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Is Innovation the Engine of Economic Growth? A Cross-Country Analysis

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ABSTRACT
Purpose: The aim of this study is to examine the existence and differentiation of the impact of innovation on economic growth across country groups through a panel data analysis covering 93 countries between 2011 and 2023. The research investigates whether innovation affects economic growth and whether this effect varies according to country income groups.
Methodology: Data from the World Bank and the Global Innovation Index (GII) were used in the study, and empirical analyses were conducted using Ordinary Least Squares (OLS) and Fully Modified Ordinary Least Squares (FMOLS) methods. The preference for panel data analysis allowed for the consideration of structural differences between countries and changes over time.
Findings: The findings indicate that innovation has a significant and positive effect on economic growth. Furthermore, it was determined that the impact of innovation on growth is higher in low- and middle-income countries, while it is relatively lower in high-income countries.
Originality: This study provides an original contribution to literature by comparatively analyzing the effect of innovation on economic growth across country groups. The results reveal that innovation should be at the center of development policies to achieve sustainable growth goals.
Keywords*:* Innovation, Economic Growth, Panel Data Analysis, Income Groups, Global Innovation Index.
JEL Codes*:* O30, O47, C33.

İnovasyon, Ekonomik Büyümenin İtici Gücü mü? Ülkeler Arası Bir Analiz

ÖZET
Amaç: Bu çalışmanın amacı, 2011-2023 yılları arasında 93 ülkeyi kapsayan panel veri analizi ile inovasyonun ekonomik büyüme üzerindeki etkisinin varlığını ve bu etkinin ülke gruplarına göre farklılaşıp farklılaşmadığını incelemektir. Araştırmada, inovasyonun ekonomik büyüme üzerindeki etkisinin olup olmadığı ve bu etkinin ülke gelir gruplarına göre değişip değişmediği araştırılmıştır.
Yöntem: Çalışmada Dünya Bankası ve Küresel İnovasyon Endeksi (GII) verileri kullanılmış, ampirik analizler En Küçük Kareler (OLS) ve Tam Modifiye Edilmiş En Küçük Kareler (FMOLS) yöntemleriyle gerçekleştirilmiştir. Panel veri analizi tercih edilerek ülkeler arasındaki yapısal farklılıklar ve zaman içindeki değişimler dikkate alınmıştır.
Bulgular: Elde edilen bulgular, inovasyonun ekonomik büyüme üzerinde anlamlı ve pozitif bir etkisi olduğunu göstermiştir. Ayrıca, inovasyonun büyüme üzerindeki etkisinin düşük ve orta gelirli ülkelerde daha yüksek, yüksek gelirli ülkelerde ise görece daha düşük olduğu belirlenmiştir.
Özgünlük: Bu çalışma, inovasyonun ekonomik büyüme üzerindeki etkisini ülke grupları bazında karşılaştırmalı olarak analiz ederek literatüre özgün bir katkı sunmaktadır. Sonuçlar, sürdürülebilir büyüme hedeflerine ulaşmada inovasyonun kalkınma politikalarının merkezinde yer alması gerektiğini ortaya koymaktadır.
Anahtar Kelimeler: İnovasyon, Ekonomik Büyüme, Panel Veri Analizi, Gelir Grupları, Küresel İnovasyon Endeksi.
JEL Kodları: O30, O47, C33.

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1. INTRODUCTION

The relationship between innovation and economic growth has been a persistent focus in literature, gaining renewed importance amid globalization, intensified competition, and rapid technological change (WIPO, 2023: 13; Hausman, 2022).

At the theoretical level, innovation has long been acknowledged as an engine of growth. Schumpeter's (1934: 167) concept of "creative destruction" illustrates how entrepreneurial innovation transforms economic structures, while Romer's (1990) endogenous growth theory and Aghion and Howitt's (1992, 2009) models emphasize the accumulation of knowledge and R&D as the foundation of sustainable development. These theories collectively highlight that innovation is not a peripheral element but rather a constitutive driver of modern economies.

On the empirical side, studies confirm that innovation's impact on economic growth is multifaceted and varies across countries. For example, Gyedu et al. (2021) show that innovation has a stronger and more stable effect in G7 countries compared to BRICS, and that this relationship is bidirectional. This divergence suggests that innovation outcomes are shaped not only by technological inputs but also by structural conditions such as institutional quality, human capital, and knowledge diffusion (Hausman, 2022).

Recent contributions have further clarified the heterogeneous channels through which innovation influences growth. For instance, Bate et al. (2023) demonstrate that the determinants of innovation performance vary substantially across income groups, highlighting that institutional environments, human capital and R&D capacity drive growth differently across countries. Similarly, Çemberci et al. (2022) emphasize that innovation also operates indirectly, for example by attracting foreign direct investment (FDI) and thereby accelerating technology transfer. Dempere et al. (2023) provide further evidence that innovation not only supports GDP growth, but also mobilizes self-employment and entrepreneurial activity, reinforcing the labor market dimension of innovation-driven growth.

Another dimension concerns small and medium-sized enterprises (SMEs), where financial access, collaborative networks, and supportive institutions determine whether innovation diffuses broadly or remains concentrated (Gerguri and Ramadani, 2010; Kim and Lee, 2016). Moreover, the institutional and legal environment—including intellectual property rights and market openness—plays a decisive role in fostering innovation, especially in developing economies (Zhao, 2022; Ojekemi et al., 2022).

