“Policy priorities for improving Global Innovation Index score and innovative performance in upper-middle-income countries: Implications for Armenia”

AUTHORS

Svetlana Dallakyan
Anna Makaryan
Verej Isanians
Hamlet Mkrtchyan
Harutyun Sargsyan
Gayane Tovmasyan
Svitlana Bilan

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Svetlana Dallakyan (Armenia), **Anna Makaryan** (Armenia), **Verej Isanians** (Armenia), **Hamlet Mkrtchyan** (Armenia), **Harutyun Sargsyan** (United States), **Gayane Tovmasyan** (Armenia), **Svitlana Bilan** (Hungary)

POLICY PRIORITIES FOR IMPROVING GLOBAL INNOVATION INDEX SCORE AND INNOVATIVE PERFORMANCE IN UPPER-MIDDLE-INCOME COUNTRIES: IMPLICATIONS FOR ARMENIA

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Svetlana Dallakyan, Ph.D., Associate Professor, M. Kotanyan Institute of Economics, National Academy of Sciences of the Republic of Armenia, Armenia; Brusov State University, Armenia; Khacahtur Abovyan Armenian State Pedagogical University, Armenia.

Anna Makaryan, Ph.D., M. Kotanyan Institute of Economics, National Academy of Sciences of the Republic of Armenia, Armenia. (Corresponding author)

Verej Isanians, Ph.D., Chief Research Officer, Nexus Intellect Research NGO, Armenia.

Hamlet Mkrtchyan, Ph.D., Lecturer of the Chair of International Economic Relations, Armenian State University of Economics, Armenia.

Harutyun Sargsyan, Student, Faculty of Computer Science and Engineering, Northwestern University, United States.

Gayane Tovmasyan, Ph.D. in Economics, Armenian State University of Economics, Armenia; Public Administration Academy of the Republic of Armenia, Armenia; Yerevan State University, Armenia; Brusov State University, Armenia.

Svitlana Bilan, Dr., Associate Professor, Kautz Gyula Faculty of Business and Economics, Széchenyi István University, Hungary.

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Abstract

As an upper-middle-income country, Armenia should develop and implement targeted policies, such as increased R&D investments, education reforms, and industry-academia collaboration, to enhance its innovation performance. Strengthening these areas is expected to contribute to higher Global Innovation Index (GII) rankings, reflecting improved national innovation capacity.

This study aims to estimate the impact of various GII components (including pillars, sub-indices, and sub-pillars) on the overall GII and pillar scores for upper-middle-income countries. Based on these findings, the study seeks to identify Armenia's key policy priorities and provide targeted recommendations for enhancing its innovation performance. This study employs a cross-sectional regression to analyze the factors influencing GII scores in upper-middle-income countries, assessing the impact of sub-indices, pillars, and sub-pillars. The analysis reveals that market sophistication and creative outputs strongly influence GII scores among upper-middle-income countries, contributing significantly to national innovation performance. Additionally, knowledge and technology outputs, human capital and research, and infrastructure pillars show a statistically significant impact at the 5% level. Notably, even minor improvements in innovation output sub-index scores account for substantial variations in GII rankings. These findings suggest that Armenia should prioritize targeted education reforms, increase R&D investment, and strengthen university-industry linkages to enhance its innovation ecosystem and improve its global competitiveness.

Keywords innovation, knowledge-based economy, Global Innovation Index, education, R&D, upper-middle income country, Armenia

JEL Classification O30, 038

INTRODUCTION

The government of Armenia attaches importance to building a knowledge-based economy, supporting entrepreneurship, and strengthening science-economy linkages to apply and commercialize scientific research results via technology transfer offices (TTOs) and innovations economy-wide (Government of Armenia, 2021a, 2021b) since TTOs play a facilitating role in commercializing university technology (Abd Rahman et al., 2011). The government could design various policies and measures to improve the innovative performance of the economy that would result in higher scores on the Global Innovation Index (GII) as well (one of the best tools to measure innovation performance across more than 100 economies, released annually by the

World Intellectual Property Organization (WIPO, 2023)). However, the timeline of the measures and priorities could vary from country to country. The priorities of low-income nations could substantially differ from the ones of upper-middle-income economies, such as Armenia (classification according to the World Bank's thresholds (Hamadeh et al., 2022)). These priorities must be based on the estimates that describe the economy's innovation performance. Therefore, these estimates, along with the recommendations for specific policy strategies and options proposed by various scholars, could assist the government in crafting specific and targeted measures and policies that significantly matter for a particular upper-middle-income country, in general, and Armenia. Hence, that could assist the government in prioritizing the role of a specific pillar in explaining significant changes in the GII index and higher index scores, which is in line with the government's decrees and strategies.

1. LITERATURE REVIEW

Innovations and entrepreneurial culture, specifically in the case of entrepreneurial universities that shape the culture and develop required skills by building linkages with the private sector, could be crucial in increasing the economy's competitiveness and driving economic growth to strengthen the university-private sector.

By supporting technology transfer offices (TTOs), the government could design specific research and development (R&D) tax incentive schemes. However, to prioritize respective policy strategies, the government needs to rely on the respective estimates based on the utilization of appropriate techniques.

1.1. Innovation, entrepreneurship, and competitiveness nexus

To ensure the economy's competitiveness, the role of three major factors, innovation, knowledge, and entrepreneurship, is emphasized; meanwhile, in the framework of the knowledge-based economy, education is the major driver (Popescu & Crenicean, 2012). The differences in the growth rates of the EU member states' economies are explained by the growth potential of new ventures that spread across the country (Crudu, 2019). Hence, efficiency needs to be the focus of both new (growing) and existing companies (Crudu, 2019).

