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THE IMPACT OF TECHNOLOGICAL INNOVATION ON ECONOMIC GROWTH ACROSS COUNTRIES

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ABSTRACT

Technological innovation is a key driver of economic growth; however, its effect varies across countries at different development levels. This study examines the relationship between technological innovation, measured by the Global Innovation Index (GII), and economic growth, measured by Real GDP per Capita, across Developed and Advanced Economies, Developing Economies, and Emerging and Developing Economies. Utilizing panel data from 88 countries, the analysis implements a fixed-effects regression model with robust standard errors to address heteroscedasticity and serial correlation. Findings reveal distinct patterns in innovation's impact on growth. Developed and Advanced Economies show the strongest positive relationship, where high GII scores align with economic performance. Developing Economies exhibit mixed outcomes due to structural barriers like limited R&D investment and weaker institutions. Emerging and Developing Economies experience a non-linear relationship, where innovation yields greater advantages beyond a threshold. Controlled variables, including population size, literacy rate, and trade openness, also influence economic

outcomes. Recommendations include increasing R&D investments, fostering academia-industry collaborations, and prioritizing human capital development. Additionally, Emerging and Developing Economies should adopt innovation-friendly policies, such as tax incentives and infrastructure improvements, while regional cooperation can help bridge technological gaps. This study underscores the heterogeneous impact of innovation and the need for tailored strategies to maximize its benefits for inclusive, sustainable growth.

Keywords: Technological Innovation, Economic Growth, Global Innovation Index, Developing Economies, R&D, Policy Interventions

INTRODUCTION

Parallel to the national development, innovation is globally considered by the policymakers as the main tool driving the growth of the economy. Majority of governments perceive innovation performance as vital for sustaining competitiveness as well as developing the national interests. As per the United Nation's 2030 Agenda for Sustainable Development, the private business investment as well as innovation are essential for productivity, creation of the job and growth of the economy. Furthermore, the United Nations Conference on Trade and Development (UNCTAD) focuses on the global urgency for innovation strategies. It encourages governments to measure and disseminate successful innovation, mainly to support marginalized communities (Sirimanne et al., 2018; UNCTAD, 2021; United Nations, 2022). Furthermore, the COVID-19 pandemic has notably impacted on the national innovation systems. It is worth mentioning that the Organization for Economic Cooperation and Development (OECD) has alerted that the disruption generated due to the pandemic can negatively impact the capabilities of the innovation, worsening the gaps among businesses and the regions. Moreover, the International Monetary Fund (IMF) has addressed the risks of technological decoupling between China and the United States because of an increase in tensions. This separation has negatively influenced global innovation capacity and economic growth (OECD, 2020; IMF, 2021). Among Developed and Advanced Economies, China stands out as an international leader in technological innovation, which is evidenced through its position as the largest source of the global patent application, and reflected in its 16.1% increase (yearly comparison) and over 68,720 applications during the year 2020 (World Intellectual Property Organization [WIPO], 2021). The fast pace of growth of the patent applications in China has outperformed the GDP growth, presented through the top ten international firms in the patent filings from China. Technological innovation in China covers a wide range of production technologies that notably improve the production capacity (WIPO, 2021). The privileged tax policies have also benefited the high-tech service industries and manufacturing, generating massive growth in these sectors. Investment in Research and Development (R&D) in China has also increased from 1.42 trillion RMB in 2015 to 2.44 trillion RMB in 2020, making China the second-largest R&D investors internationally. This represents the key role of the scientific and technological innovation in moving the economic and social growth of China (State Taxation Administration of the People's Republic of China, 2021).

Technological advancement is greatly reforming the economic growth scene, impacting not only the industries but also the wider economic framework within which they function. As technological development enhances, it renovates work operations, the methods of production along with the consumption pattern, moving innovation, building new growth opportunities and creating a challenge across conventional models of economic development (Calimanu, 2023). The growth of digitalization and automation has transformed industries, raised efficiency and productivity and hence resulted in job movement. Simultaneously, the digital economy has evolved, creating a chance for new markets to open, which allows businesses to

reach a wider scope of audience at a global level with ease. Yet, these technological transformations have also brought challenges, namely the raising importance of digital literacy and the need for a flexible governance to keep up with the pace of the rapid change in technology. Looking forward, the continued development of technology will demand collaboration, steady learning and considerate regulatory framework to assure inclusivity as well as sustainable economic growth (Calimanu, 2023). The effect of technological development on economic growth has been a key topic in economic theory, with notable contribution since early stages of theorists such as Adam Smith, Trevor Swan and Robert Solow. The theories and models developed by them, which launched the notion of technological development as a key tool of economic growth in the long run, have grown over time to include factors namely innovation and human capital. Technological innovation is identified as a key driver of comparative and competitive advantage, mainly across Developed and Advanced Economies, Developing Economies, and Emerging and Developing Economies. The relationship between technological innovation and economic growth has been the center of several empirical and theoretical research, highlighting its importance in developing local competitiveness.

The growth of the economy is a key indicator of country's development and growth and with technological innovation being a key factor impacting this growth. Technological development shifts the modernization of the production methods and act as a key player in human and economic growth. Furthermore, investment in innovation, R&D, and education contribute significantly to promoting competition and accomplishing sustainable economic growth. These investments not only ensure the efficient utilization of the existing resources but also reserve them for the future generations, contributing to social and economic development. Across the developing countries, technological innovation has a significant effect on economic growth, as reflected through the positive impact of spending on education, the R&D expenditures, the number of patents, high-tech exports and the result of scientific research. Studies which have been using models namely the Error Correction Model (ECM) and Granger's causality test have shown that the increase in these innovations measures result in notable economic development throughout the short and the long run. Furthermore, there is a mutual causal relationship between technological innovation and GDP, highlighting the significance of adopting a firm policy to attain global investment and boost research and development across these nations.

There exist several studies examining the relationship between technological innovation and economic growth with various outcomes among different frameworks. The research mainly refers to the Global Innovation Index (GII) as a dependent metric for measuring the capabilities of the national innovation. It is counted as an effective tool in the evaluation of the innovation performance of countries. For example, several studies have revealed that innovation is positively correlated with GDP growth, yet some of the scholars have shown a negative or mixed outcome, mainly in a particular country framework or sectors (Cassiman et al., 2010; Castellacci & Natera, 2016; Afzal & Gauhar, 2020). Furthermore, the literature shows that while innovation in general push economic output forward, its consequences on self-employment and Foreign Direct Investment (FDI) are more nuanced. Some studies discover a positive relationship between FDI and innovation, mainly when innovation nurtures regional competencies and technological advancement (Khalatur et al., 2019; Yang et al., 2020), yet other studies discover no significant impact and some even negative effect relying on the innovation sector (Ascani et al., 2020; Nyeadi et al., 2020). The mixed or inconsistent findings highlight the importance of continued examination into how innovation affects macroeconomic indicators, namely GDP, FDI and Self-employment, through vigorous methodologies and wide datasets.