Taken together, the literature suggests that innovation is indeed a key pillar of economic growth, but the intensity and the transmission mechanisms of this effect differ significantly across contexts. This variability creates a research gap, particularly concerning systematic cross-country comparisons along income groups. Accordingly, the main research question of this study is direct and essential: To what extent does innovation act as a genuine driver of economic growth, and how does this effect differ across country income groups? By focusing on this question, the study aims to fill the gap in comparative research and to offer policy-relevant insights.

The contribution of this paper is threefold. First, it provides a cross-country empirical test using panel data for 93 countries over 2011–2023. Second, by explicitly distinguishing between income groups, it identifies whether marginal returns to innovation differ across high-income and low-/middle-income countries, consistent with the frameworks suggested by Bate et al. (2023). Third, it integrates Global Innovation Index (henceforth, GII) into the econometric model as a holistic measure of innovation activities, thereby recognizing its different growth-transmission channels: (i) human capital and R&D, (ii) foreign direct investment and technology transfer, (iii) entrepreneurship and employment, and (iv) institutional and legal structures. In this study, "innovation" is thus operationalized through GII, ensuring conceptual clarity and alignment with theory and policy.

In sum, this study hypothesizes that innovation has a significant and positive influence on economic growth, while the magnitude and direction of this relationship are expected to vary according to a country's level of development. This heterogeneity can provide meaningful guidance for differentiated policy design. In line with this objective, the remainder of the study proceeds as follows: the next section outlines the conceptual framework and data structure, followed by the methodology. Subsequently, empirical findings are presented and discussed, and the final section concludes with policy recommendations and implications for future research.

2. CONCEPTUAL FRAMEWORK

Innovation occupies a central role in ensuring the sustainability of economic growth and enhancing welfare in contemporary economies. World Intellectual Property Organization (henceforth, WIPO, 2024: 250) defines innovation as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).” In an era of rapid digitalization, green transition, and intensified global competition, innovation’s contribution to growth has become a strategic priority for both policymakers and scholars.

The relationship between innovation and economic growth has long been debated. In particular, the role of innovation in sustaining economic growth has become increasingly pronounced in contemporary economies, where globalization has accelerated and pressures related to competition and productivity have intensified (WIPO: 12, 2023; Hausman, 2022). Schumpeter’s (1934: 15) concept of creative destruction underscored innovation as the fundamental engine of development. Later, Romer’s (1990) endogenous growth theory and Aghion and Howitt’s (1992, 2009) models emphasized knowledge accumulation and R&D-driven technological change as the foundation of sustainable long-run growth. These frameworks collectively establish that entrepreneurial and research activities trigger structural transformation, productivity increases, and welfare gains.

This theoretical framework has been increasingly supported by recent empirical studies. For example, Gyedu et al. (2021), employing a GMM-type VAR model for G7 and BRICS countries, show that innovation exerts a stronger and more stable effect on economic growth in G7, whereas the effect in BRICS appears weaker and more volatile. Importantly, they identify a bidirectional causal relationship, reinforcing the idea that growth and innovation co-evolve through entrepreneurship and technological progress in line with Schumpeterian and endogenous growth theories.

At the same time, evidence suggests that this relationship is contingent on structural factors. Institutional quality, human capital, and knowledge diffusion shape the transmission channels of innovation (Aytar, 2020: 37-38; Hausman, 2022), while Ojekemi et al. (2022) emphasize the decisive role of institutional structures in developing economies. Complementary studies highlight specific channels: Rajput et al. (2012) and Çemberci et al. (2022) report that GII scores correlate strongly with GDP growth, largely mediated by foreign direct investment (FDI) and trade openness, while Dempere et al. (2023) show that innovation stimulates entrepreneurship and employment-driven growth.

Recent contributions also stress that new dynamics—such as the COVID-19 pandemic, digital transformation, and green transition—further complicate the innovation–growth nexus. For instance, Akcigit and Ates (2021) analyzed the short- and long-term effects of the COVID-19 pandemic on innovation activities, highlighting that digital innovation has served as a critical lever for growth during times of crisis. Qureshi et al. (2021), in their examination of Latin American countries, instead emphasized the joint role of digitalization and institutional capacity in linking innovation to economic outcomes. Bate et al. (2023) support this perspective by demonstrating in a cross-country GII analysis that differences in institutional quality and income levels critically explain the heterogeneity of innovation’s impact on growth. Aklilu et al. (2025: 37) emphasize the role of green innovation in economic growth and sustainable development, demonstrating that the widespread adoption of environmentally friendly technologies leads to both increased employment and productivity. Numerous studies underscore the importance of innovation for inclusive growth, noting in particular that investments in digital infrastructure significantly enhance innovation capacity, especially in low- and middle-income countries (Crespi et al., 2020; George et al., 2020; Qureshi et al., 2021; WIPO, 2024:21-23).

