Bilgi | *Journal of Social Sciences*
Sosyal Bilimler Dergisi
ISSN 1302-1761 E-ISSN 2645-9051

Bilgi, 2024, 26 (1): 65-96

ARAŞTIRMA MAKALESİ

Küresel İnovasyon Girdi Boyutunun Çıktı Boyutunu Etkilemesine Yönelik Bir Yapısal Eşitlik Modeli Uygulaması

Furkan Fahri Altınbaş[1]

MAKALE BİLGİSİ

Başvuru:
17. 08. 2024
Kabul: 15. 05. 2024
Online Yayım:
29. 05. 2024

Anahtar Kelimeler:
İnovasyon
Küresel İnovasyon Endeksi
Ülkeler

Kaynak Gösterimi
Altınbaş, Furkan Fahri. (2024). Küresel İnovasyon Girdi Boyutunun Çıktı Boyutunu Etkilemesine Yönelik Bir Yapısal Eşitlik Modeli Uygulaması, Bilgi Sosyal Bilimler Dergisi, 26 (1), 65-96. doi.org/10.54838/bilgisosyal.1344835

Özet

Amaç - Küresel İnovasyon Endeksi (GII) raporlarında belirtilen ülkelerin GII bileşen nicelikleri üzerinden, inovasyon girdi boyutunun inovasyon çıktı boyutuna olan etkisi ölçülmüştür.

Yöntem/Metodoloji/Dizayn- Ülkelere ait 2008-2022 GII raporlarında belirtilen ilgili değerlerle, inovasyon girdi boyutunun inovasyon çıktı boyutuna olan etkisi yapısal eşitlik modeli ile ölçülmüştür.

Sonuçlar- İlk olarak inovasyon girdi boyutunun çıktı boyutunu çok yüksek, anlamlı ve pozitif yönde etkilediği tespit edilmiştir. İkinci olarak etkisel yapıya en fazla katkı sağlayan bileşenin ‘‘kurumlar’’, ‘‘beşeri sermaye ve araştırma’’, ‘‘altyapı’’ ve ‘‘pazar gelişmişliği’’ olduğu gözlenmiştir

Katkı/Farklılıklar- İnovasyon girdi ve çıktı bileşenleri ilişkilerin incelenmesi açısından bu çalışma inovasyon literatürüne katkı sağladığı değerlendirilmiştir. Ayrıca küresel anlamda ülkelerin inovasyon girdi ve çıktı arasındaki bağın gelişmesi için hangi inovasyon girdi bileşenlerinin geliştirilmesi konusunda çıkarımlar sağlanmıştır..

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Bilgi
Journal of Social Sciences
Sosyal Bilimler Dergisi
ISSN 1302-1761 E-ISSN 2645-9051

Bilgi, 2024, 26 (1): 65-96

RESEARCH ARTICLE

A Structural Equation Model Application For Global Innovation Input Dimension To Affect Output Dimension

Furkan Fahri Altınbaş [1]

ARTICLE INFO

Submitted:
17. 08. 2024
Accepted: 15. 05. 2024
Published Online:
29. 05. 2024

Keywords:
Innovation
Global Innovation Index
Countries

To cite this article
Altınbaş, Furkan Fahri. (2024). A Structural Equation Model Application For Global Innovation Input Dimension To Affect Output Dimension, Bilgi Journal of Social Sciences, 26 (1), 65-96. doi.org/ 10.54838/ bilgisosyal.1344835

Purpose - The influence of the innovation input dimension on the innovation output dimension has been measured based on the values of the GII criteria of the countries specified in the Global Innovation Index (GII) reports.

Methodology/Approach/Design- The effects of the innovation input dimension on the innovation output dimension has been measured using a structural equation model with the relevant values indicated in the GII reports for the years 2008 to 2022 for each country.

Findings Firstly, it has been ascertained that the input dimension of the innovation has a notable and constructive effect on the output dimension. Secondly, it has been observed that the criteria contributing the most to the relational structure are 'institutions', 'human capital and research', 'infrastructure', and 'market sophistication'.

Originality/Value- The assessment of this study suggests a potential contribution to the field of innovation. Additionally, significant revelations have been obtained regarding the augmentation of the global interplay between the innovation input and output of various countries, precisely determining the specific innovation input criteria that require refinement.

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Introduction

The rapidly changing world economy, driven by technological advancements and global competition, has led countries to reassess their development strategies. In this context, the concept of innovation, which is a determining factor in the competition among nations, is gaining increasing importance. Innovation extends beyond the mere creation of new products or services; it encompasses a broad approach that transforms business processes, organizational structures, and societal dynamics. Therefore, innovation is now regarded not only as a driver of economic growth but also as a key to achieving multidimensional goals such as sustainable development, competitiveness, and quality of life. This is because innovation is a force that shapes countries' economic, social, and technological advancements. Innovation surpasses the limitations of traditional production methods and, by providing a competitive advantage, supports national economies through sustainable growth. Moreover, innovation not only enhances the competitiveness of businesses but also raises the skills of the workforce, contributing to individual and societal well-being. On another note, the utilization of innovation in public services and the resolution of societal challenges enables the formulation of strategies aligned with sustainable development goals. In conclusion, the concept of innovation has evolved into a dynamic force that influences countries' economic progress, societal advancement, and technological innovation. It is the driving force behind transformations that go beyond individual sectors and has the potential to elevate nations on the global stage. Through innovation, countries can achieve economic prosperity, enhance competitiveness, and address societal challenges, ultimately contributing to the realization of sustainable development objectives

