instrumental, which were insignificant to the dependent variable in the OLS. It could be influential on Income indirectly and through KNW. Therefore, the regression model was analyzed using the Two-Stage Least Squares (2SLS) method.

Table 4 below shows the OLS model vs. IV model comparisons. In the first model, if one unit increases the KNW score, a 25.4% increase in the income of a country's KNW score would have 25.4% more Income. For the first model, the adj. R^2 for this model is 0.15, with a residual standard error of 0.09. The explained variance is low, but its p-value is small ($F = 33.38$, p-value <0.001). The estimated KNW coefficient value is 0.25, but the coefficient values in the model may also include error measurements.

The variables' coefficients in the first model were changed in Table 4. Except for the constant value and the INFR variable, the variables' absolute coefficient values increased with adding the instrumental variables to the second model.

Table 4: Comparison of OLS and 2SLS Models

Model	Variables	Estimate	Std.Error	t value	Pr(>|t|)	Sig.
Model OLS	(Intercept)	-0.03	0.01	-3.08	0.00214	**
	KNW	0.25	0.03	7.90	1.03E-14	***
	CRT	-0.09	0.03	-2.78	0.0055	**
	INS	-0.03	0.02	-1.91	0.05692	.
	INFR	0.07	0.03	2.69	0.0074	**
Model IV	(Intercept)	-0.03	0.01	-3.07	0.00223	**
	KNW	0.26	0.05	5.09	4.61E-07	***
	CRT	-0.09	0.04	-2.21	0.0278	*
	INS	-0.03	0.02	-1.90	0.0576	.
	INFR	0.07	0.03	2.64	0.00856	**

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*'.*

As seen in Table 5 below, the *F* statistics of the 2SLS model was 480.4 on 6 and 713 *df*, *p*-value <0.01. Adjusted R-squared is computed that 80% of the variance found in the dependent variable (Income) can be explained by the predictor variables.

Table 5: F Test Results

Adj. R^2	Multiple R^2	Residual standard error	*df*1, *df*2	*F*-statistic	*p-value*
0.8	0.8017	0.0857	(6), (713)	480.4	< 2.2e-16

If the details in Table 6 are closely examined, then the regression of exogenous and instrumental variables on KNW. All variables are statistically significant apart from the variable of INFR, and the variable of INS was found significant at level 0.05.

Table 6: The Estimation of Coefficients of all Variables by 2SLS

Variables	Estimate	Std. Error	t value	Pr(>|t|)	Sig.
(Intercept)	-0.07	0.01	-7.68	5.42E-14	***
INS	0.21	0.03	6.94	8.73E-12	***
HUM	0.07	0.02	4.14	3.87E-05	***
INFR	0.02	0.02	0.95	0.341	.
MAR	0.22	0.02	9.95	<2E-16	***
KNW	0.04	0.02	2.01	0.0452	*
BUS	0.40	0.03	14.20	<2E-16	***
CRT	-0.07	0.01	-7.68	5.42E-14	***

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*'.*

The model equation is given in Eq. 4 below. The most influential factor was business sophistication on countries' incomes, while the less was knowledge and technology output.

$$\boldsymbol{Income} = -0.07 + 0.21\boldsymbol{INS} + 0.07\boldsymbol{HUM} + 0.02\boldsymbol{INFR} + 0.22\boldsymbol{MAR} + 0.04\boldsymbol{KNW} + 0.40\boldsymbol{BUS} - 0.07\boldsymbol{CRT} \quad (4)$$

The model equation indicates that for every unit increase in Business sophistication, the mean of the dependent variable (Income) also tends to increase by 0.40235 when other variables are held constant.

4.3. Model Accuracy

There is no specific method to test the accuracy of the 2SLS model. However, some authors suggest the *F*-statistics of instrumental variables should be larger than 10, providing the maximum bias in IV estimators is less than 10 % (Takashi Yamano, n.d.).

Other tests used to assess the model accuracy and their results are given in Table 7 below. The Weak instruments test checks for the weakness of instrumental variables using the *F*-test in the first stage. The null hypothesis assumes that the instrumental variables are weak. It is seen from Table 7 that the null hypothesis was rejected (*p*<0.01), and the variables were vital.

Table 7: 2SLS Model's Accuracy Results

	df1	*df2*	*Statistic*	*p-value*	*Sig.*
Weak-instruments	3	713	27.97	<2e-16	***
Wu-Hausman	1	714	0.18	0.67	
Sargan	2	NA	0.92	0.63	

Another criterion is the Wu-Hausman *F* test, which tests the presence of the endogenous variable. The null hypothesis assumes consistency with the coefficients of the 2SLS and OLS models. Rejection of the null hypothesis implies the existence of endogeneity and the requirement for instrumental variables. However, it is said that the consistency of this test would give more accurate results as the sample size increases (Hoffmann, 2022). Accepting the null implies that the OLS and IV estimates are similar, and endogeneity might not have been a major issue. According to the test result, it can be considered that there is no need for a 2SLS model (p-value >0.05).