The national innovation ecosystem and entrepreneurial culture catalyze the development of economies worldwide (Pradhan et al., 2020; Labunska et al., 2023). However, the relationships among entrepreneurship, innovation, and economic growth are complex, and these three could be affected by various forces (Pradhan et al., 2020). In turn, innovativeness drives the growth of new ventures and innovation inputs (namely R&D and innovation expenditures), which is crucial to spurring innovations nationwide (Fiorentino et al., 2021; Triyonowati et al., 2023; Kuzior et al., 2024). Recognizing the role of innovation as a driver of development and progress, the national governments globally stress the role of innovation performance in ensuring competitiveness and policies that support the Global Innovation Index (Dempere et al., 2023). Moreover, sustained economic growth could be promoted by science and technology, which requires investments (Wang & Xu, 2021; Ojaghlou & Tercan, 2024). Therefore, research and development investments channeled to building scientific infrastructure must be supported by the talents and learning institutions to ensure sustainable innovations producing significant results (Sarpong et al., 2023). Therefore, the need for modern research infrastructure, R&D personnel capabilities, absorptive potential, and entrepreneurial universities is stressed (Song & Wen, 2023). Meanwhile, tax credits, fiscal subsidy policy incentives, and other tax incentives could drive technological progress and promote the growth of developing and/or emerging industries (Song & Wen, 2023; Zimmermann, 2024). Hence, collaboration in innovations has become a standard in the era of digital transformation and Industry 4.0, leading to technology convergence and innovations across industries (Ahn et al., 2020). In this framework, the universities play a pivotal role in shaping the respective ecosystem and "university–industry–government–public–environment interactions" (Apostu et al., 2022, p. 11).

1.2. GII and empirical evidence

Relying on the panel data of 105 countries covering the period from 2013 to 2021, Nasir and Zhang (2024) used various econometric models to exam-

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ine the Innovation Input Index, the Innovation Output Index, and the Innovation Efficiency Index as independent variables to explain the changes in the GII as a dependent variable. Nasir and Zhang (2024) relied on three instrumental variables, ICT imports, ICT, and high-tech exports, to address endogeneity and identified that the inputs, outputs of innovation, and efficiency positively affect the GII. Coutinho and Au-Yong-Oliveira (2024) utilized hierarchical multiple linear regressions based on the data of 64 countries covering various regions and GDP levels, particularly from the Global Innovation Index 2022. Including inputs and outputs from respective pillars, the results showed a statistically significant positive relationship between business sophistication, innovative indicators in knowledge and technology, and creativity outputs, with human capital, scientific research, and infrastructure affecting less significantly. Utilizing ordinary least squares (OLS) and two-stage least squares (2SLS) econometric models and relying on the annual data from 2015 to 2020, Sıcakyüz (2023) analyzed the relationship between the components (respective pillars) of the GII and national income. The article showed that business sophistication had the most significant positive impact on income, followed by market sophistication, while the results of creative activity negatively correlated with income. Based on World Bank reports, the Global Innovation Index, and data from 120 countries spanning from 2013 to 2019, Dempere et al. (2023), by utilizing generalized linear and standard error models with group correction, found a significant positive relationship between GDP and innovation indicators and a negative relationship between innovation and self-employment. Bate et al. (2023) utilized a robust methodology and variance analysis to identify the factors that underpin innovation effectiveness in 63 countries (classified by income level) and stratified by income level. The authors identify that the level of business sophistication emerged as the most significant factor in shaping the outcomes of innovation activity, contributing to 76.7% of the knowledge outputs and 60.8% of creative outputs (Bate et al., 2023). Knowledge absorption and innovation linkages are the most crucial components; meanwhile, human capital, R&D, and infrastructure significantly affect innovation (Bate et al., 2023; M. Brycz & H. Brycz, 2022).

1.3. Higher education institution and its role as a technology transfer office (TTO) in spurring innovations and policy strategies

Based on the panel data of 79 economies from 1995 to 2017, Okolo et al. (2023) show that tertiary education positively and strongly affects technological innovations and leads to economic growth via national intellectual capital and research. Considerable funding channeled to R&D and education could spur innovations that translate into the expansion of the economy (Boțoroga et al., 2022). Meanwhile, the initiatives of the government need to be focused on increasing the number of science, technology, engineering, and mathematics (STEM) graduates, and, in the case of developing countries, investments in tertiary education need to gain more credibility to spur innovations (Okolo et al., 2023). Providing funding for research and development (R&D) for both public research institutions and higher education sectors is the strategy that the governments of developing countries could opt for to increase the share of high-tech exports in total exports (Mohamed et al., 2022). Moreover, the governments need to increase the efficiency of the required infrastructure (intellectual property rights system), strengthen cooperation (assisting in teaming up R&D consortium), or facilitate the mobility of knowledge workers (among workers from public and private institutions) (Afcha & Lucena, 2020).

Therefore, spending on education should not be merely increased; it needs to be targeted and channeled to building education infrastructure (Mohamed et al., 2022), increasing the number of graduates from tertiary education institutions along with supporting teaching and research activities (Apostu et al., 2022). Channeling more public funding to R&D processes and innovation activities in universities needs to be coupled with strengthening university-industry collaboration and interactions and active engagement of students in R&D activities (Mabrouka et al., 2018). Moreover, it is necessary to attract researchers who conduct R&D activities and ensure young employment by offering cash subsidies, some R&D incentives, and schemes for employers of young graduates (Boțoroga et al., 2022). Meanwhile, to spur

innovation and creativity in the educational system, the role of entrepreneurship is emphasized (Popescu & Crenicean, 2012).