In today's world, global economic and technological transformations emphasize how innovation can make a difference among countries. As the value of high-tech products and knowledge-based services increases, countries with innovation capabilities can secure a significant position in global value chains. Similarly, countries with inadequate innovation capacity may struggle to gain a competitive advantage and could lag behind in economic development. Innovation has emerged as a decisive factor in terms of economic growth, sustainable development, and competitiveness in the rapidly changing and evolving landscape of today. Moreover, innovation processes have become a fundamental strategic tool for a country or organization to sustain and propel their existence forward. Successful innovation goes beyond the generation of creative ideas; it also encompasses the feasibility, effectiveness, and value of these ideas. In light of this perspective, the comprehension and evaluation of the interplay between the prerequisites for innovation input and the yardsticks for innovation output carry noteworthy importance. The sway exerted by the determinants of innovation input on the gauges set for innovation output assumes a central role in capturing the essence of an entity's or a nation's potential for innovation and the resultant outcomes. Accurately measuring and analyzing this relationship can support the making of strategic decisions. In conclusion, the current era's global economic and technological shifts underscore the pivotal role of innovation in distinguishing countries' positions. Nations possessing innovation capabilities can harness opportunities in the ascent of high-tech products and knowledge-based services. On the contrary, countries with limited innovation capacities may grapple with competitiveness and could potentially lag in economic advancement. Innovation has risen to prominence as an essential determinant of economic growth, sustainable development, and competitive advantage, within the swiftly evolving global landscape. Furthermore, innovation processes have emerged as strategic cornerstones for sustaining and advancing the prospects of countries and organizations alike. However, the success of innovation extends beyond ideation, encompassing the viability, efficacy, and utility of conceived notions. In this context, appreciating and gauging the interplay between criteria that drive innovation and those that produce innovation outcomes assumes paramount importance. The interconnectedness of innovation's input and output criteria significantly influences the innovative potential and achievements of entities. Accurately quantifying and scrutinizing this relationship stands instrumental in steering strategic deliberations. Considering the contextual backdrop, as part of the study's delineation, the evaluation of the influence exerted by the innovation input dimension upon the innovation output dimension has been executed employing the methodologies of SEM and path analysis. These methodological tools have been wielded with the dataset consisting of GII component values attributed to nations during the interval spanning from 2008 to 2022. Accordingly, the literature section of the research elucidates essential aspects related to innovation and expounds upon prior studies conducted in the realm of innovation. Ultimately, the conclusion section draws inferences and engages in discussions based on the quantitative values obtained in alignment with the findings.

1. Literatur Review

The word "innovation" is etymologically stemming from the term "innovatus." "Innovatus" signifies 'renewal,' 'rejuvenation,' and 'novelty.' Accordingly, innovation is explained within the framework of differentiation and renewal as the reorganization of existing structures or the complete transformation into entirely new entities (Giunchigla, 2013: 2). The concept of innovation, in a general sense, encompasses a process of generating and implementing previously non-existent ideas concerning a situation or event. The diversification and differentiation in the realization of ideas indicate the innovation of positive returns or added value (Barutçugil, 1981; Yalçınkaya, 2010).

The concept of innovation was first described as the 'Driving Force of Development' by Schumpeter (1934). Within this context, Schumpeter (1934) categorized innovation into five distinct groups. These are: The implementation of a novel and different service or product to the market with multiple functionalities that did not exist before; the development of various methods and approaches in the provision of a product or service, both technically and scientifically; enabling the supply of the product or service in markets different from those previously served; utilization of different raw materials and methods in the creation of the product or service compared to what was used before; and enhancement of market competitiveness for the product or service within the context of a situational perspective.

In today's context, types of innovation are categorized into four categories based on Schumpeter's innovation framework. Accordingly, these types of innovation are explained in the following bullet points (OECD and Eurostat, 2005: 52-55):

• Service and Product Innovation: Service and product innovation refers to innovative activities that render a product or service distinctively preferable compared to its predecessors. In this regard, product and service innovation encompasses activities aimed at enhancing the elements constituting a product or service and deriving added value from the product or service.

• Process Innovation: Process innovation describes the achievement of optimal transportation methods for products. In process innovation, changes are made in methods, technical operations, materials, and software to yield positive results. This leads to decreased production and transportation costs and an elevated level of production quality.

• Marketing Innovation: Marketing innovation encompasses methods employed in the design, packaging, positioning, pricing, and market introduction of a product. Marketing innovation aims to address customer needs and manage the perception that the product is distinct and novel compared to previous offerings.

• Organizational Innovation: Organizational innovation entails the implementation of novel methods that bring about positive outcomes in the commercial activities and relationships of organizations.

The pivotal contribution of innovation to the enhancement and progress of nations' economies is of paramount importance. This is because through innovation, countries can introduce products and services to the market that address societal needs or facilitate people's lives, enabling them to establish a foothold in markets through differentiation and diversification (Porter, 1990; Clark and Guy, 2010; Drucker, 2002; Vukoszavlyev, 2019: 88). Within this context, countries consistently monitor their own innovation performances. They do so to enhance their innovation performance by addressing shortcomings, enhancing competencies, and ensuring the sustainability of their strengths, thereby employing various strategies, methods, policies, management practices, and activities. Moreover, countries also observe the innovation performances of other nations. As a result, they can forge collaborations and partnerships with countries that exhibit strong innovation performances to augment their own innovation capabilities. Consequently, countries perpetually require metrics to measure their innovation performances.