The Sargan test, on the other hand, is used to test if the instrumental variables are exogenous. However, it is argued that this test is valid when the number of instrumental variables in the model exceeds the number of x variables. Instrumental variables in the model are exogenous (p-value>0.05).

The test result, as mentioned above, is confusing in concluding the model's accuracy. Because it has been revealed that the effect of mediating variables is not weak; hence, the presence of endogeneity is not needed.

Although in the first OLS model, the factors such as business and market sophistication components, human capital, and research have no significant impact on income, the 2SLS model showed that the power of these instrumental variables could not be ignored. Hence, the 2SLS model's parameter coefficients (Table 6) are considered in this study.

5. Discussion and Conclusion

This study investigated the effects of the factors that determine the countries' global innovativeness index on their economy.

In the study, business sophistication was the most impactful factor on income. The second influential of these factors was the market sophistication component impacting the country's revenue. Based on the information, the following conclusion may be drawn. Licensing and commercialization of technology developed through knowledge production, the formation of spin-off companies from universities, international joint-based projects, and publication and citation in prestigious journals with high impact factors contribute to the countries' income.

The study's other finding is that countries with political and operational stability and effective governments contribute more to the country's economy. Governments' development policies, decisions, the creative and inventive environment they create, and the incentives they provide in this environment will assist the country's economy. For instance, organizations like Mindlab, founded in

Denmark in 2001 to foster creativity and innovation, demonstrate the significance governments place on innovation. This organization, which embodies innovative concepts for internal development and policy creation and is staffed by five full-time employees with various skills, is backed by the Ministry of Economy and Business Affairs (Celia Lee & Ma, 2020). This positive environment created by Denmark is also reflected in the GII 2020 report. When a ranking is made in the category of the political environment in the report, it is seen that Singapore has the highest score (100), Switzerland ranks second (94.2), Denmark ranks fifth (91.7), China ranks seventh (90.9), and the United States ranks 16th (83.7) (Cornell, INSEAD, & WIPO, 2020). In particular, strategic objectives such as the business and policy environment created by the countries, which are among the parameters that determine the GII, and the infrastructure services they provide affect the nations' incomes.

The contribution of the general infrastructure to the country's economy is another result. This factor is explained by the variables of power output, logistics performance, and gross capital formation of countries. Unsurprisingly, a country's logistics performance contributes to the country's economy. Public investments include roads, information and communication structures, water, electricity, education, and healthcare facilities. Public utilities implicate adequate and functional infrastructure stock and create a facilitative operational environment. Such an environment supports and promotes the transformation of business ideas and creative and innovative thinking into products capable of satisfying identified needs of members of the public (Ubom & Ubom, 2014).

Because it is thought that logistics costs constitute the most significant part of all input costs in all sectors, the quality of railroad and port infrastructure is substantial in the development of logistics infrastructure (Erkan, 2014). Mozambique, which has a low economic level, ranks first in this general infrastructure category, according to the GII 2020 study, which can be interpreted mainly in terms of power output. It is followed by Qatar, Norway, Sweden, United Arab Emirates, and China. The US, on the other hand, ranks 15th.

The contribution of energy to the economy, one of the primary production sources, is extensively explored in the literature. Some believe that growing energy consumption directly correlates with increased productivity and, thus, economic growth (Stern, 2011). Hence, it is apparent that countries with abundant energy resources and high energy output will contribute to GDP. Likewise, this study supports Lean and Smyth's work that hydroelectricity use and trade have a long-term positive impact on economic growth in Bhutan when viewed in the context of increased production(Lean & Smyth, 2014).

An outstanding result of the research is an inverse relationship between creative outputs and country income. Creative work includes services and products such as entertainment and media, intangible assets such as global brand value, and online assets such as mobile applications. Although this is an unexpected result, it may be related to the fact that creative outputs are exported outside of the country where they were created or that output in the country where they were created is less valued than abroad. Another explanation for this finding might be the risks associated with new service or product features that have yet to be proven. Moreover, the cultural traits of more inventive nations are likely to differ from those of less innovative ones. A country's cultural features might affect its attitudes to authorities, religion, technology, and training. However, considering each component of creative output, investigating its relationship with country income may be a future study.

Conflict of Interest

The authors reported no conflict of interest.