TTOs are essential in university-based innovation (Brantnell et al., 2022). Based on the role of 176 university TTOs from 28 European countries, Bolzani et al. (2020) find that 71% of those TTOs are engaged both in science and technology entrepreneurship education processes and various initiatives. They are pivotal in developing entrepreneurship skills among the students and faculty. The level of engagement (outside of traditional activities such as IP protection, and ensuring income from inventions) varies across the TTO characteristics, with older and autonomous ones focusing on technology transfer activities. The knowledge transfer offices need to concentrate on upgrading the skills of the staff, utilizing effective governance and monitoring practices while promoting an entrepreneurial mindset among key factors such as staff (including non-academic) and students, building and strengthening ties with the ecosystem stakeholders (Compagnucci & Spigarelli, 2024). Abd Rahman et al. (2011) studied two cases of existing TTOs in Malaysia within two research universities and stressed the importance of commercialization. In the case of Ghana, TTOs' significant role in strengthening university researchers-industry linkages translates into higher incomes that the industry would benefit from intellectual properties. Moreover, universities must nurture the role of TTOs, and the industry would benefit from the R&D output via patent and licensing from TTOs (Abdulai et al., 2022, p. 730).

1.4. Choice of R&D incentive schemes

One of the first attempts to justify the role of tax incentives as an R&D policy tool was made by Bozeman and Link (1984). Sterlacchini and Venturini (2018) find that R&D tax incentives could cause a statistically significant increase in the intensity of R&D expenses. R&D tax incentive schemes need to be tailored to face the heterogeneity concerning the needs of SMEs vs. large companies and should be carefully designed. Meanwhile, the indirect support for business R&D needs is to be regulated along with the utilization of direct support measures (Appelt et al., 2016). In the case of private R&D, direct funding and tax credits are not substitutes and direct support to small- and medium-sized enterprises (SMEs) is preferred (Busom et al., 2014). At the same time, subsidies are a better option for young knowledge-based companies (Busom et al., 2014). Although tax incentives are pretty easy to administer and can be available to many companies, there could be a risk of labeling other expenses as R&D costs and targeted R&D subsidies could be preferred in the case of projects with a high degree of uncertainty (Svensson, 2024). Regular R&D tax credits are more likely to be claimed by large companies rather than SMEs who regularly invest in R&D and introduce innovations; hence, tax authorities need to assist the SMEs by raising their awareness and simplifying the procedure to claim the incentive and making the scheme stable (Labeaga et al., 2021).

In nearly all the estimation methods discussed above, one of the major concerns was the data compatibility issue at the pillar and particularly sub-pillar level of the GII, thus making the comparisons inappropriate (in the case of panel estimation techniques) since the indicators covered have been either excluded and/or substituted with new ones over a couple of years. Therefore, cross-sectional data analysis (cross-sectional regression) based on data from a specific income group country could be an option. Like Nasir and Zhang (2024), the impact of the Innovation Input Index and the Innovation Output Index on the GII could be estimated in the case of upper-middle-income countries. Similarly, and like Coutinho and Au-Yong-Oliveira (2024), Bate et al. (2023), and Sıcakyüz (2023), the impact of sub-pillar indices on the pillar, along with the impact of the pillars on the GII could be estimated. The estimates and the choice of the respective tools could assist the government in promoting and supporting innovation-driven entrepreneurship, companies, and industries while nurturing R&D-driven and entrepreneurial to strengthen university-industry linkages.

Therefore, the purpose of this paper is to estimate the impact of the respective pillars, sub-indices, and sub-pillars on the GII and pillar scores (WIPO, 2023) for upper-middle-income countries to highlight Armenia's policy priorities based on various policy recommendations.

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2. METHODOLOGY

The main two models of this study are defined as follows:

$$Global\ Innovation\ Index\ score = f\begin{pmatrix} Innovation\ Input\ sub-index\ score, \\ Innovation\ Output\ sub-index\ score \end{pmatrix}. \quad (1)$$

$$Global\ Innovation\ Index\ score = f\begin{pmatrix} Institutions\ pillar\ score, \\ Human\ capital\ and\ research\ pillar\ score, \\ Infrastructure\ pillar\ score,\ Infrastructure\ pillar\ score, \\ Market\ sophistication\ pillar\ score, \\ Business\ sophistication\ pillar\ score, \\ Knowledge\ and\ technology\ outputs\ pillar\ score, \\ Creative\ outputs\ pillar\ score \end{pmatrix}. \quad (2)$$

In addition, in the case of individual pillars, the model is defined as follows:

$$Pillar\ score = (score\ of\ Sub-pillar1,\ score\ of\ Sub-pillar2,\ score\ of\ Sub-pillar3). \quad (3)$$

The original sample of upper-middle-income courtiers included 33 economies classified as countries of interest and covered by the WIPO (WIPO, 2023). China was identified as an outlier. The country over-performed the entire sample of upper-middle-income nations since the scores of China were much higher than the average sample-wide scores. Then, Guatemala was excluded owing to the lowest scores reported. In addition, upon testing for the evidence of new outliers, Malaysia, Turkey, Bulgaria, and Thailand were excluded. Then, the sample size was reduced to 27. Based on pillar scores, Russia and Paraguay were excluded as outliers concerning the human capital and research pillar. North Macedonia and Serbia were excluded in the case of the infrastructure pillar. Hence, the dataset contained 23 (Albania, Argentina, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Botswana, Brazil, Colombia, Costa Rica, the Dominican Republic, Ecuador, Georgia, Jamaica, Jordan, Kazakhstan, Mauritius, Mexico, the Republic of Moldova, Montenegro, Namibia, Peru, and South Africa) countries to estimate the models. It is admitted that the sample size is relatively small; however, the estimates could assist the governments of upper-middle-income countries, namely Armenia, in prioritizing their efforts. The description of all variables included in various regression equations is provided in Table 1, the descriptive statistics of the pillars, innovation input and output sub-indices, and the GII in Table 2, and cross-correlation among pillars in Table 3.