One of the internationally recognized and frequently utilized scales for measuring countries' innovation performances in academic research is the Global Innovation Index (GII), known for its validity and reliability in the international arena (Pop and Pop, 2018: 2). The GII was first measured in 2007 by INSEAD (Institut Européen d'administration des Affaires), an educational institution in France focused on business education. Subsequently, the World Intellectual Property Organization (WIPO) joined the measurement of countries' innovation performances in 2011, followed by Cornell University in 2013 (Cornell University et al., 2020). Currently, GII reports from 2007 to 2022 are available (WIPO, 2022). One of the most significant attributes of the GII is its role in guiding countries in formulating policies related to long-term output growth, enhanced productivity, and business expansion by comprehensively analyzing various dimensions of innovation within countries (Al Quallab et al., 2018: 1).

The GII is structured upon a bifurcated framework, encompassing the innovation input index and the innovation output index. The innovation input sector is formulated based on five designated criteria, in juxtaposition to the innovation output sector, which is underpinned by a pair of criteria. Additionally, within the scope of GII, there are a total of 21 variables associated with seven criteria, along with 103 sub-variables linked to these 21 variables. Quantitatively, GII, sub-indices, criteria, variables, and sub-variables for countries range from "1" to "100," where "1" indicates the lowest value and "100" represents the highest value. The arithmetic average of sub-variables calculates variables, the arithmetic average of variables computes criteria, the arithmetic average of criteria determines sub-indices, and finally, the arithmetic average of sub-indices derives countries' GII values (Cornell University et al., 2019; Duarte and Carvalho, 2020: 5, WIPO: 2022: 90). Accordingly, the aforementioned GII sub-indices, criteria, and variables are illustrated in Table 1.

Table 1: GII Sub-Indices, Criteria, and Variables.

Innovation Input Sub-Indices			
Criteria	**Variables associated with the Criteria**		
Institutions	Political environment	Regulatory environment	Business environment
Human capital and research	Education	Tertiary education	Research and development (R&D
Infrastructure	Information and communication technologies (ICTs)	General infrastructure	Ecological sustainability
Market sophistication	Credit	Investment	Trade, diversification, and market scale
Business sophistication	Knowledge workers	Innovation linkages	Knowledge absorption
Innovation Out Sub-Indices			
Criteria	**Variables associated with the Criteria**		
Knowledge	Knowledge crea-	Knowledge impact	Knowledge diffusion

and technology outputs	tion		
Creative outputs	Intangible assets	Creative goods and services	Online creativity

Reference: Ay Türkmen ve Aynaoğlu, 2017: 262, WIPO, 2022: 89

Within the framework of categorizing GII into innovation input and output sub-indices as presented in Table 1, the efficiency of countries' innovation performance can be assessed by comparing the output sub-index with the input sub-index (Usman and Liu, 2015: 32; Hancıoğlu, 2016: 130). Furthermore, based on the input-output relationship within GII, countries' innovation performance efficiencies and effectiveness can be quantitatively measured using various numerical methods.

By categorizing criteria as inputs and outputs within the GII framework, countries can analyze the relationships between GII input criteria and GII output criteria, identifying which GII input component(s) contribute to specific GII output component(s), and vice versa. By employing this analytical method, nations are enabled to boost their innovation effectiveness. This is achievable through the development of strategies and policies that align, connect, and integrate GII inputs with GII outputs, fostering a cohesive and interdependent structure. Such efforts enable countries to elevate the quantitative measures, efficiencies, and effectiveness of their innovation performance (Cornell University et al., 2020). Furthermore, the repercussions of innovation input criteria on innovation output criteria not only affects economic growth but also holds significant importance in achieving objectives beyond mere financial expansion, including competitive advantage, sustainable development, and societal well-being. The profound comprehension of this interrelation is essential for organizations and nations to bolster their innovation capacities and forge a sustainable future. This understanding paves the way for strengthening innovation capacities of organizations and nations, thereby contributing to the construction of a sustainable future marked by progress and well-being across various dimensions (Sohn et al., 2015)