The impact of innovation on economic growth is not limited to large-scale firms (Bay and Çil, 2016; Çil, 2025; Çil and Bay, 2015; Yalçın and Çil, 2023). Gerguri and Ramadani (2010) examined the role of SMEs in innovation processes, demonstrating that access to financial resources, collaborative networks, and institutional support are crucial for the widespread adoption of innovation. The authors emphasize that innovation not only leads to the creation of new technologies and products, but also enhances productivity, generates employment, and improves quality of life. This highlights the necessity of adequate financing and supportive institutional infrastructure for SMEs, an aspect directly reflected in the GII's pillars of market and business sophistication (Kim and Lee, 2016; European Commission, 2021).

From a broader perspective, it has been shown that increases in patent activity are strongly correlated with economic growth, and that technological progress generates positive externalities not only for innovative firms but for the entire economy (Hasan and Tucci, 2010; Griliches, 1992). Endogenous growth models emphasize the role of human capital in enhancing innovation capacity (Lucas, 1988; Romer, 1990), while also highlighting the critical importance of education and skills development for the widespread diffusion of technological advances at the societal level.

Overall, the literature converges on a multidimensional framework whereby innovation contributes to economic growth through:

- Human capital accumulation (Lucas, 1988; Romer, 1990);
- Entrepreneurship and creative destruction (Schumpeter, 1934; Aghion and Howitt, 1992, 2009);

- Institutional and legal infrastructure (North, 1990; Zhao, 2022; Ojekemi et al., 2022);
- Knowledge diffusion and international linkages (Rajput et al., 2012; Çemberci et al., 2022; Dempere et al., 2023);
- And structural dynamics such as digitalization and green innovation (Akcigit and Ates, 2021; Aklilu et al., 2025; Bate et al., 2023).

Based on this framework, the GII emerges as a widely recognized and robust tool to measure innovation performance across multiple pillars. Its seven dimensions—institutional environment, human capital and research, infrastructure, market sophistication, business sophistication, knowledge/technology outputs, and creative outputs—capture the very mechanisms emphasized in both theoretical and empirical studies. Accordingly, the research builds on the following hypotheses:

H1: Higher levels of innovation, as measured by the GII, are positively associated with economic growth.

H2: The positive effect of innovation on economic growth differs across country income groups; it is larger in low- and middle-income countries than in high-income countries.

This expectation is consistent with the technological-gap and diminishing-marginal-returns perspectives: as absorptive capacity improves, innovation investments can yield higher marginal growth returns in low- and middle-income economies.

In the existing literature, the impact of innovation on economic growth has predominantly been examined in the context of high-income countries or specific regional groups. This study, however, is among the few that conduct a comparative analysis of the effect of innovation on economic growth using a recent (2011–2023) panel dataset covering both high- and low/middle-income countries across 93 nations. Accordingly, this research quantitatively analyzes the impact of innovation on economic growth using GII data and aims to offer insights into innovation policy by comparing the findings with theoretical and empirical literature.

2.1. Data

In this study, a balanced panel dataset covering the period from 2011 to 2023 was constructed to analyze the relationship between innovation and economic growth. The analysis includes 93 countries, selected based on the availability of uninterrupted data in both the GII and the World Bank's World Development Indicators (WDI) databases for the years 2011 to 2023. This approach ensures the preservation of both the number of observations and data integrity in the panel data analysis (Baltagi, 2021: 8).

Table 1. Variables, definitions and sources

Variable	*Symbol*	*Definition*	*Source*	*Transformation*
GDP per capita (constant 2015 US$)	lnPCGDP	Real GDP per capita obtained from the World Bank WDI series (API_NY.GDP.PCAP.KD_DS2), expressed in constant 2015 US dollars and converted into natural logarithms	World Bank (2025a)	Natural logarithm
Global Innovation Index (overall score)	lnGII	Overall Global Innovation Index score covering seven pillars (Institutions, Human capital & research, Infrastructure, Market sophistication, Business sophistication, Knowledge/technology outputs, Creative outputs), expressed in natural logarithms	WIPO, Global Innovation Index Reports (2011-2023)	Natural logarithm
Country income classification	Group	Categorization of countries into "high-income" versus "low- and middle-income" groups	World Bank Income Classification (2025b)	No transformation

Gross domestic product (GDP) per capita was employed as an indicator of economic growth. The per capita GDP data were obtained from the World Bank's WDI database, specifically using the "API_NY.GDP.PCAP.KD_DS2" series, and are expressed in constant 2015 US dollars (World Bank, 2025a). GDP is defined as the total value added generated by resident producers within a country, with taxes on products included and subsidies deducted (Ahmad and Schreyer, 2016:26). GDP figures expressed at constant prices are adjusted for inflation, allowing for meaningful comparisons of economic growth across different periods. Per capita GDP is calculated by dividing the total GDP by the mid-year population and is widely used as a measure of average welfare across countries (Barro, 1991).

GDP, as used in this study, represents the sum of value added by all resident producers in the economy (Ahmad and Schreyer, 2016:26). In this calculation, taxes on products are included, while subsidies are subtracted. It should be noted that GDP does not account for the depreciation of produced assets, nor does it consider factors such as the depletion of natural resources or environmental degradation. The GDP data utilized in this research are reported in constant 2015 US dollars. Expressing GDP at constant prices eliminates the effects of inflation, thereby enabling the comparison of economic growth across different time periods. Per capita GDP, on the other hand, is an economic indicator calculated by dividing a country's total GDP by its mid-year population (Barro, 1991). This measure is widely used to assess the average level of welfare and economic performance within a country. Finally, the use of logarithmic transformations provides elasticity interpretations of the estimated coefficients, ensuring that results can be expressed in percentage terms rather than in absolute units.