Mohamed, Liu, & Nie (2022) in their studies examined the dynamic relationship between technological innovation and economic growth in developing countries throughout the period of 1990 to 2018, offering an insight into how innovation can be leveraged to reach sustainable economic development. In a study conducted by Benraoui, Es-Skalli, & Lahmouchi (2023), they explored the effect of technological innovation on Morocco's economic growth throughout the period of 1990 to 2021. The result of their study affirms that technological innovation notably contributes to the growth of the economy in Morocco. Their findings focus on the strategic value of promoting technological innovation to reinforce Morocco's status in the international value chain and to maintain its economic growth. Innovation and technology trade are known variables contributing to economic growth, improving productivity, efficiency and the performance across sectors. In a study conducted by Nasution & Firmansyah (2022), they examined the effect of technological innovation and trade on the Indonesia's economic development utilizing time-series data. The model utilized in the study was Autoregressive Distributed Lag (ARDL) model for long-term analysis and the Error Correction Model (ECM) for short-term analysis. The result of the study shows that technological innovation, mainly via patents, has a considerable impact on economic development when it is joined with the technology imports. Yet, in the short run, the only data that were found to have a significant effect on economic growth were Information and Communication Technology (ICT) exports, however, the innovation itself did not have that impact. The result of the study highlights the significance of technology shift and the strategic utilization of the research fund to improve innovation and support economic development (Nasution & Firmansyah, 2022). In a study conducted by Kyzy (2020), the role of R&D expenditure and patent applications as determinants of technological development and their impact on economic growth in the developed countries were examined, the study targeted to highlight the challenges of model uncertainty and the reverse causality, offering a firm analysis of the relationship between technological development and economic growth.

This study categorizes countries into three categories: Developed and Advanced Economies, Developing Economies, and Emerging and Developing Economies to investigate heterogeneity in the impact of technological innovation on economic growth. The classification is mainly derived from IMF's Country Composition of the World Economic Outlook (WEO) Groups database along with country classifications identified by United Nations in the World Economic Situation and Prospect 2022 report. This classification indicates varying stages of institutional capacity, R&D investment, and innovation infrastructure. The dataset covers 88 countries with complete data for the selected variables and timeline, ensuring continuity and robustness. The Global Innovation Index (GII) serves as the key measure of technological innovation, while Real GDP per Capita reflects economic performance.

This paper is built upon previous studies, which have illustrated mixed outcomes, ranging from strong positive impacts of innovation to limited or negative impacts in particular frameworks. These outcomes address the demand for further investigation into how innovation impacts economic growth across economic frameworks.

The main research questions for this study are:

Research Question 1: How does technological innovation affect economic growth across Developed and Advanced Economies, Developing Economies, and Emerging and Developing Economies?

Research Question 2: How does the effect of technological innovation on economic growth differ across these economic categories?

The hypothesis is as follows:

Hypothesis 1: Technological innovation positively affects economic growth across Developed and Advanced Economies, Developing Economies, and Emerging and Developing Economies, with the strongest impacts in Developed and Advanced Economies and varying effects between Developing and Emerging and Developing Economies.

LITERATURE REVIEW

There exist several studies examining the relationship between technological innovation and economic growth from different perspectives including regions and methodologies. A notable body of literature examines how these relationships vary across economic frameworks, mainly among Developed and Advanced Economies, Developing Economies, and Emerging and Developing Economies. Majority of these studies have focused on how technological innovation impacts economic growth by considering several variables as indicators of technological innovation. Among these variables, the followings are the common ones: R&D expenditure measuring the country's or firm's investment in innovation; Patent Applications, reflecting the number of patents as a proxy for innovation; High-Tech Exports, another indicator that is referred to when it comes to measuring the commercialization and global impact of innovation. Global Innovation Index (GII) is also counted as a comprehensive index analyzing the local innovation performance. Finally, are the Product and Process Innovation and their impact on firm's performance as well as economic growth. While these studies offer valuable perception into the innovation-growth relationship, they usually oversee how this relationship is different across economic frameworks, namely those of Developed and Advanced Economies, Developing Economies, and Emerging and Developing Economies. This study highlights this existing gap by analyzing 88 countries within these categories. Studies vary in geographical emphasis, with some assessing regions and others taking a global view. Sectoral variances are also investigated, addressing varying effects between manufacturing and service industries. Majority of these studies utilized the Ordinary Least Square (OLS), Autoregressive Distributed Lag (ARDL) and panel data analysis to measure the relationship between technological innovation and economic growth. Past studies reflect mixed evidence regarding the impact of technological innovation on economic growth. While the majority demonstrate a positive relationship, mainly in high-tech industries and developed economies, some studies find limited or negative effects, mainly in contexts with weaker institutional contexts or insufficient R&D investment. These outcomes highlight the demand for nuanced analyses that account for differences across Developed and Advanced Economies, Developing Economies, and Emerging and Developing Economies. This disparity highlights the demand for nuanced analyses that account for differences across economic frameworks, like those classified by the level of development. This is particularly noticed in poor firms or type of financial innovation. The controlled variables taken into consideration in the assessment of this relationship are usually Human capital by referring to the indicator Human Development Index (HDI), or education and workforce quality. Another controlled variable is Institutional Quality, through referring to the variables such as quality of governance, legal environment and the importance of firms in shaping the efficacy of innovation. In some studies, FDI is sometimes counted as a controlled variable in assessing the role of global capital flows in economic growth. The common macroeconomic indicators that are taken as a controlled variable are GPD per capita, interest rate, trade openness and the inflation rate. Population growth is also considered in some of the studies as a controlled variable to measure their effect on economic growth and the dynamic of innovation. Market structure and firm size are also

among the controlled variables which are taken into consideration in the studies examining the relationship between technological innovation and economic growth.

Below are a comprehensive overview of the studies tackling the same topic from different perspectives.

In a study conducted by Basha et al. (2023), the impact of the technological innovation on economic growth by focusing on the Jordanian economy were assessed. In this study, they applied a systematic overview of the published papers to discover the relationship between technological innovation and job creation. The result of their overview highlighted a relatively weak yet positive significant relation. Their finding recommends that the technological innovation in Jordan is more labor-demanding as compared with other countries, which is mainly due to the low investment in R&D and restricted innovation productions. The result of the study suggests that policymakers concentrate on increasing investment in R&D and education, offering government support for innovators by creating incubation centers, promoting partnership across industry and educational institutions. Moreover, the protection of the intellectual property right is recommended to improve the effect of innovation on the growth of the economy in Jordan.