When examining the literature, numerous studies related to innovation are identified, underscoring the significance of innovation for countries and other organizations. In this context, Capello and Lenzi (2012) conducted a panel data analysis using regional development, innovation, and economic growth data for European Union countries for the year 2010. They explored the relationship between the regional development dimension and the innovation dimension, as well as the interplay of the innovation dimension and economic flourishing. The research exposed that local advancement had a constructive and marked influence on innovation. Rajput's (2012) assessment encompassed the appraisal of the innovation achievements within the BRICS consortium, specifically India and China. The study delved into the time span from 2007 to 2012, drawing insights from the GII component metrics of these two nations. The research encompassed an analysis involving Russia, South Africa, and Brazil, all constituents of the BRICS alliance. Their respective GII values and gross domestic product (GDP) statistics were integrated into the study framework, aiming to investigate the Granger causality nexus existing between innovation and GDP. The findings highlighted China and India's strong potential to transform innovation inputs into outputs due to their prominent "infrastructure" advantages. However, these countries were noted to have weaker "human capital research" capacities. The research additionally detected bidirectional significant relationships between innovation and GDP. Zhirnova and Absalyaonova (2013) analyzed Russia's innovation problems using various innovation indicators. The investigation accentuated the shifting role of higher-level learning in fostering innovation undertakings and advancing the cultivation of innovation maturity. They recommended that funding for research and development (R&D) in Russia should prioritize productivity over student numbers. Sohn et al. (2015) employed SEM to delve into the ramifications of the GII input dimension on the GII output dimension, drawing from GII component values for the specific year 2013.They identified "business sophistication" and "infrastructure" as the most influential input criteria on the structural relationship. Additionally, "creative outputs" emerged as the output component with the greatest contribution to the relationship between GII input and output dimensions. Şipoş and Bizoi (2015) employed linear regression to examine the ramifications of the innovation dimension on the logistics performance dimension using Summary Innovation Index and Logistics Performance Index component values for 24 European countries in 2012. The study revealed a positive and significant relationship between the innovation dimension and logistics performance. Alparslan et al. (2018) conducted correlation and regression analyses to explore the relationship between cultural codes and innovation levels for 62 countries based on Globe project and GII component values for the year 2016. The findings emphasized the importance of improving knowledge and high-tech exports to enhance Turkey's economic performance. Elverdi and Atik (2021) employed SEM to assess the consequences of the information and communication technology (ICT) infrastructure dimension on innovation and the implications of innovation on economic growth for 127 countries in 2017. The research indicated a pronounced and promising affiliation between ICT infrastructure, innovation, and economic growth. Guillén and Deckert (2021) conducted linear regression analysis to examine the impact of cultural map variables on the innovation dimension using data on 61 countries for 2017. All cultural variables, except "conflict," were found to have a considerable and positive repercussion on the innovation domain. Sey and Aydın (2021) employed ARDL bounds testing and Toda-Yamamoto method to explore the long-term relationship and causality between high-tech product exports, R&D expenditures, patent applications, and economic growth in Turkey for the period 1990-2008. The study revealed a positive long-term relationship between high-tech product exports and innovation variables. In conclusion, reviewing the literature, it is evident that the relationships between GII input and output criteria have only been addressed by Sohn et al. (2015). Thus, further research is needed to determine the functional structure of these inputs and outputs in relation to their interplay, in light of the importance of analyzing the relationships between GII input and output criteria for understanding the dynamics of innovation.

3. Methodology

3.1. Data, Data Analysis, and Model of the Study

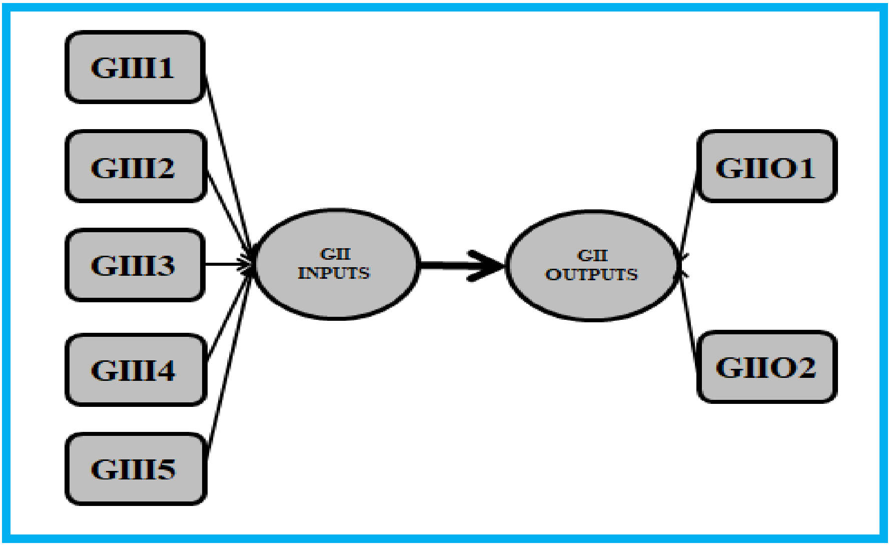
Within the confines of the research, a SEM was utilized to ascertain the influence of the input dimension on the output dimension, specifically in the context of the GII. The data for this research comprises values of GII criteria as reported in a total of 15 GII reports spanning the years 2008 to 2022. Given that the 2007 GII report did not provide country-specific GII component values, the data from 2007 was excluded from the study. As the data used in the research was obtained from openly available sources and did not involve any experiments or observations, ethical approval was not sought. To facilitate the study, abbreviations of the GII input and output dimension criteria are presented in Table 2.

Table 2: Abbreviations of GII Criteria

Innovation Inputs Criteria	Abbreviations	Innovation Outputs Criteria	Abbreviations
Institutions	GIII1	Knowledge and technology outputs	GIIO1
Human capital and research	GIII2		
Infrastructure	GIII3		
Market sophistication	GIII4	Creative outputs	GIIO2
Business sophistication	GIII5		

In the study, a model has also been constructed based on the literature to examine the influence of GII input criteria on GII output criteria. In the research, path analysis within the framework of SEM was utilized to determine the research objective related to the model. This is because path analysis allows for the assessment of the extent to which variables associated with criteria contribute to the relationship between criteria. Thus, specific strategies can be developed for the relationship between criteria rather than the overall structure (Hair et al., 1998). The process of gathering data involved the use of the IBM SPSS 21 AMOS software, and the graphical model is outlined in Figure 1.

Figure 1: Research Architecture



4. Findings

Before undertaking the path analysis aimed at validating the research framework, a Confirmatory Factor Analysis (CFA) was executed to ascertain the extent to which factor loadings accurately depict the constructs and to evaluate the appropriateness of the research architecture. Within the scope of CFA, unrelated level, one-factor level, primary level, and secondary level models were tested to identify which of these models best fits the data (Meydan and Şeşen, 2015: 25). Accordingly, the goodness-of-fit values of the CFA models according to the research architecture are exhibited in Table 3.

Table 3: Goodness-of-Fit Values of CFA Models.