To measure the level of innovation, data from the GII were used. The GII, prepared through the collaboration of the WIPO, INSEAD (Institut Européen 'administration des affaires), and Cornell University, is an internationally recognized index that evaluates countries' innovation capacities in a multidimensional manner (WIPO, 2023: 6-7). The index consists of seven main components: institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge and technology outputs, and creative outputs (WIPO, 2023:58). Each main component is further detailed with relevant sub-indicators. For example, the human capital and research component includes indicators such as educational attainment, student-teacher ratios, access to higher education, and R&D activities, while the knowledge and technology outputs component covers knowledge production, impact, and diffusion. This structural framework enables the GII to provide a comprehensive assessment of countries' innovation capacities (WIPO, 2023). The GII data was compiled from the annually published GII reports between 2011 and 2023.

In this study, countries were classified into two groups— "low and middle income" and "high income"— according to the World Bank's current income classification (World Bank, 2025b). Analyses were conducted separately for all countries, for low- and middle-income countries, and for high income countries. This distinction is important for examining whether the impact of innovation on economic growth differs across country groups.

3. METHOD

In this study, panel data analysis was employed to examine the impact of innovation on economic growth. Panel data analysis combines both cross-sectional (countries) and time-series (years) dimensions, allowing for the simultaneous investigation of heterogeneity across countries and changes over time (Baltagi, 2021: 7; Hsiao, 2014: 32). This approach considers the fact that structural differences among countries—such as institutional arrangements, educational attainment, and technological infrastructure—may influence the relationship between economic growth and innovation. It also enables the control of such heterogeneity through fixed effects (FE) or random effects (RE) models (Wooldridge, 2010: 489–491).

One of the main reasons for preferring panel data analysis is its ability to account for structural differences across countries that may affect the relationship between economic growth and innovation. By employing fixed or random effects models, panel data analysis provides a means to control for this heterogeneity (Hsiao, 2014: 11-12). Furthermore, panel datasets contain more data points compared to pure time series or cross-sectional datasets, which leads to more reliable and consistent estimates and increases the degrees of freedom (Wooldridge, 2010:14-18). Panel data analysis also allows for the examination of dynamic relationships and lagged effects among variables, which is crucial for understanding how the impact of innovation on economic growth evolves over time. Finally, panel cointegration tests help determine whether a long-term relationship exists between variables, playing a critical role in analyzing the sustainability of the relationship between innovation and economic growth (Kao, 1999).

The stationarity properties of the variables were first examined using panel unit root tests, including Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS), ADF-Fisher, and PP-Fisher at both levels and first differences (Levin et al., 2002; Im et al., 2003). Following this, the Kao panel cointegration test (Kao, 1999) was employed to test long-run relationships among the series. For cointegrated series, regression analyses were conducted using both panel fixed effects with Ordinary Least Squares (OLS) and the Fully Modified Ordinary Least Squares (FMOLS) method (Pedroni, 2001). To determine the appropriate panel specification, the Hausman test (Hausman, 1978) was used to choose between fixed effects and random effects estimators. The results indicated that the fixed effects model was appropriate in all country groups.

Unit root test specifications: We implemented LLC, IPS, ADF-Fisher, and PP-Fisher tests under two deterministic specifications: (i) constant only and (ii) constant plus linear trend. We did not estimate a specification without constant and trend. The results reported in Tables 2–7 correspond to the constant-only case; constant-plus-trend results are qualitatively identical and available upon request. In sum, all series are I(1): levels are generally non-stationary, while first differences are stationary at the 1% level across tests.

Clarification on income-group comparisons: The World Bank country income classification was used solely to split the sample into two subsamples (high-income; low- and middle-income). It was not included as a dummy regressor in the econometric specifications. All group comparisons are based on separate estimations for each subsample. The following model will be estimated (Equation 1):

$$ln(PCGDP_{it}) = \alpha_i + \beta ln(GII_{it}) + \varepsilon_{it} \quad (1)$$

$ln(PCGDP_{it})$denotes the natural logarithm of real GDP per capita for country i in year t and is the dependent variable. $ln(GII_{it})$ is the independent variable. α_i captures country fixed effects; ε_{it} is the idiosyncratic error term. Indices i and t denote cross-sectional units (countries) and time (years).

For cointegrated panels, we also estimate long-run elasticities using panel FMOLS, which applies semi-parametric corrections for endogeneity and serial correlation, following Phillips and Hansen (1990), Kao and Chiang (2000), and Pedroni (2001). We estimate constant-only and constant-plus-trend specifications. Full estimation details are available upon request.

In the panel regressions, both the fixed effects model using OLS and FMOLS method were utilized (Pedroni, 2001). To choose between the fixed effects and random effects models, the Hausman test was applied (Hausman, 1978). The Hausman test assesses whether the fixed effects are random and guides the selection of the appropriate model. OLS aims to provide more accurate estimates of the relationships among variables by controlling for time-invariant individual effects of each unit (country). In this model, different intercepts are included for each country, capturing unobserved heterogeneity across countries (Baltagi, 2021: 7; Hsiao, 2014: 34-35).