Table 1. Description of variables included in various models

Source: WIPO (2023).

Variable	Variable description
GII	Global Innovation Index score
INPUT	Innovation input sub-index score
OUTPUT	Innovation output sub-index score
INST	Institutions pillar score
PE	Political environment sub-pillar score of institution pillar
RE	Regulatory environment sub-pillar score of institution pillar
BE	Business environment sub-pillar score of institution pillar
HCR	Human capital and research pillar score
EDU	Education sub-pillar score of human capital and research pillar
TE	Tertiary education sub-pillar score of human capital and research pillar
RD	Research and development (R&D) sub-pillar score of human capital and research pillar
INFR	Infrastructure pillar score
ICT	Information and communication technologies (ICTs) sub-pillar score of Infrastructure pillar
GI	General infrastructure sub-pillar score of infrastructure pillar
ES	Ecological sustainability sub-pillar score of infrastructure pillar
MS	Market sophistication pillar score

Table 1. Description of variables included in various models

Variable	Variable description
CREDIT	Credit sub-pillar score of market sophistication pillar
INVEST	Investment sub-pillar score of market sophistication pillar
TDMS	Trade, diversification, and market scale sub-pillar score of market sophistication pillar
BS	Business sophistication pillar score
KW	Knowledge workers sub-pillar score of business sophistication pillar
IL	Innovation linkages sub-pillar score of business sophistication pillar
KA	Knowledge absorption sub-pillar score of business sophistication pillar
KTO	Knowledge and technology outputs pillar score
KC	Knowledge creation sub-pillar score of knowledge and technology outputs pillar score
KI	Knowledge impact sub-pillar score of knowledge and technology outputs pillar score
KD	Knowledge diffusion sub-pillar score of knowledge and technology outputs pillar score
CO	Creative outputs pillar score
IA	Intangible assets sub-pillar score of creative outputs pillar
CGS	Creative goods and services sub-pillar score of creative outputs pillar
OC	Online creativity sub-pillar score of creative outputs pillar

The following principles were applied while including various independent variables in a given regression equation, especially concerning sub-pillar scores. First, no more than two independent variables per regression equation, namely, if there were two independent variables with at least 22 observations. When the number of observations was 23, two independent variables were included in a single equation, and the same was done when the number of observations could have reached 22 upon excluding outliers. Second, only a single independent variable per regression equation if the number of observations was greater and/or equal to 20 and less than 22. Third, no estimation if the number of observations of independent variables was less than 20 upon excluding outliers. Before estimating equations, the natural log of all the variables was taken. Then, the cross-sectional regression technique was utilized to analyze the relationship between the variables of interest.

No evidence of multicollinearity was found, and all required tests were performed after estimating equations (evidence of heteroscedasticity, customarily distributed residuals, no model specification errors).

In the case of the second model, and especially the pillars of the innovation input sub-index, infrastructure, and market sophistication pillar scores were incorporated in one equation; business sophistication and human capital and research and pillar scores into the second equation, and the institution pillar score in the third equation. In the case of the innovation output sub-index, the creative output pillar and the knowledge and technology outputs pillar scores were incorporated in a separate equation.

In the case of the second model, it was found that changes in the institution and business sophistication pillar scores do not explain statistically significant changes in the GII index. However, the study attempted to estimate the impact of the scores of the sub-pillars of business sophistica-

Table 2. Descriptive statistics of the pillars, innovation input and output sub-indices, and the GII

Source: Calculations based on the GII Report (WIPO, 2023).

	INST	HCR	INFR	MS	BS	KTO	CO	INPUT	OUTPUT	GII
Mean	48.45	28.45	38.18	32.40	27.39	19.02	20.65	34.97	19.83	27.40
Median	49.10	29.70	38.70	32.30	27.70	19.20	18.80	35.18	20.10	27.79
Maximum	70.60	39.90	45.40	51.60	37.60	29.90	33.20	42.74	29.00	33.62
Minimum	24.30	17.50	28.70	22.00	20.50	10.10	11.10	27.94	10.80	20.55
Std. Dev.	12.16	5.07	4.64	7.80	4.57	5.54	7.18	3.50	5.46	3.28
Skewness	0.02	–0.11	–0.47	0.78	0.57	0.05	0.42	0.06	–0.02	–0.34
Kurtosis	2.39	3.00	2.44	3.03	2.99	1.96	1.77	2.61	2.10	2.68
Jarque-Bera	0.35	0.05	1.15	2.34	1.24	1.05	2.13	0.16	0.77	0.53
Probability	0.84	0.98	0.56	0.31	0.54	0.59	0.34	0.92	0.68	0.77
Sum	1,114.30	654.30	878.20	745.30	629.90	437.50	474.90	804.40	456.20	630.30
Sum Sq. Dev.	3,254.96	564.54	472.67	1,339.29	459.37	674.80	1,133.76	269.65	656.67	236.93
Observations	23	23	23	23	23	23	23	23	23	23

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Table 3. Cross-correlation among pillars

Source: Calculations based on the GII Report (WIPO, 2023).