Measure	Good Goodness-of-Fit	Acceptable Goodness-of-Fit	Irrelevant	Second-order	Single-factor	First-order
Ki-kare(X^2)	$0 \leq X^2 \leq 2$.sd	2.sd$\leq X^2 \leq 3$.sd	37,793	35,667	32,28	27,27

					2	4
Anlamlılık(p)	0,05<p≤1,00	0,01<p≤0,05	0,05	0,05	0,04	0,04
Kika-re/sd(X^2/sd)	0≤ X^2/sd≤2	2≤ X^2/sd≤3	2,907	2,743	2,483	2,098
SRMR	0≤SRMR≤0,05	0,05≤SRMR≤0,10	0,090	0,090	0,080	0,070
GFI	0,950≤ GFI≤1	0,90≤GFI≤0,95	0,850	0,880	0,900	0,916
AGFI	0,90≤AGFI≤1,00	0,85≤AGFI≤0,90	0,795	0,800	0,850	0,865
NFI	0,95≤NFI≤1,00	0,90≤NFI≤0,95	0,885	0,900	0,910	0,928
CFI	0,97≤CFI≤1,00	0,95≤NFI≤0,97	0,885	0,900	0,930	0,951
RMSEA	0≤RMSA≤0,05	0,05≤RMSA≤0,08	0,085	0,080	0,075	0,075

When examining Table 3, it is evident that the revelations from the primary level, CFA are all within an acceptable range of fit. On the other hand, it can be observed that the single-factor, second order, and irrelevant CFA models show acceptable fit for some measurement indicators. Therefore, considering that the primary level CFA model is closer to acceptable fit values compared to other CFA models, it better represents the adequacy of the research architecture than the other CFA models. Additionally, since the measurement indicators of the primary level CFA model are within an acceptable level of fit, there was no need for modification. For the determination of construct validity in CFA, both compositional and discriminant validity need to be established. To assess compositional and discriminant validity, Composite Reliability (CR) and Average Variance Extracted (AVE) values between relevant variables are determined (Büyükyılmaz and Fidan, 2017: 512). To ensure compositional validity within the framework of CFA, it is essential that CR values exceed 0.700, while AVE values should surpass the threshold of 0.500, with CR values demonstrating superiority over AVE values. To ascertain discriminant validity, it is required that the square root of

AVE exceeds the correlation value between factors (Fornell and Lacker, 1981; Hair et al., 1998). Accordingly, the determined values are presented in Table 4.

Table 4: CR and AVE Values.

<table>
<tr><th>Criteria</th><th>Averages</th><th>Standard Deviances</th><th>Cronbach Alpha</th><th>CR</th><th>AVE</th><th>AVE square root</th><th>Correlation</th></tr>
<tr><td>GIII1</td><td>62,5211</td><td>16,07003</td><td rowspan="7">0,940</td><td rowspan="5">0,952</td><td rowspan="5">0,946</td><td rowspan="5">0,973</td><td rowspan="7">0,640</td></tr>
<tr><td>GIII2</td><td>32,6873</td><td>14,78860</td></tr>
<tr><td>GIII3</td><td>33,5479</td><td>13,01185</td></tr>
<tr><td>GIII4</td><td>48,2648</td><td>12,83849</td></tr>
<tr><td>GIII5</td><td>33,7056</td><td>10,97322</td></tr>
<tr><td>GIIO1</td><td>27,6148</td><td>12,05842</td><td rowspan="2">0,899</td><td rowspan="2">0,895</td><td rowspan="2">0,946</td></tr>
<tr><td>GIIO2</td><td>37,7366</td><td>12,35464</td></tr>
</table>

When scrutinizing Table 4, it is apparent that both the CR value pertaining to the Inputs dimension and the CR value associated with the outputs dimension surpass the threshold of 0.700. Additionally, their corresponding AVE values also surpass the threshold of 0.500. Furthermore, the CR values for the dimensions are higher than their respective AVE values. Therefore, based on all these values, it is determined that the construct validity of the model is established. Upon in-depth scrutiny of Table 4, it becomes evident that the square root of AVE values linked to the dimensions outstrips the correlation value that connects these dimensions. This empirical evidence highlights the attainment of discriminant validity with regard to the model.

Table 5: Correlation Values Among Criteria.

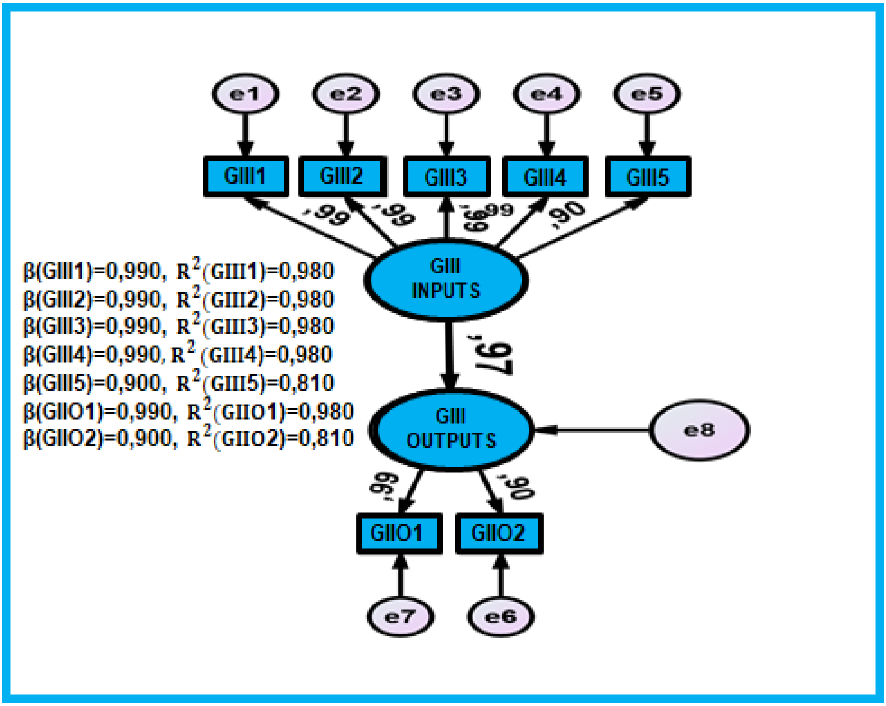
Bileşenler	GIII1	GIII2	GIII3	GIII4	GIII5	GIIO1	GIIO2
GIII1	1						
GIII2	,990**	1					
GIII3	,994**	,997**	1				
GIII4	,972**	,981**	,980**	1			