The FMOLS method, originally developed by Phillips and Hansen (1990) and later extended to the panel data context by Pedroni (2001) and Kao and Chiang (2000), is specifically designed for cointegrated panels. It corrects for potential endogeneity among regressors and serial correlation in the error terms, thereby providing more reliable long-run estimates. Unlike conventional OLS, FMOLS employs semi-parametric corrections (via kernel estimators and bandwidth selection) to deal with serial dependence and regressor–error correlation. FMOLS is widely used for analyzing long-term relationships and offers consistent and efficient parameter estimates in the presence of cointegration. In the empirical literature, the FMOLS approach has been extensively applied to examine the long-run linkages between growth, trade, financial development, energy use, and innovation, owing to its robustness in small samples and heterogeneous panels (Pedroni, 2001; Phillips and Hansen, 1990). In this study, both constant-only and constant-with-trend specifications were estimated to ensure the robustness of long-run coefficients. The kernel estimates were implemented using the Newey–West bandwidth selection procedure, increasing the reliability of the FMOLS results across different country groups. We select fixed effects over random effects based on the Hausman test (Hausman, 1978). Estimation follows standard practice (Baltagi, 2021: 8-9; Hsiao, 2014:11).

In line with the principle of parsimony, the model specification deliberately excludes additional control variables. Unlike narrow proxies of innovation, the GII already incorporates multiple dimensions—such as human capital, institutions, infrastructure, and business sophistication—that would otherwise be introduced as separate controls. Including them separately may lead to double-counting and obscure the explanatory power of innovation itself. Therefore, this minimalist specification allows us to directly test whether innovation alone, when measured comprehensively, exerts a significant and distinct impact on countries' economic growth.

4. FINDINGS

4.1. Panel Unit Root Tests

The results of the panel unit root tests are presented in Table 2 and Table 3. According to Table 2, for the level values of economic growth (PCGDP) and the GII, the LLC, IPS, ADF-Fisher, and PP-Fisher tests do not reject the null hypothesis of a unit root, indicating that the series are non-stationary. When the first differences are taken (Table 3), both variables become stationary at the 1% significance level across all tests. These results suggest that the series are integrated of order one, I(1), and are therefore suitable for panel cointegration analysis (Levin et al., 2002; Im et al., 2003).

Table 2. Unit root tests for variables (level)

Method	Economic Growth (p-values)	GII (p-values)
Levin, Lin & Chu t*	-4.0715***	-1.2841
	(0.0000)	(0.0996)
Im, Pesaran and Shin W-stat	2.5430	2.1552
	(0.9945)	(0.9844)
ADF - Fisher Chi-square	182.0330	205.5770
	(0.5685)	(0.1549)
PP - Fisher Chi-square	207.9530	222.1460
	(0.1291)	(0.0360)

Note: Values in parentheses are p-values. "***" denotes significance at the 1% level.

Reported statistics are based on the constant-only specification; constant-plus-trend tests yield the same order of integration (I(1)) for all series.

Table 3. Panel unit root test results (first differences)

Method	Economic Growth (p-values)	GII (p-values)
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-16.6056***	-31.9934***
	(0.0000)	(0.0000)
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-17.5294***	-26.1046***
	(0.0000)	(0.0000)
ADF - Fisher Chi-square	701.5360***	885.7840***
	(0.0000)	(0.0000)
PP - Fisher Chi-square	1051.5200***	1116.6300***
	(0.0000)	(0.0000)

Note: Values in parentheses are p-values. "***" denotes significance at the 1% level.

Results for the panel unit root tests for the analysis of high-income countries are presented in Table 4. With respect to the PCGDP variable, whereas the LLC test results indicate that the variable is stationary at the 1% level of significance, the other tests indicate non-stationarity of level values. This conclusion suggests that despite the LLC test results, the general conclusion among the tests is that the series under PCGDP contains a unit root at level values making the series non-stationary. For the GII variable, the LLC test result indicates that the series is stationary at the 5% level, while the IPS test shows that the series is stationary at the 1% level. Conversely, the results from ADF-Fisher and PP-Fisher tests do not support the results from the LLC and IPS tests. Thus, the GII series is concluded to exhibit the presence of unit root at its level values.

Table 4. Unit root tests for variables (level) – High income countries

Method	Economic Growth (p-values)	GII (p-values)
Levin, Lin & Chu t*	-2.9381***	-1.6546**
	(0.0017)	(0.0490)
Im, Pesaran and Shin W-stat	2.5695	-3.1332***
	(0.9949)	(0.0009)
ADF - Fisher Chi-square	60.9326	99.0594
	(0.9815)	(0.1587)
PP - Fisher Chi-square	68.2448	62.0739
	(0.9204)	(0.9759)

Note: Values in parentheses are p-values. "***" denotes significance at the 1% level.

However, when looking at the first difference variables in Table 5, there is clear evidence of unit root absence according to all tests (LLC, IPS, ADF-Fisher, PP-Fisher) at the 1% significance level both for the economic growth variable and the GII indicators. This means that data for these variables are stationary at the first difference or I(1) process of GII. The same result emerges based on panel unit root tests run for the high-income country group with the entire series are found to be non-stationary at level, and stationary at first differences. Since variables considered for analysis were found to be non-stationary at levels but stationary at first differences/panel unit root tests, the series are I(1) and suitable for panel cointegration tests according to Levin et al. (2002) and Im et al. (2003).