	Institutions	Human capital and research	Infrastructure	Market sophistication	Business sophistication	Knowledge and technology outputs	Creative output
Institutions	1.00						
Human capital and research	–0.26	1.00					
Infrastructure	–0.38	0.27	1.00				
Market sophistication	0.15	0.37	0.16	1.00			
Business sophistication	0.02	0.13	0.44	–0.06	1.00		
Knowledge and technology outputs	–0.54	0.43	0.46	0.18	0.16	1.00	
Creative output	–0.26	0.17	0.17	0.23	0.10	0.47	1.00

tion on the pillar. These estimates are essential in prioritizing the actions and measures to improve the business innovation performance and assist them in managing the innovations in the medium term and over the long run. Before estimating pillar-level regression equations, outliers to the sub-pillar scores of corresponding pillars were first identified (see Table 4) to determine how independent variables should be combined and included in various equations. In the case of the market sophistication pillar, due to the relatively large number of outliers identified, only one regression equation was estimated. Due to the different sample sizes of three sub-pillars of the knowledge and technology outputs pillar, three different regression equations were estimated. Three different regression equations were run in the case of the creative outputs pillar.

3. RESULTS AND DISCUSSION

A percent increase in the innovation input sub-index score could cause a 0.629 % increase in the GII score, other things being equal. A similar change in the innovation output sub-index score could lead to a 0.346% change in the GII score (see Table 5, Estimation 1). The results are explained by the higher average of the innovation input pillar scores compared to the average of the innovation output pillar scores (see Table 1). In addition, the changes in independent variables could explain about 99% variance in the GII score values (see Table 5, Estimation 1). This implies that the government of Armenia could ensure higher and statistically significant changes in the GII score if it channels its efforts into improving the performance of the innovation input index pillars.

Table 4. Identified outliers per sub-pillar

Source: Calculations based on the GII Report (WIPO, 2023).

Pillar	Sub-pillar 1	Sub-pillar 2	Sub-pillar 3
Human capital and research	Education Mauritius	Tertiary education Mauritius (excluded to incorporate both sub-pillars into a single equation)	Research and development (R&D) Mexico, Brazil
Infrastructure	Information and communication technologies (ICTs) Mauritius	General infrastructure sub-pillar Mauritius (excluded to incorporate both sub-pillars into a single equation)	Ecological sustainability sub-pillar score of infrastructure
Market sophistication	Credit	Investment Azerbaijan, Bosnia and Herzegovina, the Dominican Republic, Mauritius, Montenegro, South Africa, Jordan, Brazil, Jamaica, Columbia, Mexico	Trade, diversification, and market scale Jamaica, Mauritius, Mexico, Brazil, Dominican Republic, Ecuador, Armenia, Azerbaijan
Business sophistication	Knowledge workers	Innovation linkages	Knowledge absorption
Knowledge and technology outputs	Knowledge creation No outliers identified	Knowledge impact Brazil, Colombia, Namibia	Knowledge diffusion Belarus, Bosnia and Herzegovina
Creative outputs	Intangible assets	Creative goods and services Mexico, the Dominican Republic	Online creativity Mauritius, Montenegro

Table 5. Estimation results 1 (Method: Ordinary least squares)

Source: Calculations based on the GII Report (WIPO, 2023).

Dependent variable $LGII_i$	Estimation 1	Estimation 2	Dependent variable $LGII_i$	Estimation 3	Estimation 4
$LINPUT_i$	0.629 (25.508)***		$LINFR_i$	0.353 (2.133)**	
$LOUTPUT_i$	0.346 (41.069)***		LMS_i	0.269 (2.959)***	
$LHCR_i$		0.320 (2.614)**	$LKTO_i$		0.154 (2.787)**
LBS_i		0.192 (1.372)	LCO_i		0.208 (4.234)***
constant	0.052 (0.587)	1.604 (2.807)**	constant	1.091 (1.741)*	2.238 (15.391)***
R-squared	0.992	0.331	R-squared	0.446	0.738
Adjusted R-squared	0.991	0.265	Adjusted R-squared	0.391	0.712
Sample	23	23	Sample	23	23

Note: *t* statistic values in parentheses. *** denotes significant at 1% significance level; ** denotes significant at 5% significance level; * denotes significant at 10% significance level.

As stated above, changes in the institution pillar score could not cause significant changes in the GII score. One possible explanation could be that the scores of this pillar of upper-middle-income countries are relatively high, and the average score is the highest among other pillars (see Table 2). Hence, further efforts channeled to improving the institutional and/or regulatory environment or crafting policies aimed at easing doing business in Armenia would probably not cause statistically significant changes in the GII score and would not significantly affect the innovation performance of the economy. On the contrary, the government of an upper-middle-income country aimed to improve the score, and the performance of the business sophistication pillar would pay off, thus resulting in a significant change in the scores of the GII.

The most significant impact on the changes in the GII score could be reported in the case of the increase in the scores of the market sophistication and creative outputs (see Table 5, Estimations 3 and 4). A change in the respective scores of these pillars by 1% could cause an increase in the GII score by 0.269% and 0.208%, respectively (see Table 5, Estimations 3 and 4).

The coefficients of knowledge and technology outputs, human capital and research, and infrastructure pillar scores are significant at a 5% significance level (see Table 5, Estimations 2–4). The changes in the scores of the respective pillars by 1% could lead to an increase in the GII score by 0.154%, 0.320%, and 0.353% accordingly (see Table 5, Estimations 2–4). Hence, the priorities of the government need to be focused on initiating measures and undergoing reforms that will primarily target mainly the performance of market sophistication, human capital and research, creative outputs and knowledge and technology outputs, and infrastructure. This would translate into higher performance of business sophistication pillar (forcing it to start causing a significant role in explaining changes in the GII score) and lead to higher innovation output sub-index score as well.