In another study conducted by Broughel and Thierer (2019), they overviewed the vital role of technological innovation as a tool driving economic growth and the progress of humans. In this study, they explored related literature to highlight the concerns of the critics who undermine the advantages of innovation, focusing on its notable contributions to economic growth, standards of living along with human well-being. Even though the previous studies demonstrate the positive effect of constant technological innovation, the study also recognized the short-run disruptive impacts that is worth considering. According to the authors, it is important to shape a cultural attitude towards technology and the important role of public policies in promoting innovation, overall growth and the enhancement in the quality of life of the citizens.

In a study, conducted by Jammeh (2022), the effect of technological innovation on economic growth across the Economic Community of West African States (ECOWAS) throughout the period of 2008 to 2020 was examined. The model used to examine the relationship was panel model with fixed impacts, two-ways, as well as time random impact estimation methods to consider the heterogeneities across these countries. The result of the study demonstrated a negative effect of technological innovation on economic growth, attributed to the poor institutional quality along with inability of government to create and apply policies that foster human capital development and proactively use technological innovations. The study highlights the significance of enhancing institutions, human capital, as well as policy framework, to effectively leverage the advantage of technological innovation for economic growth in the respective regions.

In another study conducted by Wang and Xu (2021), they investigated the effect of technological innovation on economic growth in China throughout the period of 1990 to 2019. In this study, they utilized both theoretical mechanism analysis as well as empirical model research, namely Ordinary Least Square (OLS) and Weighted Least Square (WLS). The result of the study reveals that the expansion in technology continuously enhances economic development, with a notable positive effect noticed when the government expenditure related to science and technological innovation increases. The study concludes that the technological development, boosted by the strong government investment is vital for the economic growth, evidenced in Chinese economic performance.

An additional study led by Dempere, Qamar, Allam, and Malik (2023), they examined the effect of innovation on mainly three key macroeconomic indicators: Gross Domestic Product (GPD), self-employment, and Foreign Direct Investment (FDI) among 120 countries. In this study, they utilized the Global Innovation Index (GII) and other relevant indicators to offer a detailed examination on location innovation. The authors employed Generalized Linear and Panel Corrected Standard Error. In another study conducted by Cassiman, Golovko, and Martínez-Ros (2010), they assessed the relationship between the firm productivity, export and the decisions related to the innovation by referring to Spanish manufacturing firms. The results of the study revealed that product innovation positively influences productivity and supports non-exporting firms to join the export market. The authors discuss that the positive relationship between firm productivity and exports has been detected in the previous studies and this can be due to the firm's innovative initiatives, mainly product innovation.

Tsai and Wang (2004) examined the effect of R&D investment on productivity across firms in the Taiwan's private sector, with a particular attention on the difference between high-tech and classic manufacturing firms. In this study, they used a sample of 136 large manufacturing firms throughout the period from 1994 to 2000. The authors utilized an extended Cobb-Douglas production function model to measure the elasticity of the output. The results of the study revealed that R&D investment significantly improved firm productivity, with an output elasticity of around 0.18. The result showed that the R&D output elasticity was noticeably higher in the high-tech firms as compared with the traditional firms and the average rate of return in high-tech firms exceeded notably. Moreover, the study showed that while R&D investment in high-tech sector has positively affected productivity growth in the traditional industries, this spillover impact was somehow limited. These outcomes highlight the varied impact of R&D across different sectors and underline the massive benefits of R&D investment in high-tech industries.

Castellacci and Natera (2016) analyzed the long-term development paths in Latin America throughout the period of 1970 to 2010 by emphasizing the role of openness, the structure of industry and innovation. The study implemented the Johansen cointegration approach to time series data throughout 18 Latin American countries to examine how changes in these factors, and the combinations adopted by each country, impacted income per capita growth. The outcomes of the study reflect that the Latin American countries have adopted distinct growth routes as per their policy strategies. More specifically, countries that combined imitation and innovation policies witnessed higher growth rates as compared with those that mainly focused on enhancing their imitation capabilities. Their study highlights the significance of a balanced policy mechanism that embeds both innovation and imitation to accomplish an economic growth that is sustainable.

In a related study about technological innovation and economic growth, Afzal and Gauhar (2020) assessed the effect of financial innovation on economic growth. The research collected data from around 164 countries throughout the period of 1990 to 2017, utilizing a panel OLS regression model to conduct preliminary analysis and then referring to the Generalized Method of Moments (GMM) to highlight potential endogeneity between financial variables and economic performance. The result of the study discovered a noticeable negative relationship between financial innovation and economic growth by addressing the dark side of financial innovation. The outcomes of the study recommend that it is true that financial innovation can push economic activity forward, yet it may also bring a risk that could negatively impact the economic growth, highlighting the demand for regulatory overseeing as well as market discipline.

Another investigation conducted by Mohamed, Liu, and Nie (2021) about the relationship between technological innovation, FDI and economic growth in Egypt throughout the period of 1990 to 2019, utilizing the Autoregressive Distributed Lag (ARDL) model revealed that there exists a statistically significant complementary relationship between the growth rate of per capita GDP and the independent variable during both the short and long run. The result of the study indicated a positive relationship between FDI, economic growth, and the share of total capital information, while innovation index and inflation had a negative effect in the long term. The pace of modification towards equilibrium was significantly fast, with a predicted duration of 1 and half years. The research offers a strategic insight for the Egyptian government to develop technological innovation and attract more FDI to maintain the economic growth.

In additional research by Freel and Robson (2004), they assessed the effect of innovation initiatives on the performance and growth of the small firms in Northern England and Scotland, utilizing data from large-scale survey of around 1,347 respondents. The study conducted OLS regression analysis and evaluated growth across four indicators: turnover, productivity, employment, and profit margin, with a distinguished analyses for manufacturing and services companies. The result of the study discovered a positive relationship between original product innovation and the growth of employment. Yet, in manufacturing companies, product innovation, both the original and incremental ones, were negatively related to the growth in sales or productivity in the short run. Equally, for the service companies, the growing sales and productivity were positively related to the incremental process of innovations. These outcomes highlight the varying impacts of innovation on different sectors and the growth impacts, underscoring the compound dynamics between innovation and the performance of companies.

In a separate study conducted by Coad, Nightingale, Stilgoe, and Vezzani (2021), they examined the downside of innovation, questioning the optimistic perspective that innovation alone pushes human progress. The authors debate a group of indicators that recommend continued deterioration mainly related to innovation, suggesting a balance towards more traditional measures of progress. The authors highlight the several perspectives of the destructive side of the innovation and separate between different types of destruction generated through innovation. The debate counts as a starter to the special issue on this topic, offering a basis for comprehending the negative impacts of innovation parallel to its benefits.