Table 5. Panel unit root test results (first differences) – High income countries

Method	*Economic Growth (p-values)*	*GII (p-values)*
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-18.5433***	-23.3922***
	(0.0000)	(0.0000)
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-15.1878***	-20.1257***
	(0.0000)	(0.0000)
ADF - Fisher Chi-square	363.0360***	451.1130***
	(0.0000)	(0.0000)
PP - Fisher Chi-square	551.6250***	562.7260***
	(0.0000)	(0.0000)

Note: Values in parentheses are p-values. "***" denotes significance at the 1% level.

Table 6 presents the results for the level of panel unit root tests for low- and middle-income countries. In the case of the economic growth variable (PCGDP), while the LLC test indicates stationarity at the 1% level of significance, the IPS test and the Fisher tests (both ADF and PP) do not reject the null hypothesis of non-stationarity. The ADF-Fisher test has a p-value close to the 10% significant level, while the other two tests do not provide even near significance. Hence, we conclude that the economic growth series is generally not stationary at the level values.

In the case of the GII variable, all tests of unit root at the level values (LLC, IPS, ADF-Fisher, and PP-Fisher) indicate that we do not reject the null hypothesis of the presence of a unit root. This evidence suggests that the GII series is generally not stationary at its level values, thus indicating its unit root, which may also exhibit I(1) characteristics.

Table 6. Unit root tests for variables (level) – Low/middle income countries

Method	*Economic Growth (p-values)*	*GII (p-values)*
Levin, Lin & Chu t*	-2.9559***	-4.3626
	(0.0016)	(0.9999)
Im, Pesaran and Shin W-stat	1.0984	7.0385
	(0.8640)	(0.9999)
ADF - Fisher Chi-square	121.1000	58.5376
	(0.0743)	(0.9997)
PP - Fisher Chi-square	139.7050	64.9191
	(0.0054)	(0.9975)

Note: Values in parentheses are p-values. "***" denotes significance at the 1% level.

Table 6 reveals that for the first difference of both economic growth and GII, LLC, IPS, ADF-Fisher, and PP-Fisher tests confirm stationarity at the 1% level. Consequently, both economic growth and GII turn stationary after first differencing. Therefore, it is established that for the low- and middle-income countries under consideration, both economic growth and GII are non-stationary at level but become stationary after first differencing. Hence, they are inferred to be I(1) and are suitable for panel cointegration tests, as suggested by Levin et al. (2002) and Im et al. (2003).

The results of the panel unit root tests are shown in Table 7, which are similar across overall, high income only, and low and middle income only. It can be observed that all the variables have a unit root because they are non-stationary at all tests and significant levels in their levels. The first difference of each variable, however, is found stationary at one percent level of significance across all tests. Given that the PCGDP and GII are integrated of order one I(1) process, we proceed to the panel cointegration tests.

Table 7. Panel unit root test results (first differences)- Low/middle income countries

Method	*Economic Growth (p-values)*	*GII (p-values)*
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-7.7353***	-20.5405***
	(0.0000)	(0.0000)
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-9.7912***	-16.3779***
	(0.0000)	(0.0000)
ADF - Fisher Chi-square	338.5010***	426.4800***
	(0.0000)	(0.0000)
PP - Fisher Chi-square	499.8990***	543.5550***
	(0.0000)	(0.0000)

Note: Values in parentheses are p-values. "***" denotes significance at the 1% level.

4.2. Panel Cointegration Results

According to the results of the Kao panel cointegration test presented in Table 8, a long-term cointegration relationship between economic growth and the GII was identified for all countries, as well as for both the low-middle and high-income country groups. In all groups, the ADF statistics were found to be significant, with p-values well below 1%. This finding indicates that there is a statistically significant long-term relationship between the variables (Kao, 1999).

Table 8. Kao Test results

Country Group	*t-Statistic*	*Prob.*
ADF – Low- and Middle-Income Countries	-6.9721	0.0000
ADF – High Income Countries	6.8330	0.0000
ADF – All Countries	11.3343	0.0000

After establishing the presence of cointegration, both the panel fixed effects model (OLS) and the FMOLS method were employed to analyze the long-term relationship between the variables (Pedroni, 2001).

4.3. Long-Term Coefficient Estimates

Following the confirmation of cointegration, panel fixed effects and FMOLS estimations were conducted.

Table 9. GII and Economic Growth: OLS Results of All Countries

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
GII	0.0929	0.0015	61.4955	0.0000
C	5.5288	0.0617	89.5804	0.0000
R-squared	0.7605			
Adjusted R-squared	0.7579			
F-statistic	291.9568			0.0000
Hausman statistic	125.4380			0.0000

According to Table 9, the impact of innovation on economic growth is positive and quite substantial. A 1% increase in the GII is associated with a 0.093% increase in per capita GDP.This effect is statistically significant at well below the 1% significance level ($p<0.01$). Furthermore, the explanatory power of the model is notably high; innovation accounts for 76% of the variation in economic growth ($R^2 = 0.76$). Based on the results of the Hausman test, the fixed effects model was preferred ($p<0.01$). These findings indicate that innovation has a significant effect on the economic growth of countries.