GIII5	,989**	,991**	,992**	,985**	1		
GIIO1	,988**	,993**	,993**	,992**	,993**	1	
GIIO2	,986**	,977**	,980**	,976**	,984**	,986**	1

****p<.01**

Table 5 presents the relationship values between the criteria. Upon examining Table 5, it is observed that the relationship values between the criteria are positively directed, significant (**p<.01), and at a very high level. According to Table 13, correlation values above 0.990 were observed among certain criteria. At first glance, this could indicate a multicollinearity problem. Consequently, the inter-criteria correlations were measured using the rho and Somer's d correlation coefficients in addition to the Pearson correlation coefficient. The relationships between criteria ranged from 0.930 to 0.850. Therefore, multicollinearity is not applicable within the scope of inter-criteria relationships for these correlation coefficients. Within this context, it is evaluated that the GII criteria are complementary to each other and that the criteria are integrated into a cohesive structure. To determine the accuracy of the model indicated in Figure 1 and to ascertain the relationship between GII input criteria influencing GII output criteria, the standard path analysis method was employed. In accordance with this, the diagrammatic representation of the conventional path analysis for the constructed model is provided in Figure 2.

Figure 2: Standard Path Analysis Diagram for the Model



The primary level Confirmatory Factor Analysis (CFA) model specifies the structure of relationships among latent variables. Therefore, the standard path analysis depicted in Figure 2 also explains the relationship model (effect values) between these dimensions, making the goodness-of-fit values of the path analysis model match the goodness-of-fit values of the primary level CFA.

In path analysis, non-standardized regression values indicate how a one-unit change in latent variables (dimensions) brings about changes in the factors influencing those dimensions (observed variables) and in other dimensions. As such, non-standardized regression values facilitate the establishment of linear equations between dimensions and the factors they influence. Accordingly, within the scope of path analysis, the non-standardized values and equations generated based on these values are illustrated in Table 6.

Table 6: Non-Standardized Regression Values for Dimensions and Criteria.

Dimensions and Criteria			**Value**	**Standard Error**	**t**	**p**
GII OUTPUTS	←	**GII INPUTS**	0,761	0,014	55,937	***
GIII1	←	**GII INPUTS**	1	------	------	***
GIII2	←	**GII INPUTS**	0,923	0,01	89,253	***
GIII3	←	**GII INPUTS**	0,813	0,009	94,226	***
GIII4	←	**GII INPUTS**	0,792	0,014	57,272	***
GIII5	←	**GII INPUTS**	0,683	0,009	78,818	***
GIIO2	←	**GII OUTPUTS**	1	------	------	***
GIIO1	←	**GII OUTPUTS**	0,999	0,014	70,071	***
Equations						
GII OUTPUTS	←	**GII INPUTS**	GII OUTPUTS=GII INPUTS (0,761)+e8			
GIII1	←	**GII INPUTS**	GIII1=GII INPUTS (1)+e1			
GIII2	←	**GII INPUTS**	GIII2=GII INPUTS (0,923)+e2			
GIII3	←	**GII INPUTS**	GIII3=GII INPUTS (0,813)+e3			
GIII4	←	**GII INPUTS**	GIII4=GII INPUTS (0,792)+e4			
GIII5	←	**GII INPUTS**	GIII5=GII INPUTS (0,683)+e5			
GIIO2	←	**GII OUTPUTS**	GIIO2=GII OUTPUTS (0,988)+e7			
GIIO1	←	**GII OUTPUTS**	GIIO1=GII OUTPUTS (1)+e6			

Upon examination of Table 6, it is evident that all non-standardized effect values from the GII INPUTS dimension to the GII OUTPUTS dimension and within the dimensions themselves are significant and positive. According to Table 6, it can be deduced that within the context of Table 6, GIII1 (1) has the highest contribution to the positive changes in the observed variables (criteria) of the GII INPUTS dimension, leading to changes in the GII OUTPUTS dimension. Subsequently, GIII2 (0.923), GIII3 (0.813), GIII4 (0.792), and GIII5

(0.683) criteria follow suit. This phenomenon might stem from countries prioritizing the establishment of a preparatory environment, particularly within the "institutions" component, to foster the creation of innovation output criteria compared to other criteria. Upon scrutinizing Table 5, it is evident that the component most susceptible to the positive changes induced by the GII INPUTS dimension is GIIC2 (1). This outcome suggests that, generally, the "creative outputs" component of the GII INPUTS dimension exhibits a more outcome-oriented structure compared to the "knowledge and technology outputs" component. Furthermore, the average of non-standardized regression values for GII input criteria [(1 + 0.923 + 0.813 + 0.792 + 0.683) / 5 = 0.842] is lower than the average of non-standardized regression values for GII output criteria [(1 + 0.999)/2] = 0.9995), confirming the attainment of innovation performance effectiveness.