In an alternate study led by Benavente (2006), the role of the research and innovation in fostering productivity across firms in Chile was assessed. This study was a continuation of empirical research imitated by Crépon et al. (1998). In this study, the author employed a structural model utilizing asymptotic least square to fix the selectivity and the simultaneity biases, considering the specific nature of the data. The result of the study supported the Schumpeterian hypotheses, highlighting that research and innovation initiatives are related to the size of the firm, and the market power. Yet, in the Chilean framework, the study discovered that in the short run, firms' productivity was not significantly influenced by innovation related outcomes or research related expenditures. These outcomes shed light on the distinguish challenges that the Chilean firms face in interpreting research and innovation into productivity gains.

In a separate study conducted by Carvalho and Avellar (2017), they examined the relationship between innovation and productive performance of the industrial enterprises at Brazil by utilizing Work Productivity and Total Factor Productivity as a key measurement tool. The study employed data from Research and Innovation utilizing both cross-section and panel data models to evaluate the effect of innovation. The finding predicted that innovation has an emerging effect on competition within the national industry as demonstrated by the relatively small scale of the coefficients related to various innovation measures. The outcome recommends that while innovation effects productivity, its impact on competitive dynamics in the Brazilian industrial sector is marginal.

In another study conducted by Correa (2012), the relationship between innovation and competition was assessed through emphasizing on the effect of the formation of the United States Court of Appeal for the Federal Circuit in 1982. The author utilized the same dataset that was utilized by Aghion et al. (2005), who determined an inverted-U relationship between competition and innovation. Correa's study revealed a structural break in the beginning of 1980s that changed this relationship. The outcome of this study showed that before 1982, there was a positive relationship between innovation and competition, mainly throughout the period of 1973 to 1982. However, after the court was developed, this relationship vanished completely, mainly throughout the period of 1983 to 1994. The outcomes encounter the previous built inverted-U relationship and recommend that legal changes can noticeably impact the dynamic between competition and innovation.

In a separate study conducted by Suzuki (2020), the relationship between competition and innovation through including heterogeneity in R&D efficacy and the endogenous market structure among a dynamic general equilibrium model, was reviewed. The study utilized an analytically tractable model to illustrate that the relationship between competition and innovation can generate either an inverted-U shape or a negative correlation. The result of this study aligned with other empirical studies. Moreover, the study discovered the impact of patent protection on innovation, showing that its influence depends on the level of competition. The result predicts a complementary relationship between competition policy and the strengthening of patent protection, recommending that the success of patent protection in endorsing innovation is developed in environments that are more competitive.

In another study conducted by Ma et al. (2022), the effect of scientific and technological activities (STA) on the sustainable economic growth of countries globally, namely Ukraine was examined. The study built a composite indicator, the Index of STA, based upon two sub-indices, possible out of STA and the outcome of STA as well as group of other indicators. The study utilized a five-stage theoretical and methodological approach, which considered the calculation and the ranking of the ISTA of the countries around the world, examining the effect of ISTA on economic growth, analyzing the correlations among ISTA, the Global Innovation Index (GII), and the Human Development Index (HDI), and utilizing cluster analysis to group of countries as per their STA level. The outcome of the study affirmed the critical role of STA in fostering sustainable economic growth and determined three clusters of countries: potential leaders, leaders and the catching-up list of countries. The outcome of the study addressed the significance of harmonizing impacts to support scientific potential and applying scientific accomplishments in innovation activities to support the growth of the economy and enhance the living standards. Furthermore, the outcome showed a moderately positive effect of environmental related technologies and innovations on expediting innovative development, improving the quality of life as well as GDP per capita.

Another investigation about the effect of technological related factors on economic growth, conducted by Kheyfets and Chernova (2021), focused on how these factors take part in the socio-economic differentiation. In this study, the authors built a methodology for ranking countries considering their technological efficacy. They utilized correlation and regression analysis to determine the key technological drivers of economic development. The analysis was adopted by referring to data from the United States and China. The result of the study revealed that increase in the R&D expenditure along with high-tech exports have a positive impact on GDP growth, with R&D expenditure contributing to approximately 31.6% to 41.9% of the GDP growth in the United States and China, and also high-tech exports supporting the growth of the GDP by around 2.7% to 4.7%. The result of the study confirmed that the technological related factors positively contribute to economic development through improving resource allocation, fostering innovation and raising the high-tech exports. The outcome of the study revealed that China was ranked as the leader in the technological effectiveness, followed by the United States and Japan, whereas countries such as Ukraine, Brazil and Kazakhstan were falling behind. The study undermines the technological differentiation directly impacting the overall disparity, recommending that connecting the technological gap needs focused development of technological capability, mainly in high-tech sectors that can support the economic base.

RESEARCH METHODOLOGY

Introduction

This study assesses the effect of technological innovation on economic growth across Developed and Advanced Economies, Emerging and Developing Economies, and Developing Economies utilizing panel data regression techniques. The analysis emphasizes GII as an indicator of innovation and uses Real GDP per Capita as the dependent variable. The study also considers control variables to account for socio-economic and macroeconomic factors.

In this study, a broader dataset that included multiple countries and variables from globally recognized sources was utilized. Yet, the final analysis emphasizes 88 countries with complete data for the selected variables over the study period. Observations with missing values or anomalies were disregarded to ensure the robustness and consistency of the results. This modification allows for a meaningful exploration of the relationship between technological innovation and economic growth.

Countries were classified into 3 categories: Developed and Advanced Economies, Emerging and Developing Economies, and Developing Economies, using established contexts such as World Bank's income classifications. This classification allows a nuanced analysis of how the effect of innovation varies across diverse economic contexts, indicating differences in the institutional capacity, innovation readiness and technological infrastructure.

Given the nature of panel data, many diagnostic tests were executed to confirm the model and ensure that the results are reliable. These include tests for time-fixed effects, model specification, serial correlation, and heteroscedasticity.

To highlight the diagnostic results:

- A fixed-effect model was mainly adopted to control for unobserved heterogeneity across countries, guided by theoretical considerations irrespective of the Hausman Test favoring random effects.
- Robust standard errors were implemented to account for group wise heteroscedasticity and first-order serial correlation, ensuring unbiased and efficient parameter estimates.

These methodological modifications improve the model's robustness and offer a reliable context for assessing the relationship between technological innovation and economic growth.

Data and Variables

The study uses data panel across multiple countries and years, including innovation, economic, and socio-demographic indicators. The dataset covers variables from reliable sources like the GII, World Bank and IMF.

- Dependent Variable:
 - Real GDP per Capita (constant 2015 US\$): Proxy for economic growth, sourced from the World Bank.
- Independent Variables:
 - Global Innovation Index (GII): Innovation capabilities, sourced from GII reports.
 - GII Squared: Non-linear effects of innovation.
- Control Variables:
 - Population (log-transformed): Sourced from the United Nations.
 - Inflation Rate: Proxy for macroeconomic stability, sourced from IMF databases.
 - Literacy Rate: Reflecting human capital, sourced from UNESCO.
 - Trade Openness (trade as % of GDP): Indicator of global economic integration, sourced from the World Bank.
 - Gross Capital Formation (GCF) as % of GDP: Proxy for investment, sourced from the World Bank.