Table 10. FMOLS results of all countries

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
Overall GII Score	0.2432	0.0009	266.2388	0.0000

The results obtained using the FMOLS method similarly indicate that innovation has a positive and significant effect on economic growth (Table 10). According to the FMOLS model, a 1% increase in the GII is associated with a 0.243% increase in per capita GDP, and this effect is also highly significant at well below the 1% level. The fact that the FMOLS coefficient is approximately 2.6 times larger than the FE coefficient suggests that, after correcting for serial correlation and endogeneity, the long-term marginal effect of innovation increases.

Table 11. GII and economic growth (OLS): Low and middle income countries

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
GII	0.0747	0.0044	16.9868	0.0000
C	5.9191	0.1358	43.5824	0.0000
R-squared	0.3181			
Adjusted R-squared	0.3041			
F-statistic	22.8169			0.0000
Hausman statistic	59.0413			0.0000

The findings for low- and middle-income countries are presented in Table 11. According to the OLS results, the effect of innovation on economic growth is positive and significant; a 1% increase in the GII is associated with a 0.075% increase in per capita GDP ($p<0.01$). The explanatory power of the model is moderate, with innovation accounting for approximately 32% of the variation in economic growth ($R^2 = 0.32$). The Hausman test indicates that the fixed effects model is appropriate ($p<0.01$). These results support the conclusion that innovation also has a significant impact on the economic growth of low- and middle-income countries.

Table 12. FMOLS: Low and middle income countries

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
Overall GII Score	0.2591	0.0014	180.7011	0.0000

The analysis conducted using the FMOLS method also finds that the effect of innovation on economic growth is positive and significant (Table 12). According to the FMOLS model, a 1% increase in GII is associated with a 0.259% increase in per capita GDP ($p<0.01$). Therefore, the effect of innovation is higher in this group (FMOLS = 0.259), which, in line with the theory of marginal returns, suggests that in economies with a larger technology gap, the contribution of innovation investments to growth may be greater (Fagerberg et al., 2010:18-19).

Table 13. GII and economic growth (OLS): High income countries

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
GII	0.0591	0.00189	31.3589	0.0000
C	7.3768	0.0943	78.2272	0.0000
R-squared	0.6464			
Adjusted R-squared	0.6380			
F-statistic	0.0000			0.0000
Hausman statistic	42.1754			0.0000

The findings for high income countries are presented in Table 13. According to the OLS results, the effect of innovation on economic growth is positive and significant; a 1% increase in the GII is associated with a 0.059% increase in per capita GDP ($p<0.01$). The explanatory power of the model is high, with innovation accounting for approximately 65% of the variation in economic growth ($R^2 = 0.65$). The Hausman test indicates that the fixed effects model should be preferred ($p<0.01$). These results demonstrate that innovation also has a significant impact on the economic growth of high-income countries. Comparing elasticities across subsamples, both OLS and FMOLS indicate larger effects in low- and middle-income countries (OLS ≈ 0.075; FMOLS ≈ 0.259) than in high-income countries (OLS ≈ 0.059; FMOLS ≈ 0.213), thereby confirming revised H2.

Table 14. FMOLS: High income countries

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
Overall GII Score	0.2130	0.0007	310.5076	0.0000

The analysis conducted using the FMOLS method also reveals that the effect of innovation on economic growth is positive and significant (Table 14). According to the FMOLS model, a 1% increase in the GII is associated with a 0.213% increase in per capita GDP ($p<0.01$). In the high-income group, the long-term coefficient of innovation is 0.213, indicating that in advanced economies, innovation supports growth through more sophisticated channels. The fact that this coefficient is lower than that of the low- and middle-income group is consistent with the expectation of diminishing marginal returns.

These findings demonstrate that innovation has a positive and statistically significant effect on economic growth across all country groups. Moreover, the effect of innovation on growth is found to be higher in low- and middle-income countries, suggesting that innovation policies should be tailored according to the stage of development. Our results are consistent with those of Aghion & Howitt (2009) and Fagerberg et al. (2010:18-19), confirming that innovation should play a central role in development strategies.

5. DISCUSSION and CONCLUSION

The primary research question of this study is to determine whether innovation has a significant and statistically valid effect on economic growth, using a panel data analysis covering 93 countries over the period 2011–2023. The rationale for selecting this question lies in the central role that innovation plays in achieving sustainable growth in today's global economy, a point frequently emphasized in both theoretical and empirical literature. Moreover, there is a growing body of evidence suggesting that cross-country differences in growth are largely attributable to differences in innovation capacity. In particular, the multifaceted effects of technological advancements and knowledge accumulation on economic performance have necessitated a more detailed and comparative examination of the role of innovation in growth dynamics.

The findings of this study clearly demonstrate that innovation is one of the fundamental determinants of economic growth, and that this relationship holds true for both high-income and low-/middle-income countries. Panel unit root and cointegration tests reveal a long-term and statistically significant relationship between per capita GDP and GII. Estimates obtained using fixed effects (FE) and fully modified ordinary least squares (FMOLS) methods empirically confirm that the effect of innovation on economic growth is positive and significant. These results provide direct support for H1, confirming that increases in innovation capacity—as captured by GII—positively contribute to sustainable economic growth.