In the case of Estimation 4 (see Table 5), changes in variables included in the equation could explain about 71% of variance in the GII score. Since these pillars are grouped in the innovation output sub-index, the average scores thereof are lower than the scores of the innovation output sub-index pillar scores (see Table 2), and the GII score is the average of these two sub-indices (WIPO, 2023). Therefore, small changes in the innovation output sub-index scores could explain relatively high variance in the GII score values. These results are expected since the slight increase in scores of the innovation output sub-index pillars could increase the GII score with a relatively high score of the innovation input sub-index. Hence, a higher increase in the score of the innovation input sub-index would be required to result in higher changes in the GII score.

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In the short run and over the medium term, the government of Armenia needs to focus on human capital and research, market sophistication, and infrastructure pillars. This would translate into higher performance of creative knowledge and technology outputs and business sophistication pillars in the medium term and over the long run (mainly resulting in statistically significant changes in the GII score caused by changes in the score of business sophistication). One of the explanations for the coefficient of business sophistication pillar score being insignificant might be attributed to the relatively small sample size of upper-middle-income countries that was obtained. However, the insignificant coefficient of the business sophistication pillar score could be explained by the fact that the average score of this pillar was the lowest among all pillars of the innovation input sub-index, and relatively low pillar scores of economies of interest not always were associated with relatively low GII scores. Therefore, it is assumed that a further increase in expenditure on education, the number of graduates in science and engineering, expenditure on R&D by private companies via incentive schemes, nurturing university-industry R&D collaboration, and strengthening cluster development initiatives (WIPO, 2023) would translate into the higher performance of business sophistication pillar and innovation output sub-index pillars in the medium term and over the long run.

The changes in scores of all three sub-pillars of the human capital and research pillar could cause highly significant and positive changes in the pillar score (see Table 6, Estimations 5 and 6).

A percent increase in the score of the education sub-pillar could lead to an increase in the human capital and research pillar score by 0.653%, ceteris paribus. In comparison, the exact change in the tertiary education sub-pillar score could cause an increase in the respective pillar score by 0.307% (see Table 6, Estimation 5). Although the changes in the R&D sub-pillar have a highly significant impact on the score of the human capital and research pillar score, a percent change in the score of the sub-pillar could cause an increase in the pillar score by only 0.118% (see Table 6, Estimation 6). The results reiterate and highlight the need for substantially increasing the funding that the government of Armenia allocates to promote R&D activities, along with ensuring a significant number of scientists and engineers perform R&D to boost the innovation performance of the economy (Boțoroga et al., 2022). The government needs to increase expenditure on education to ensure and increase the supply of highly skilled labor force to boost the competitiveness of Armenia via an increase in productivity to improve the innovation performance of the economy and private companies through higher scores of business sophistication and knowledge and technology outputs pillars as well. Therefore, constant and targeted edu-

Table 6. Estimation results 2 (Method: Ordinary least squares)

Source: Calculations based on the GII Report (WIPO, 2023).

Dependent variable $LHCR_i$	Estimation 5	Estimation 6	Dependent variable $LINFR_i$	Estimation 7	Dependent variable LBS_i	Estimation 8	Estimation 9
$LEDU_i$	0.653 (5.576)***		$LICT_i$	0.461 (6.512)***	LKW_i	0.415 (6.151)***	
LTE_i	0.307 (5.443)***		LGI_i	0.229 (5.442)***	LIL_i	0.261 (5.692)***	
LRD_i		0.118 (3.762)***			LKA_i		0.156 (2.215)**
constant	–0.205 (–0.386)	3.155 (49.911)***	constant	1.021 (3.560)***	constant	1.143 (0.001)***	2.853 (14.062)***
R-squared	0.720	0.414	R-squared	0.841	R-squared	0.720	0.189
Adjusted R-squared	0.690	0.386	Adjusted R-squared	0.825	Adjusted R-squared	0.692	0.151
Sample	22	22	Sample	22	Sample	23	23

Note: *t* statistic values in parentheses. *** denotes significant at 1% significance level; ** denotes significant at 5% significance level.

cation initiatives (namely focused on the increase in the number of STEM graduates and tertiary education funding (Okolo et al., 2023; Mabrouka et al., 2018) and enrollment rate (Apostu et al., 2022) and building education infrastructure (Mohamed et al., 2022)) could drive both innovation performance and sustainable economic development of the country, since, in the case of a knowledge-based economy, education is the major driver (Popescu & Crenicean, 2012).

The changes in scores of only two sub-pillars (ICT and general infrastructure sub-pillars) of infrastructure could cause highly significant changes in the infrastructure pillar scores (see Table 6, Estimation 7). An increase in the score of the ICTs sub-pillar by 1% could cause an increase in the Infrastructure pillar score by 0.461%, ceteris paribus. In comparison, the exact change in the general infrastructure sub-pillar could cause a change in the respective pillar by 0.229% (see Table 6, Estimation 8).