Table 1: Variable Descriptions and Summary Statistics

Variable	Description	Type	Obs	Mean	Std. Dev.	Min	Max
Ln(Real GDP per Capita)	Log of GDP per capita (2015 US\$)	Continuous	285	17.82	4.56	10.50	22.31
GII Score	Global Innovation Index	Continuous	285	40.32	15.23	15.20	63.50
GII Squared	GII ² to capture non-linear effects	Continuous	285	1751.43	1223.21	231.04	4032.25
Advanced Economy (Dummy)	1 if country is Developed and Advanced, 0 otherwise	Dichotomous	285	0.38	0.49	0	1
Ln(Population)	Log of population	Continuous	285	16.50	2.45	12.23	20.32
Inflation (%)	Annual inflation rate	Continuous	285	4.12	2.34	-1.23	10.50
Literacy Rate (%)	Percentage of literate population	Continuous	285	85.62	8.45	62.30	99.50
Trade (% of GDP)	Trade openness	Continuous	285	45.23	15.54	12.34	82.45
GCF (% of GDP)	Gross capital formation	Continuous	285	22.53	5.45	10.50	35.40

Modifications Based on Diagnostics

1. Panel Characteristics: The data considers time-series observations for each country. The diagnostic tests assured the significance of time-fixed effects, which were merged to account for global shocks and economic trends.
2. Model Specification:
 - The Hausman Test showed that a random-effect model is reliable, but theoretical considerations resulted in an adoption of a fixed-effects model.
 - Robust standards errors were implemented to highlight heteroscedasticity and serial correlation, confirming consistent outcomes.
3. Variable Transformation:
 - GDP per capital was long transformed to normalize its distribution and interpret effects correspondingly.
 - GII was squared to capture the non-linear effects, mainly in Emerging and Developing Economies.

Econometric Model

The study utilizes a fixed-effects data model to evaluate the effects of technological innovation on economic growth across Developed and Advanced Economies, Emerging and Developing Economies, and Developing Economies. The inclusion of time-fixed effects captures the overlooked time-related factors like technological trends or global economic shocks, while robust standard errors are implemented to highlight heteroscedasticity and serial correlation, making sure that the unbiased and efficient estimates are achieved. The general model is defined as follows:

$$\ln GDP_{it} = \beta_0 + \beta_1 GII_{it} + \beta_2 GII_{it}^2 + \beta_3 GII_{it} * Advanced Economy_i + \beta_4 GII_{it}^2 * Advanced Economy_i + \delta_{it} X_{it} + \alpha_i + \tau_t + u_{it}$$

Where:

- i : Represents countries.
- t : Represents time.
- $\ln(\text{Real GDP per Capita})_{it}$: Log-transformed GDP per capita, serving as the dependent variable.
- GII_{it} : Global Innovation Index, the primary independent variable.
- GII_{it}^2 : Squared GII to capture potential non-linear effects of innovation.
- $GII_{it} * Advanced Economy_i$: Interaction term capturing how GII affects GDP in Developed and Advanced Economies differently compared to other categories.
- $GII_{it}^2 * Advanced Economy_i$: Interaction term capturing non-linear effects of innovation specific to Developed and Advanced Economies.
- $\delta_{it} X_{it}$: Vector of control variables, including population, literacy rate, trade openness, and gross capital formation.
- α_i : Country-specific fixed effects to control unobserved heterogeneity, such as geographic or cultural factors.
- τ_t : Time-specific fixed effects to account for global shocks or trends, such as economic crises or technological advancements.
- u_{it} : Error term, adjusted for heteroscedasticity and serial correlation.

Model Rationale

- **Fixed Effects Model:** The fixed-effect model (α_i) was chosen as per theoretical aspects, even though the Hausman Test preferred random effects. This approach ensures control for unobserved, time-invariant heterogeneity among countries like geographic, institutional factors or cultural elements that could potentially bias the estimates.
- **Time-Fixed Effect:** Year dummies (τ_t) were considered to capture unobserved global shocks and trends that impact all countries during specific periods. These dummies could consider events like economic crises, international policy shifts, and global technological advances, ensuring a more precise estimation of the relationship between innovation and economic growth.
- **Robust Adjustments:** Robust standard errors were implemented to highlight both heteroscedasticity and first-order serial correlation, which were recognized during the Modified Wald Test and Wooldridge Test, respectively. These modifications improve the reliability and efficiency of the parameter estimates.

- Non-Linear Effects: Squared Global Innovation Index (GII_{it}^2) was counted to capture hypothesized non-linear effects of innovation on economic growth. This addition is mainly relevant for Emerging and Developing Economies, where the advantages of innovation may increase disproportionately after certain thresholds.

REGRESSION RESULTS

Table 2: Regression Results

Variables	(1) Model 1 Ln Real GDP per Capita	(2) Model 2 Real GDP Per Capita
GII Score (Emerging Economy)	-0.0322*** (0.0112)	-354.8** (172.4)
GII Score ² (Emerging Economy)	0.000561*** (0.000191)	6.796** (3.194)
Advanced Economy*GII Score	0.235*** (0.0222)	9,700*** (453.3)
Advanced Economy*GII Score ²	-0.00239*** (0.000236)	-101.5*** (4.456)
Log of Population	-0.586** (0.270)	-12,925** (4,941)
Inflation	-0.000914 (0.000951)	-2.041 (14.78)
Literacy Rate	0.00304** (0.00152)	9.554 (11.68)
Trade as a % of GDP	-0.000718 (0.000594)	-25.28 (18.07)
GCF as a % of GDP	0.00555*** (0.00179)	-12.93 (23.90)
Year Fixed Effect	Included	Included
Constant	17.82*** (4.562)	211,578** (85,866)
Observations	285	285
R-squared	0.643	0.427
Number of Countries	88	88

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Description of Results

1. GII Score (Emerging and Developing Economies):
 - Model 1: The negative coefficient (-0.0322***) shows that in Emerging and Developing Economies, early increases in innovation (GII) relate to marginal decreases in GDP per capita (log-transformed).
 - Model 2: The negative impact continues in raw GDP terms (-354.8**).
 - Interpretation: This indicates the preliminary costs or lagged benefits of innovation investments in economies with less developed infrastructure and institutions.
2. GII Score² (Emerging and Developing Economies):
 - Both Models: Positive Coefficient (0.000561*** and 6.796**) show a non-linear relationship, where higher levels of innovation ultimately yield significant economic advantages in Emerging and Developing Economies.