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Resume

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APPENDIX-1: GII Main and Sub Indexes

1. INSTITUTIONS
    1.1. Political environment
        1.1.1. Government effectiveness
    1.2. Regulatory environment
        1.2.1. Regulatory quality
        1.2.2. Rule of law
        1.2.3. Cost of redundancy dismissal
    1.3. Business environment
        1.3.1. Ease of starting a business
        1.3.2. Ease of resolving insolvency
2. HUMAN CAPITAL AND RESEARCH
    2.1. Education
        2.1.1. Expenditure on education
        2.1.2. Government funding/pupil, secondary, % GDP/cap
        2.1.3. School life expectancy, years
        2.1.4. Pupil-teacher ratio, secondary
    2.2. Tertiary education
        2.2.1. Tertiary enrolment, % gross
        2.2.2. Graduates in science and engineering,
        2.2.3. Tertiary inbound mobility,
    2.3. Research and development (R&D)
        2.3.1. Researchers, FTE/mn pop.
        2.3.2. Gross expenditure on R&D, % GDP
        2.3.3. Global corporate R&D investors, top 3, mn US$
        2.3.4. QS university ranking, top 3
3. INFRASTRUCTURE
    3.1. Information and communication technologies (ICTs)
        3.1.1. ICT access
        3.1.2. ICT use
        3.1.3. Government's online service
        3.1.4. E-participation
    3.2. General infrastructure
        3.2.1. Electricity output, GWh/mn pop.
        3.2.2. Logistics performance
        3.2.3. Gross capital formation, % GDP
    3.3. Ecological sustainability
        3.3.1. GDP/unit of energy use
        3.3.2. Environmental performance
        3.3.3. ISO 14001 environmental certificates/bn PPP$ GDP

4. MARKET SOPHISTICATION
  4.1. Credit
    4.1.1. Ease of getting credit
    4.1.2. Domestic credit to private sector, % GDP
    4.1.3. Microfinance gross loans, % GDP
  4.2. Investment
    4.2.1. Ease of protecting minority investors
    4.2.2. Market capitalization, % GDP
    4.2.3. Venture capital investors, deals/bn PPP$ GDP
    4.2.4. Venture capital recipients, deals/bn PPP$ GDP
  4.3. Trade, diversification, and market scale
    4.3.1. Applied tariff rate, weighted avg., %
    4.3.2. Domestic industry diversification
    4.3.3. Domestic market scale, bn PPP$
5. BUSINESS SOPHISTICATION
  5.1. Knowledge workers
    5.1.1. Knowledge-intensive employment, %
    5.1.2. Firms offering formal training, %
    5.1.3. GERD performed by business, % GDP
    5.1.4. GERD financed by business, %
    5.1.5. Females employed w/advanced degrees, %
  5.2. Innovation linkages
    5.2.1. University-industry R&D collaboration
    5.2.2. State of cluster development and depth
    5.2.3. GERD financed by abroad, % GDP
    5.2.4. Joint venture/strategic alliance deals/bn PPP$ GDP
    5.2.5.Patent families/bn PPP$ GDP
  5.3. Knowledge absorption
    5.3.1. Intellectual property payments, % total trade
    5.3.2. High-tech imports, % total trade
    5.3.3. ICT services imports, % total trade
    5.3.4. FDI net inflows, % GDP
    5.3.5. Research talent, % in businesses
6. KNOWLEDGE AND TECHNOLOGY OUTPUTS
  6.1. Knowledge creation
    6.1.1. Patents by origin/bn PPP$ GDP
    6.1.2. PCT patents by origin/bn PPP$ GDP
    6.1.3. Utility models by origin/bn PPP$ GDP
    6.1.4. Scientific and technical articles/bn PPP$ GDP
    6.1.5. Citable documents H-index
  6.2. Knowledge impact

- 6.2.1. Labor productivity growth, %
- 6.2.2. New businesses/th pop.
- 6.2.3. Software spending, % GDP
- 6.2.4. ISO 9001 quality certificates/bn PPP$ GDP
- 6.2.5. High-tech manufacturing, %

6.3. Knowledge diffusion

- 6.3.1. Intellectual property receipts, % total trade
- 6.3.2. Production and export complexity
- 6.3.3. High-tech exports, % total trade
- 6.3.4. ICT services exports, % total trade

7. CREATIVE OUTPUTS

7.1. Intangible assets

- 7.1.1. Trademarks by origin/bn PPP$ GDP
- 7.1.2. Global brand value, top 5.000, % GDP
- 7.1.3. Industrial designs by origin/bn PPP$ GDP
- 7.1.4. ICTs and organizational model creation

7.2. Creative goods and services

- 7.2.1. Cultural and creative services exports, % total trade
- 7.2.2. National feature films/mn pop. 15–69
- 7.2.3. Entertainment and media market/th pop. 15–69
- 7.2.4. Printing and other media, % manufacturing
- 7.2.5. Creative goods exports, % total trade

7.3. Online creativity

- 7.3.1. Generic top-level domains (TLDs)/th pop.
- 7.3.2. Country-code TLDs/th pop. 15–69
- 7.3.3. Wikipedia edits/mn pop. 15–69
- 7.3.4. Mobile app creation/bn PPP$ GDP