The results indicate that the government of Armenia needs to prioritize "going online" strategies by offering more and more services online through changes in the legislation enforcing an increase in online transactions by the private sector and enabling access to these services through high-quality internet access, especially for the elderly people to address the "digital divide" problem. At the beginning of 2022, according to the Caucasus Barometer database (CRRC-Armenia Foundation, 2021), about 79% of adult respondents (18+) surveyed ($N = 1,648$) stated that they were internet users, and the average age of non-users was circa 65. "Going online" strategies adopted by the government of Armenia could force private companies to increase spending on software and adopt digitalization strategies that would positively affect the scores of the knowledge impact sub-pillar and knowledge and technology outputs pillar accordingly. Overall, digitalization and digital transformation of companies lead to an increase in firm-level innovations (Chen & Kim, 2023; Liu et al., 2023; Radicic & Petković, 2023). The new country digitalization strategy to be drafted could address the digital divide problem, and with a strong component aimed to increase the level of digital maturity of particularly small and medium-sized enterprises of Armenia, it would lead to higher performance of the knowledge and technology outputs pillar as well.

The government could increase public investments channeled to fixed capital acquisition and initiate reforms and specific measures to boost private business investments in capital goods. This would allow them to produce more sophisticated products with higher value-added and increase the labor force's productivity, thus resulting in higher performance of the knowledge and technology outputs pillar and the trade, diversification, and market scale sub-pillar of the market sophistication pillar. Therefore, the government could design targeted and differentiated incentive schemes based on the industry and the goods and/or services produced while importing high-tech and ICT services to boost the production and supply of services with higher value-added, thus ensuring higher diversification.

Ecological sustainability sub-pillar score changes proved to have no impact on explaining statistically significant changes in the infrastructure pillar score. Therefore, the government of Armenia needs to be concerned with the widespread adoption of energy-efficient and green technologies by both the public and private sectors. It is vital to draft strategies that will prioritize sustainability and "going green" principles by providing respective incentives to consumers and private businesses since a "green economy" is considered one of the factors explaining the competitiveness of the EU countries (Strilets et al., 2024).

Although the changes in the market sophistication pillar score explain the highly significant changes in the GII index score, due to a limited number of countries remaining after removing outliers, only the role of credit sub-pillar score changes turned out to be insignificant in explaining respective changes in the pillar score. This result could imply that an increase in credit and/or loan supply available for companies, namely the high-tech start-ups, per se, could not be translated into an increase in demand for such services (if the number of high-tech companies is limited or existing companies do not transform and switch to more sophisticated business practices and production of goods of higher value-added). Along with the existing funding supply, the government must prioritize and promote the production of goods from high-tech and knowledge-intensive industries and the export thereof, as well as such services. In turn,

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it would even result in changes in knowledge diffusion and knowledge impact sub-pillar scores of the knowledge and technology outputs, causing higher and statistically significant changes in the scores of respective pillars in the medium term and over the long run.

The coefficients of two of the business sophistication pillars, knowledge workers and innovation linkages, are highly significant. In contrast, knowledge absorption is significant at a 5% significance level (see Table 6, Estimations 8 and 9). A percent increase in the score of the knowledge workers sub-pillar could cause an increase in the business sophistication pillar score by 0.415%. In comparison, the change in the innovation linkages sub-pillar score would increase the respective pillar's score by 0.261% (see Table 6, Estimation 8). In addition, a percent change in the score of the knowledge absorption sub-pillar could cause an increase in the respective pillar score by 0.156% (see Table 6, Estimation 9). These results indicate that the government of Armenian needs to prioritize measures and actions that would improve the performance of business sophistication in the medium term and over the long run to report statistically significant changes in the GII score caused by the changes in the score of this pillar.

To boost the performance of the business sophistication pillar, the government of Armenia needs to draft incentives and or other schemes to boost R&D performance and promote investments in R&D by the private sector (funding from abroad as well to spur subsidiary R&D expenditures (Lenihan et al., 2023)). In addition, strengthening university and/or research institution–industry R&D collaboration via creating TTOs and empowering the university's capacity as an entrepreneurial university is necessary (Chais et al., 2017; Brantnell et al., 2022; Abdulai et al., 2022; Abd Rahman et al., 2011). The entrepreneurial universities in Armenia could promote an entrepreneurial mindset, upgrade the skills of the staff and students (Compagnucci & Spigarelli, 2024) by being actively engaged in science and technology entrepreneurship education processes and various initiatives (Bolzani et al., 2020), and deepen absorptive capacity (Sarpong et al., 2023). However, one of the key factors to ensure strong university-industry cooperation is the respective legislation that would strictly regulate areas of university-industry collaboration (Sitenko et al., 2024).

In the case of SMEs, direct support for performing R&D activities could be a preferred policy tool Armenia could introduce (Busom et al., 2014), and targeted R&D subsidies could be a better choice in the case of projects with a high degree of uncertainty (Svensson, 2024). However, diversified R&D incentive schemes need to be introduced for large companies separately and SMEs, with simplified approaches applied in the case of SMEs (Labeaga et al., 2021; Appelt et al., 2016). The government can introduce other R&D incentive schemes for private companies along with balancing indirect support measures with direct ones (Appelt et al., 2016; Zuniga, 2023) and build a viable mechanism to assess the efficacy of the R&D spending while favoring exporters (Zaman & Tanewski, 2024).

The government can introduce other R&D incentive schemes for private companies as well. The increase in public R&D spending needs to be in line with the R&D activities of universities in the framework of enhancing the capacities of university TTOs by setting up a public agency coordinating the activities of the established TTOs. This reflects the provisions of the Annexes to the Decrees of the Government of the Republic of Armenia No. 1363-A dated August 18, 2021 (the Government of Armenia, 2021a) in line with the program of the Government of the Republic of Armenia for 2021–2026; and Concept 4.1 of Innovative Initiatives, Development, and Implementation of Programs after Approval stated in the Annex No. 1 to the Decree of the Government of the Republic of Armenia No. 1902-L dated November 18, 2021 (the Government of Armenia, 2021b).