Table 7: Standardized Regression Values for Dimensions and Criteria.

Dimensions and Criteria			Values
GII OUTPUTS	←	**GII INPUTS**	$\gamma_{\text{GII INPUTS}\rightarrow\text{GII OUTPUTS}}$=0,990
GIII1	←	**GII INPUTS**	$\beta_{\text{GII INPUTS}\rightarrow\text{GIII1}}$=0,990
GIII2	←	**GII INPUTS**	$\beta_{\text{GII INPUTS}\rightarrow\text{GIII2}}$=0,990
GIII3	←	**GII INPUTS**	$\beta_{\text{GII INPUTS}\rightarrow\text{GIII3}}$=0,990
GIII4	←	**GII INPUTS**	$\beta_{\text{GII INPUTS}\rightarrow\text{GIII4}}$=0,990
GIII5	←	**GII INPUTS**	$\beta_{\text{GII INPUTS}\rightarrow\text{GIII5}}$=0,900
GIIO2	←	**GII OUTPUTS**	$\beta_{\text{GII IOUTPUTS}\rightarrow\text{GIII1}}$=0,900
GIIO1	←	**GII OUTPUTS**	$\beta_{\text{GII OUTPUTS}\rightarrow\text{GIII1}}$=0,990

Table 7 presents the standardized regression values for dimensions and criteria. In path analysis, standardized regression values indicate the extent of change in the dependent variable's standard deviation due to a one-unit change in the independent variable's standard deviation. In this manner, the standardized regression coefficients offer insights into the magnitude of significance (expressed as contribution values) characterizing the associations among dimensions (latent variables) and their corresponding criteria (observed variables, indicators), alongside the interconnections between independent variables (latent variables, factors) and dependent variables (observed variables, indicators). Upon meticulous scrutiny of Table 7, a conspicuous observation emerges: the GII INPUTS dimension exerts a robust and affirmative impact on the GII OUTPUTS dimension (GII INPUTS→GII OUTPUTS = 0.990), thereby affirming the soundness of the model.

In addition, in light of the correlations outlined in Table 7, it becomes evident that the criteria holding the most substantial sway over the interconnected structure between GII INPUTS and GII OUTPUTS are recognized as 'institutions,' 'human capital and research,' 'infrastructure,' and 'market sophistication' (βGII INPUTS→GIII1 = 0.990, βGII INPUTS→GIII2 = 0.990, βGII INPUTS→GIII3 = 0.990, βGII INPUTS→GIII4 = 0.990). Notably, despite 'business sophistication' component significantly and positively affecting innovation output dimensions, it has a comparatively lesser impact on innovation output dimensions compared to other innovation criteria. This underscores that 'institutions,' 'human capital and research,' 'infrastructure,' and 'market sophistication' are the key drivers shaping the interconnection among GII INPUTS and GII OUTPUTS, surpassing the influence of 'business sophistication.'

Additionally, upon examination of Table 7, it becomes apparent that the criteria most influential in the relational structure between GII INPUTS and GII OUTPUTS dimensions are 'institutions' (βGII INPUTS→GIII1 = 0.990), 'human capital and research' (βGII

INPUTS→GIII2 = 0.990), 'infrastructure' (βGII INPUTS→GIII3 = 0.990), 'market sophistication' (βGII INPUTS→GIII4 = 0.990), and 'knowledge and technology output' (βGII OUTPUTS→GIIC1 = 0.990). Furthermore, considering the comprehensive perspective, it can be deduced that, in terms of the relationship between GII INPUTS and GII OUTPUTS dimensions, the average of non-standardized regression values for GII input criteria [(0.990 + 0.990 + 0.990 + 0.990 + 0.900) / 5 = 0.972] is greater than the average of non-standardized regression values for GII output criteria (0.990 + 0.900) / 2 = 0.945), signifying that the GII INPUTS dimension holds greater importance and contributes more to the relational structure than the GII OUTPUTS dimension. This suggests that countries place a higher emphasis on input-driven innovation activities compared to output-driven activities.

Conclusion

Through the determination of the relationship structure between GII input and output dimensions, countries can enhance their innovation performance. By identifying which innovation inputs generate specific innovation outputs, countries can formulate strategies and policies to bolster their innovation performance for both current and future periods. Hence, this research delves into the evaluation of the effect produced by the GII input dimension on the GII output dimension, drawing insights from GII component data covering the period 2008 to 2022.

Firstly, it is observed that the primary-level CFA model provides the best fit according to the model. The study reveals significant, positive, and high-level relationships between criteria within the scope of research. Additionally, both compositional and discriminant validity have been established in relation to the model.

Secondly, non-standardized regression values for dimensions and their respective criteria are calculated. The findings indicate that all non-standardized regression values between dimensions and within their respective criteria are significant. Furthermore, the 'institutions' component is found to contribute most significantly to positive changes in the innovation output dimension. This suggests that 'institutions' hold a higher priority compared to other GII input criteria and contribute more significantly to innovation output criteria.

Thirdly, standardized regression values for the influence of innovation inputs and outputs dimensions on each other are measured. The results indicate that the GII input dimension strongly and positively influences the GII output dimension, validating the model. Furthermore, within the context of relationships between dimensions, the criteria 'institutions,' 'human capital and research,' 'infrastructure,' and 'market sophistication' exhibit the highest contribution to the relationship structure. This highlights that, overall, 'institutions,' 'human capital and research,' 'infrastructure,' and 'market sophistication' possess more causal attributes compared to the 'business sophistication' component.