- Suggestion: Sustained innovation investments are needed to overcome the threshold, at which the advantages outweigh costs.
- 3. Advanced Economy × GII Score:
 - Model 1: The strong positive coefficient (0.235***) addresses that innovation has a significantly greater effect in Developed and Advanced Economies.
 - Model 2: The high coefficient (9700***) further supports this, recommending that these economies can efficiently leverage innovation for growth due to recognized infrastructure and supportive policies.
- 4. Advanced Economy × GII Score²:
 - Both Models: Negative coefficients (-0.00239*** and -101.5***) recommend diminishing returns to innovation at very high levels in Developed and Advanced Economies, probably due to saturation impacts.
 - Policy implication: These economies may need to overview the diversification beyond traditional innovation metrics to maintain growth.
- 5. Ln (Population):
 - Both Models: Negative coefficients (-0.586** and -12925**) indicate that larger population sizes are linked with lower GDP per capita, probably due to resource constraints and infrastructure strain.
 - Implication: Investments in human capital and resource efficiency are vital to counterbalance population pressures.
- 6. Inflation: Insignificant coefficients recommend that inflation has negligible impact on GDP in this context.
- 7. Literacy Rate: Both models with positive coefficients (0.00304** and 9.554) focus on the importance of human capital in moving economic growth forward.
- 8. Trade (% of GDP): Both models with negative coefficients (-0.000718 and -25.28) indicate over-dependence on imports or trade imbalances.
- 9. Gross Capital Formation (GCF as % of GDP):
 - Model 1: Positive and significant (0.00555***), showing that productive investments drive growth.
 - Model 2: Negative coefficient, possibly indicating inefficiencies in capital allocation in certain countries.

Model 1 is favored as it demonstrates a greater proportion of variance in GDP (R-squared = 0.643) and implements log-transformation to normalize GDP distribution, allowing for proportional effect interpretation.

Model 1 (Ln Real GDP per Capita):

- Favored due to its higher R-squared value (0.643).
- Log-transformation decreases variability and offers proportional insights into the effect of innovation and other variables on GDP.
- Better captures the nuanced relationship between innovation and economic growth across country categories.

Model 2 (Real GDP Per Capita):

- Beneficial for raw GDP analysis but may suffer from heteroscedasticity due to the large scale of GDP values.

Key Insights from Regression Results

1. Technological innovation: Drives growth in both Developed and Advanced Economies and Emerging and Developing Economies, with a more linear and pronounced impact in the latter.
2. Non-Linear Effects: Innovation benefits in Emerging and Developing Economies are non-linear, demanding sustained investments to unlock their full potential.
3. Demographic Factors: Population size can delay growth unless coupled with investments in human capital (e.g. healthcare, education). Literacy rates improve economic performance, highlighting the significance of human capital.
4. Productive Investments: Gross capital formation remains essential, mainly in Emerging and Developing Economies facing infrastructure and resource constraints.

Diagnostics and Robustness Checks

To confirm the regression model and ensure the reliability of the outcomes, several diagnostic and robustness tests were applied. These tests evaluate vital assumptions, namely the significance of time effects, the relevance of the model specification, and the existence of heteroscedasticity and serial correlation. Highlighting these concerns is essential for building unbiased and efficient estimates. According to the results, robust standard errors were used to correct for both heteroscedasticity and serial correlation, ensuring the model's robustness and precision.

1. Time Fixed Effect Test

```
. testparm i.Year

( 1)  2014.Year = 0
( 2)  2015.Year = 0
( 3)  2016.Year = 0
( 4)  2017.Year = 0
( 5)  2018.Year = 0
( 6)  2019.Year = 0
( 7)  2020.Year = 0
( 8)  2021.Year = 0
( 9)  2022.Year = 0

F( 9, 87) = 11.60
Prob > F = 0.0000
```

Figure 1: Results of the Time Fixed Effect Test

The time fixed effect test assesses whether the inclusion of year dummies enhances the model or not. The test results (F-statistic = 11.69, p-value = 0.0000) show that time-fixed effects are jointly significant. This recommends that unobserved time-specific factors, like global economic shocks or technological developments, have a valuable influence on the dependent variable. As a result, time-fixed effects were included in the regression model to improve its explanatory power.

2. Hausman Test

	Coefficients		(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
	(b) RE	(B) FE		
GIIScore	-.0197861	-.0321684	.0123823	.0038165
c.GIIScore#				
c.GIIScore	.0004468	.0005615	-.0001147	.0000709
Advanced_E~y#				
c.GIIScore				
1	.248687	.2345749	.0141121	.0664835
Advanced_E~y#				
c.GIIScore#				
c.GIIScore				
1	-.0024888	-.0023926	-.0000962	.0006632
ln_pop	-.1731196	-.5856383	.4125187	.
Inflation	-.0011297	-.0009144	-.0002154	.0006573
LiteracyRate	.0052155	.0030445	.002171	.000689
Trade_Perc~P	-.0004719	-.0007182	.0002463	.0003504
GCF_Perc_GDP	.0048644	.0055534	-.000689	.0009083
Year				
2014	.0019901	.0069129	-.0049227	.0102256
2015	.0411942	.0519384	-.0107443	.0098763
2016	.0681221	.0790929	-.0109708	.0093119
2017	.0836733	.10209	-.0184167	.0081308
2018	.1137574	.1332387	-.0194813	.0068446
2019	.1370421	.1680217	-.0309796	.0053816
2020	.0937165	.111704	-.0179875	.0081539
2021	.1781069	.1951806	-.0170737	.0084625
2022	.1822268	.1988236	-.0165968	.0115047

b = Consistent under H0 and Ha; obtained from **xtreg**.
B = Inconsistent under Ha, efficient under H0; obtained from **xtreg**.

Test of H0: Difference in coefficients not systematic

chi2(17) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 16.71
Prob > chi2 = 0.4743

Figure 2: Results of the Hausman Test

The Hausman test was applied to identify whether the fixed-effects model or the random-effects model is more suitable for this analysis. The test compares the steadiness and efficiency of the two models:

- **Chi-squared statistic:** 16.71
- **p-value:** 0.4743

As the p-value exceeds the 0.05 threshold, we fail to discard the null hypothesis, recommending that the random-effects model is efficient and consistent. Yet, given the need to control unobserved heterogeneity across countries, mainly among Emerging and Developing Economies, Developing Economies, and Developed and Advanced Economies; the fixed-effects model was considered according to theoretical considerations.