Unfortunately, model specification error was found concerning the knowledge creation sub-pillar; therefore, only the coefficients of knowledge diffusion and knowledge impact sub-pillar scores were reported, which proved to be highly significant. A percent increase in the knowledge diffusion sub-pillar score would increase the knowledge and technology outputs pillar score by 0.521% (see Table 7, Estimation 10). In comparison, the exact change in the knowledge impact sub-pillar could cause a change in the same pillar exceeding 1% (see Table 7, Estimation 11). This result states that concerning a sub-pillar score of

Table 7. Estimation results 3 (Method: Ordinary least squares)

Source: Calculations based on the GII Report (WIPO, 2023).

Dependent variable $LKTO_i$	Estimation 10	Estimation 11	Dependent variable LCO_i	Estimation 12	Estimation 13
LKD_i	0.521 (5.223)***		LIA_i	0.158 (1.829)*	
LKI_i		1.088 (3.220)***	LOC_i		0.396 (2.145)**
constant	1.392 (4.872)***	−0.526 (−0.494)	constant	2.501 (9.423)***	1.796 (3.286)***
R-squared	0.589	0.365	R-squared	0.137	0.195
Adjusted R-squared	0.568	0.330	Adjusted R-squared	0.096	0.153
Sample	21	20	Sample	23	21

Note: *t* statistic values in parentheses. *** denotes significant at 1% significance level; ** denotes significant at 5% significance level; * denotes significant at 10% significance level.

an average upper-middle income country, a change by 1% thereof could cause a higher change in the respective pillar score exceeding 1%.

The government of Armenia could ensure higher performance of the knowledge and technology outputs by crafting and implementing the steps and measures discussed above. This would translate into higher scores and better performance of this pillar through higher labor force productivity growth, software spending, high-tech manufacturing, etc.

Although the changes in the creative outputs pillar score explain the highly significant changes in the GII score, ceteris paribus, only changes in the online creativity sub-pillar score would cause an increase in the respective pillar score significant at a 5% significance level. The changes in the intangible assets sub-pillar score could result in changes in the creative outputs pillar score that prove significant at a 10% significance level. In contrast, the increase in the creative goods and services sub-pillar score would cause insignificant changes in the respective pillar score. Since ensuring a significant impact of the creative goods and services sub-pillar score on the creative outputs pillar score would require more efforts to translate into positive gains only in the medium and long term, the prime focus must be on the online creativity sub-pillar.

CONCLUSION

The purpose of the study is to estimate the impact of the respective pillars, sub-indices, and sub-pillars on the GII and Pillar scores for upper-middle-income countries to highlight Armenia's policy priorities based on various policy recommendations.

It was found that changes in the scores of market sophistication, creative outputs, knowledge and technology outputs, human capital and research, and infrastructure pillars explain statistically significant changes in the GII score. Moreover, Armenia's further efforts to improve its institutional and/or regulatory environment or design policies to facilitate the business environment would not significantly affect the economy's innovation performance. The coefficient of business sophistication pillar score being insignificant might be attributed to the relatively small sample size of upper-middle-income countries, the fact that the average score of this pillar was the lowest among all pillars of the innovation input sub-index, and the fact that these scores of economies of interest were not always associated with relatively low GII scores.

It was concluded that targeted tertiary higher education and R&D initiatives are required to drive Armenia's economy's innovation performance. The government of Armenia could substantially in-

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crease the funding allocated to promote R&D activities and prioritize designing incentives and/or other schemes to boost R&D performance. It could also strengthen university-industry collaboration via establishing technology transfer offices.

AUTHOR CONTRIBUTIONS

Conceptualization: Svetlana Dallakyan, Anna Makaryan, Verej Isanians, Hamlet Mkrtchyan, Harutyun Sargsyan, Gayane Tovmasyan.
Data curation: Svetlana Dallakyan, Anna Makaryan.
Formal analysis: Svetlana Dallakyan, Anna Makaryan, Verej Isanians, Hamlet Mkrtchyan.
Funding acquisition: Svetlana Dallakyan.
Investigation: Svetlana Dallakyan, Anna Makaryan, Verej Isanians, Hamlet Mkrtchyan.
Methodology: Svetlana Dallakyan, Anna Makaryan, Verej Isanians, Hamlet Mkrtchyan, Harutyun Sargsyan, Gayane Tovmasyan.
Project administration: Svetlana Dallakyan, Anna Makaryan, Gayane Tovmasyan.
Resources: Svetlana Dallakyan, Anna Makaryan, Verej Isanians, Svitlana Bilan.
Software: Svetlana Dallakyan, Anna Makaryan, Harutyun Sargsyan.
Supervision: Svetlana Dallakyan, Anna Makaryan.
Validation: Svetlana Dallakyan, Anna Makaryan, Verej Isanians, Hamlet Mkrtchyan, Harutyun Sargsyan, Gayane Tovmasyan.
Visualization: Svetlana Dallakyan, Anna Makaryan, Svitlana Bilan.
Writing – original draft: Svetlana Dallakyan, Anna Makaryan, Verej Isanians, Hamlet Mkrtchyan, Harutyun Sargsyan, Gayane Tovmasyan.
Writing – review & editing: Svetlana Dallakyan, Anna Makaryan, Verej Isanians, Hamlet Mkrtchyan, Harutyun Sargsyan, Gayane Tovmasyan, Svitlana Bilan.

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