Lastly, in terms of the relational structure between GII input and output dimensions, the criteria that contribute the most are 'institutions,' 'human capital and research,' 'infrastructure,' 'market sophistication,' and 'knowledge and technology output.' Therefore, this outcome reveals that these criteria hold greater priority in influencing GII output dimensions compared to the 'business sophistication' and 'creative output' criteria. In reviewing the literature, Sohn et al. (2015) found that the 'infrastructure' component had the highest contribution to the association among the GII input and output dimensions. This study's findings also align with Sohn et al. (2015) as the 'infrastructure' component stands as one of the criteria that significantly contributes to the interrelation among the GII input and output dimensions. Additionally, Sohn et al. (2015) determined that the 'creative outputs' component had the most substantial contribution among the dimensions. However, in this study, the 'knowledge and technology output' component emerges as the one with the greatest contribution. In the relationship between the GII INPUTS and GII OUTPUTS dimensions, it is observed that the average of the standard regression values of the components of the GII INPUTS dimension is higher than the average of the standard regression values of the components of the GII OUTPUTS dimension. Therefore, the GII INPUTS dimension is considered to be more important than the GII OUTPUTS dimension and contributes more to the relational structure. Accordingly, it can be said that countries prioritize input-oriented innovation activities more than output-oriented innovation activities. Within the scope of recommendations, firstly, focusing on activities driven by the "business sophistication" component, which contributes less compared to other GII input criteria, can enhance innovation performance across countries by enabling the provision, creation, and development of innovation output criteria. Additionally, strategies should be devised to amplify the influence of the "creative outputs" component, which is less affected by GII input dimensions, leading to the enhancement of overall innovation performance. In terms of methodology, forthcoming research endeavors have the potential to gauge the efficiency and productivity of countries' innovation performance, customized to the unique attributes of each nation, through the assessment of the interplay between innovation input and output criteria. Moreover, alternative approaches such as diverse correlation coefficients and canonical correlations can be utilized to ascertain the associations between innovation input and output criteria, facilitating the contrast and discourse of outcomes derived from these methodologies. Additionally, in calculating countries' innovation performance, the number of innovation input and output criteria can be expanded, or innovation performance input and output criteria unique to each country can be formulated.

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‖Beyan ve Açıklamalar/Disclosure Statements ‖

1.The author confirms that his work complies with the principles of research and publication ethics announced by **Bilgi**.

2. No potential conflict of interest and the research’s effects on any person/institution was reported by the author.

3. It was reported that the article was written by Furkan Fahri **ALTINBAŞ,** as no additional acknowledgement has been made.

Extended Abstract

A Structural Equation Model Application For Global Innovation Input Dimension To Affect Output Dimension

Name Surname

By elucidating the intricate interplay between the criteria of innovation input and output within the framework of the GII, nations have the potential to elevate their innovation capabilities. This investigation aids in identifying the specific innovation inputs that yield particular innovation outputs, enabling countries to devise strategic approaches and policies for fortifying their innovation performance, both in the present and the future. Thus, this study delves into the impact of the GII's input dimension on its output dimension, drawing upon GII component data spanning the years 2008 to 2022.

The initial finding highlights that the primary-level confirmatory factor analysis (CFA) model presents the most optimal fit within the model's context. The investigation underscores substantial, affirmative, and robust interconnections among the criteria under scrutiny. Additionally, the study establishes both the compositional and discriminant validity vis-à-vis the model. Subsequently, non-standardized regression coefficients are computed for dimensions and their corresponding constituents. The outcomes underscore the statistical significance of all non-standardized regression values both among dimensions and within their specific criteria. Furthermore, it is noteworthy that the 'institutions' component emerges as the most influential in fostering favorable changes in the innovation output dimension. This underscores the pivotal role of 'institutions' compared to other GII input constituents, accentuating their pronounced contribution to innovation output elements. Moving forward, standardized regression coefficients are employed to quantify the influence of innovation input and output dimensions on one another. The findings affirm the potent and constructive im-

pact of the GII input dimension on the GII output dimension, thus validating the model. Furthermore, concerning the dimension-to-dimension relationships, the criteria labeled 'institutions,' 'human capital and research,' 'infrastructure,' and 'market sophistication' manifest the highest levels of contribution to the structural dynamics. This underscores the overarching prominence of 'institutions,' 'human capital and research,' 'infrastructure,' and 'market sophistication' in terms of causal attributes, relative to the 'business sophistication' component. Lastly, concerning the interrelationship of GII input and output dimensions, noteworthy contributors include 'institutions,' 'human capital and research,' 'infrastructure,' 'market sophistication,' and 'knowledge and technology output.' This underscores their heightened influence on GII output dimensions, surpassing the significance of the 'business sophistication' and 'creative output' criteria. Furthermore, the study concludes that the GII input dimension holds a more substantial role than the GII output dimension. This assertion is rooted in the observation that countries primarily showcase their innovation performance guided by fundamental principles.

Regarding recommendations, firstly, emphasizing "business sophistication" activities—despite its lesser impact among GII input criteria—can elevate global innovation performance by fostering innovation output. Additionally, bolstering the influence of "creative outputs," less responsive to GII input dimensions, should be strategized for overall innovation enhancement. Methodologically, future research could gauge countries' tailored innovation efficiency and productivity based on input-output relationships. Utilizing diverse methods like various correlation coefficients and canonical correlations would offer nuanced insights and facilitate result comparison. Moreover, for a comprehensive evaluation of countries' innovation performance, expanding input-output criteria or tailoring them to each country's context could yield richer outcomes.