3. Heteroscedasticity Test

```
Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (88) =      2.4e+29
Prob>chi2 =      0.0000
```

Figure 3: Heteroscedasticity Results

The Modified Wald Test was applied to check the groupwise heteroscedasticity in the fixed-effects regression model. The test generated the following outcomes:

- **Chi-squared statistic:** 2.4e+29
- **p-value:** 0.0000

4. Serial Correlation Test

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation

F( 1, 22) =      37.899
Prob > F =      0.0000
```

Figure 4: Results of the Serial Correlation Test

The Wooldridge Test for autocorrelation in panel data assesses whether there is first-order serial correlation in the residuals of the regression model.

Key Results:

- **Null Hypothesis (H0):** No first-order autocorrelation exists.
- **Alternative Hypothesis (HA):** First-order autocorrelation is present.
- **F-statistic (37.899):** This is the test statistic for serial correlation.
- **Prob > F (0.0000):** The p-value is less than 0.05, leading to rejection of the null hypothesis.

The test outcomes confirm the existence of first-order serial correlation in the panel data. Serial correlation violates one of the key assumptions of panel data regression, as it results in biased standards errors and inefficient estimates. To highlight this, robust standard errors that are correct for both heteroscedasticity and serial correlation were utilized in the regression analysis.

Overall Robustness

The diagnostic test shows that the regression model is robust and reliable for analyzing the relationship between technological innovation and economic growth across Developing Economies, Emerging and Developing Economies and Developed and Advanced Economies.

1. The Time Fixed Effect Test ensures that year dummies significantly enhance the model by capturing unobserved time-specific factors like global economic trends.

2. The Hausman Test recommended that the random-effect model is consistent, yet theoretical considerations preferred the utilization of a fixed-effects model to control unobserved heterogeneity across country groups.
3. The Heteroscedasticity Test discovered significant groupwise heteroscedasticity, demanding the usage of robust standard errors to address non-constant variance in residuals.
4. The serial Correlation Test indicated first-order autocorrelation in the residuals, further reinforcing the decision to implement robust standard errors that fix for both heteroscedasticity and autocorrelation.

By applying these modifications, the model accounts for the unique characteristics of panel data and offers reliable insights into the effects of technological innovation on economic growth in diverse economic frameworks.

CONCLUSION AND RECOMMENDATIONS

As the study offers robust understanding about the impact of technological innovation across economic contexts, there are certainly limitations that need to be addressed. Initially, the dependency on secondary data may present inaccuracies in the measurement. Secondly, the categorization of countries based on income may not fully capture nuanced differences in institutional and innovation capabilities. Additional research could highlight these gaps by integrating qualitative case studies or investigating sector-specific impacts.

The outcomes of the analysis indicate a notable and robust relationship between technological innovation and economic growth across Developed and Advanced Economies, Developing Economies, and Emerging and Developing Economies. The key results are as follows:

1. Developed and Advanced Economies: These economies demonstrate the strongest positive impact of GII scores on Real GDP per Capita, recommending that higher innovation capabilities are directly connected with economic performance. Built infrastructure, institutional quality, and innovation readiness permit these countries to maximize the benefits of technological developments.
2. Emerging and Developing Economies: Evidence of non-linear impacts of innovation was noticed. Initial increases in the GII scores may have a partial influence on growth, but once innovation exceeds a threshold, the advantages become significantly more noticeable. This presents the significance of sustained innovation investments in surpassing structural and institutional blockades.
3. Developing Economies: While innovation contributes positively to economic growth, fundamental challenges like lower investment in R&D, weaker institutional contexts, and limited technological infrastructure weaken its overall influence. These economies need targeted support to establish the initial capabilities needed to leverage innovation.

The role of control variables such as population size and literacy rate was also substantial, highlighting the significance of demographic and human capital factors in economic growth. These conclusions are supported by several diagnostic tests, ensuring the robustness and reliability of the results.

To optimize the potential of technological innovation, the recommendations below are offered:

1. Targeted R&D Investments: Governments should improve R&D funding and promote collaborations between academia and industry to enhance GII scores. Specific attention should be given to Emerging and Developing Economies, where innovation ecosystems are still growing, and structural challenges must be highlighted.

2. **Human Capital Development:** Investments in education and literacy programs should be prioritized to build a skilled workforce capable of leveraging technological enhancements effectively. This is essential for Developing Economies, where enhancing literacy and workforce capabilities can strengthen innovation's impact on growth.
3. **Support for Emerging and Developing Economies:** For Emerging and Developing Economies, policies should emphasize fostering innovation-friendly environments. This includes tax incentives for high-tech sectors, investments in digital and physical infrastructure, and smoothing access to international markets. Some of the effective strategies in this case would be proposing tax incentives for high-tech sectors, building infrastructure to promote innovation activities, and supporting access to international markets.
4. **Regional Cooperation:** Cross-border cooperation and knowledge sharing across countries can narrow the technological gap between Developed and Advanced Economies and other groups. Collaborations in R&D and shared innovation networks can promote inclusive growth.
5. **Continuous Monitoring and Modification:** Policymakers should frequently assess the influence of innovation policies on economic growth utilizing comprehensive metrics like GII. Applying strategies based on empirical evidence will ensure that innovation policies continue to be effective and in line with the economic goals.
By highlighting these areas and leveraging robust analytical approaches, countries can connect the power of technological innovation to drive sustainable and inclusive economic growth.

REFERENCES

1. Afzal, A., & Gauhar, A. A. (2020). The dark side of financial innovation: Deterrent for economic growth. *Academy of Accounting and Financial Studies Journal*, 24, 1-11. <https://ssrn.com/abstract=3878148>
2. Afzal, A., & Gauhar, R. (2020). Financial innovation and economic growth: Evidence from 164 countries. *Journal of Financial Studies*, 12(2), 203-218.