The results also indicate that the impact of innovation on growth varies across country groups. The positive effect of innovation on growth is stronger in low- and middle-income countries, where technology transfer, knowledge diffusion, and higher marginal returns to innovation investments amplify growth outcomes. By contrast, in high-income countries, although the effect remains positive, it tends to operate through more advanced and qualitative channels—such as sustainability, digitalization, and sectoral sophistication—with relatively diminishing marginal returns. The findings of this study are also in line with new growth theories (Romer, 1990; Aghion & Howitt, 2009) and the current empirical literature. For example, Akcigit and Ates (2021) highlight the role of digital innovation during global shocks, while Aklilu et al. (2025) demonstrate the growth-enhancing effects of green innovation. The results of this study resonate with these works by showing that innovation's contribution to growth is both statistically significant and context-dependent across country groups. Furthermore, recent cross-country studies using GII (Rajput et al., 2012; Çemberci et al., 2022; Bate et al., 2023; Dempere et al., 2023) similarly emphasize that the strength of the innovation-growth nexus depends on institutional quality, FDI channels, and income-level heterogeneity. By providing a comparative analysis of the effects of innovation in both lower/middle- and high-income countries, this study offers a timely and comprehensive empirical contribution to the ongoing debate. Since the regressions are estimated in a log–log specification, the results indicate elasticities: in all country groups, innovation (GII) exerts a significant and positive percentage impact on economic growth.

From a policy perspective, the results highlight the importance of designing income-level-sensitive innovation policies. For low- and middle-income countries, strengthening absorptive capacity, accelerating technology transfer, and integrating into global innovation networks can maximize the growth effects of innovation, a point also emphasized in recent UNCTAD reports (2021: 45–52, 2023: 39–47). For high-income countries, the priority should be on enhancing the sustainability and quality of innovation, particularly in digital and green technologies, consistent with OECD (2025) and UNCTAD (2023) policy recommendations. In line with this evidence, policymakers are advised to invest in STEM education (UNCTAD, 2021:89-90, 2023:95), incentivize R&D expenditures (Appelt et al., 2016), strengthen university–industry collaboration (Guerrero and Urbano, 2019; Aytar, 2020), support SMEs through tailored tax incentives and venture capital mechanisms (OECD, 2020, 2025), and ensure effective protection of intellectual property rights (WIPO, 2022).

This study has certain limitations. The scope of the panel data set and the selection of the period are constrained by data availability. In addition, the effects of global shocks such as COVID-19 on innovation and growth could not be fully isolated. Future research could address several limitations. First, expanding the dataset with alternative indicators (e.g., patent activity, innovation surveys) may improve the robustness of results. Second, examining the subcomponents of the GII (human capital, institutions, infrastructure) across country groups would allow a clearer understanding of the channels through which innovation affects growth. Third, investigating social and green innovation dynamics as well as sector-specific innovation performance is necessary to deepen insights into the broader innovation–growth nexus. Finally, analyzing the resilience of innovation during global shocks such as COVID-19 would provide valuable lessons for crisis-sensitive policymaking. In conclusion, this study empirically validates both H1 and H2 by showing that (i) innovation acts as a genuine driver of economic growth across countries, and (ii) the strength and nature of this effect differ systematically across income groups. These results underscore the centrality of innovation in achieving sustainable growth and highlight the necessity of tailoring innovation policies to national income levels. By bridging theoretical foundations with robust empirical evidence, the study offers meaningful guidance for policymakers and contributes to the broader literature on the innovation–growth nexus.

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Compliance with Ethical Standards
It was declared by the author that the tools and methods used in the study do not require the permission of the Ethics Committee.

Ethical Statement
It was declared by the author that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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APPENDIX

Table A1. Countries included in the analysis – By group

No.	*High income Countries*	*Low-Middle Income Countries*
1	Australia	Albania
2	Austria	Algeria
3	Belgium	Argentina
4	Bulgaria	Armenia
5	Canada	Azerbaijan
6	Chile	Bosnia and Herzegovina
7	Croatia	Botswana
8	Czech Republic	Brazil
9	Denmark	Burkina Faso
10	Estonia	China
11	Finland	Colombia
12	France	Costa Rica
13	Germany	Côte d'Ivoire
14	Greece	Ecuador
15	Hong Kong	Egypt
16	Hungary	El Salvador
17	Iceland	Georgia
18	Ireland	Guatemala
19	Israel	Honduras
20	Italy	India
21	Japan	Indonesia
22	Korea, R	Jamaica
23	Latvia	Jordan
24	Lithuania	Kazakhstan
25	Luxembourg	Kenya
26	Netherlands	Kyrgyzstan
27	New Zealand	Macedonia, North
28	Norway	Madagascar
29	Panama	Malaysia
30	Poland	Mali
31	Portugal	Mexico
32	Romania	Mongolia
33	Russia	Morocco
34	Saudi Arabia	Nigeria
35	Singapore	Pakistan
36	Slovak(ia) Republic	Paraguay
37	Slovenia	Peru
38	Spain	Philippines
39	Sweden	Senegal
40	Switzerland	Serbia
41	United Kingdom	South Africa
42	United States	Sri Lanka
43	Uruguay	Tajikistan
44		Thailand
45		Tunisia
46		Türkiye
47		Uganda
48		Ukraine
49		Viet Nam
50		Zambia

Source: Worldbank (2025b)