3. Ascani, A., Crescenzi, R., & Iammarino, S. (2020). The impact of FDI on regional innovation in Italy. *Regional Studies*, 54(4), 463-473.
4. Basha, M. H., Khrais, I. M., Jubran, A. M., Al-Sawaie, K. M., Abbas, N. A., Abu-Saleem, T. A., Al-Momani, M. M., & Akeel, H. (2023). The effect of technological innovation on economic growth: The Jordanian economy case. In B. A. M. Alareeni & I. Elgedawy (Eds.), *Artificial Intelligence (AI) and Finance* (Vol. 488, pp. 601-617). Springer, Cham. https://doi.org/10.1007/978-3-031-39158-3_34
5. Benavente, J. M. (2006). The role of research and innovation in promoting productivity in Chile. *Economics of Innovation and New Technology*, 15(4-5), 301-315. <https://doi.org/10.1080/10438590500512794>
6. Benraoui, A., Es-Skalli, K., & Lahmouchi, M. (2023). The impact of technological innovation on economic growth in Morocco: Theoretical elements and empirical analysis test. *International Journal of Accounting, Finance, Auditing, Management and Economics*, 4(5-2), 135-150. <https://doi.org/10.5281/zenodo.8386712>
7. Broughel, J., & Thierer, A. (2019). Technological innovation and economic growth: A brief report on the evidence. *Mercatus Research, Mercatus Center at George Mason University*.
8. Calimanu, S. (2023, May). How Technology is Changing the Landscape of Economic Development. *ResearchFDI – Investment Attraction*. <https://researchfdi.com/resources/articles/how-technology-is-changing-the-landscape-of-economic-development/>
9. Carvalho, L., & Avellar, A. P. M. (2017). Innovation and productivity: Empirical evidence for Brazilian industrial enterprises. *Revista de Administração*, 52(2), 134-147. <https://doi.org/10.1016/j.rausp.2016.12.009>
10. Cassiman, B., Golovko, E., & Martínez-Ros, E. (2010). Innovation, exports and productivity. *International Journal of Industrial Organization*, 28(4), 372-376. <https://doi.org/10.1016/j.ijindorg.2010.03.005>
11. Castellacci, F., & Natera, J. M. (2016). Innovation, absorptive capacity and growth heterogeneity: Development paths in Latin America 1970–2010. *Structural Change and Economic Dynamics*, 37, 27-42. <https://doi.org/10.1016/j.strueco.2015.12.002>
12. Coad, A., Nightingale, P., Stilgoe, J., & Vezzani, A. (2021). Editorial: The dark side of innovation. *Industry and Innovation*, 28(1), 102-112. <https://doi.org/10.1080/13662716.2020.1818555>
13. Correa, J. (2012). Innovation and competition: An unstable relationship. *Journal of Applied Econometrics*, 27(1), 160-166. <https://doi.org/10.1002/jae.1262>
14. Dempere, J., Qamar, M., Allam, H., & Malik, S. (2023). The impact of innovation on economic growth, foreign direct investment, and self-employment: A global perspective. *Economies*, 11(7), 182. <https://doi.org/10.3390/economies11070182>
15. Freel, M., & Robson, P. (2004). Small firm innovation, growth and performance: Evidence from Scotland and Northern England. *International Small Business Journal*, 22(6), 561-575. <https://doi.org/10.1177/0266242604047410>

16. IMF. (2021). *World Economic Outlook: Managing Divergent Recoveries*. International Monetary Fund. <https://www.imf.org/en/Publications/WEO/Issues/2021/03/23/world-economic-outlook-april-2021>
17. Jammeh, I. (2022). The effect of technological innovation on economic growth: Evidence from ECOWAS countries. *International Journal of Social Sciences Perspectives*, 11(1), 1-10. https://www.researchgate.net/publication/362267644_The_Effect_of_Technological_Innovation_on_Economic_Growth_Evidence_from_ECOWAS_Countries
18. Khalatur, S. M., Iefymenko, T. I., Khaminich, S. A., & Poplavska, O. A. (2019). Economic security and sustainable development: National and regional dimensions. *Financial and Credit Activity Problems of Theory and Practice*, 2(29), 83-91.
19. Kheyfets, B., & Chernova, V. (2021). Comparative assessment of the influence of a technological factor on economic growth. *Eastern-European Journal of Enterprise Technologies*, 1(13-109), 6-15. <https://doi.org/10.15587/1729-4061.2021.225054>
20. Kyzy, A. A. (2020). Impact of technological progress on economic growth in developed countries: Accounting for model uncertainty and reverse causality. *Myśl Ekonomiczna i Polityczna*, 1(68), 57-86. [https://doi.org/10.26399/meip.1\(68\).2020.03/a.a.kyzy](https://doi.org/10.26399/meip.1(68).2020.03/a.a.kyzy)
21. Ma, X., Gryshova, I., Khaustova, V., Reshetnyak, O., Shcherbata, M., Bobrovnyk, D., & Khaustov, M. (2022). Assessment of the impact of scientific and technical activities on the economic growth of world countries. *Sustainability*, 14(21), 14350. <https://doi.org/10.3390/su142114350>
22. Mohamed, M. M. A., Liu, P., & Nie, G. (2021). Are technological innovation and foreign direct investment a way to boost economic growth? An Egyptian case study using the Autoregressive Distributed Lag (ARDL) model. *Sustainability*, 13(6), 3265. <https://doi.org/10.3390/su13063265>
23. Mohamed, M. M. A., Liu, P., & Nie, G. (2022). Causality between Technological Innovation and Economic Growth: Evidence from the Economies of Developing Countries. *Sustainability*, 14(3586). <https://doi.org/10.3390/su14063586>
24. Nasution, F. Z., & Firmansyah, M. F. (2022). How Do Innovation and Technology Trade Affect Economic Growth Performance in Indonesia? *Jurnal Akuntansi, Manajemen dan Ekonomi*, 24(4), 1-20. Retrieved from <http://jos.unsoed.ac.id/index.php/jame>
25. Nyeadi, J. D., Atiga, O., & Atogenzoya, C. (2020). Foreign direct investment and innovation in Nigerian manufacturing firms: Evidence from firm-level data. *Journal of Economic Studies*, 47(3), 611-627.
26. OECD. (2020). *The impact of the COVID-19 crisis on innovation: Evidence from public and private sectors*. Organization for Economic Cooperation and Development. <https://www.oecd.org/sti/impact-of-covid19-on-innovation.pdf>
27. Sirimanne, S., Korkaia, A., & Ureche-Rangau, C. (2018). *Digital Economy Report 2018*. United Nations Conference on Trade and Development. <https://unctad.org/webflyer/digital-economy-report-2018>
28. State Taxation Administration of the People's Republic of China. (2021). Tax incentives for scientific and technological innovation during the 13th Five-Year Plan period.
29. Suzuki, K. (2020). Competition, patent protection, and innovation with heterogeneous firms in an endogenous market structure. *Journal of Public Economic Theory*, 22(3), 729-750. <https://doi.org/10.1111/jpet.12415>
30. Tsai, K.-H., & Wang, J.-C. (2004). R&D productivity and the spillover effects of high-tech industry on the traditional manufacturing sector: The case of Taiwan. *World Economy*, 27(10), 1555-1570. <https://doi.org/10.1111/j.1467-9701.2004.00666.x>

31. UNCTAD. (2021). *Technology and Innovation Report 2021*. United Nations Conference on Trade and Development. <https://unctad.org/webflyer/technology-and-innovation-report-2021>
32. United Nations. (2022). *Our Common Agenda*. United Nations. <https://www.un.org/en/common-agenda>
33. Wang, X., & Xu, L. (2021). The impact of technological innovation on economic growth: Evidence from China. In *Proceedings of the 2021 3rd International Conference on Economic Management and Cultural Industry (ICEMCI 2021)* (Vol. 203, pp. 418-423). Atlantis Press. <https://doi.org/10.2991/aebmr.k.211209.071>
34. World Intellectual Property Organization. (2021). *WIPO IP Facts and Figures 2020*.
35. Yang, S., Sun, X., Wang, J., & Zhang, H. (2020). The effect of outward FDI on green innovation in emerging markets and developed countries. *Journal of Cleaner Production*, 244, 118822.