American Journal of Social and Humanitarian Research

Vol. 6 Issue 9 | **pp.** 2186-2195 | **ISSN:** 2690-9626
Available online @ https://globalresearchnetwork.us/index.php/ajshr

Article

Evaluate and assess the correlation between China's Innovation and E.G. Index using distributed deceleration Self-regression Model (2011-2024)

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Abstract: China has seen a remarkable shift toward an innovative economy based on advanced technology and R&D (R&D) as key instruments of growth, the government has launched policies such as"made in China 2025" and the "New High-Quality productive forces" strategy, which has helped to promote advanced industries and diminish reliance on foreign technologies.

The shift to an innovative economy in China, in which the country has moved from a growth model based on low-cost production and exports to one based on technology and knowledge, is seen as key sources of value added. The Chinese government is focused on supporting research and development, building advanced industries such as semiconductors and electric vehicles, with policies geared to enhancing domestic capabilities and reducing dependence on the outside. The results indicate a sustained rise in R&D expenditure and a notable improvement in China's position within global innovation indexes, shown by increased productivity and the emergence of new economic sectors. However, challenges remain related to technical gaps in some areas, geopolitical risks, and the need to improve the IP protection environment. The research concludes that continued success requires balancing government support with market efficiency, and deepening international cooperation to ensure sustainable economic innovation growth.this research aims to study the dimensions of China's innovative E.G., by analyzing the relationship between E.G. and innovation, challenges, and recommendations.

Keywords: Economic Growth (E.G.), innovation, innovative growth

Citation: Miklif, H. Z. Evaluate and assess the correlation between China's Innovation and E.G. Index using distributed deceleration Self-regression Model (2011-2024). American Journal of Social and Humanitarian Research 2025, 6(9), 2186-2195

Received: 10th Jun 2025
Revised: 16th Jul 2025
Accepted: 24th Aug 2025
Published: 03th Sept 2025

1. Introduction

China has experienced accelerated E.G. since the late twentieth century, and innovation was one of the main drivers of this transformation , and these transformations were radical, as it moved from an economy mainly based on cheap labor and export to a more complex economy based on innovation and advanced technology [1]. These shifts are part of a national strategy to boost qualitative growth and reduce dependence on foreign technology [2], [3].

China has steadily increased its R&D spending, surged in global innovation indices, and made progress in industries such as electric vehicles and batteries.

This innovation has contributed to raising labor productivity, creating new sectors, and stimulating local investment [4].

Innovation in China is no longer a development option but a strategic necessity to boost competitiveness and ensure continued growth in the face of global competition. However, challenges such as regional inequality, intellectual property protection, and the need to raise the efficiency of institutional innovation are also important [5], [6].

Research Problem:

Despite China's significant progress in innovation and technology, the research into whether China's success in improving innovation indicators continues to be challenged in its E.G. raises the question: To what extent do improvements in innovation support the economy's continued growth?

Research Importance:

This research is significant because innovation is a key driver of E.G. in contemporary society, and China exemplifies a notable model of innovative economic transformation. Analyzing its experience is crucial for other nations, particularly developing economies aiming to implement analogous strategies [7].

Research objectives:

1. Outline the general framework of the relationship between E.G. and innovation.
2. 2- Analysis and measurement of the relationship to the development of China's innovation indicators and their impact on E.G [8].
3. Propose policies that can support sustainable, innovative E.G..

Research hypothesis:

The research hypothesis is that advanced performance in innovation indicators, such as progress in the Global Innovation Index, is a positive support for the growth of the Chinese economy, provided that an appropriate institutional environment is in place. That is, there is a direct link between innovation and E.G. that will bring about sustainable innovative E.G.[9].

Search limits:

Spatial boundaries: The People's Republic of China.

Time limits: period from 2011 to 2024.

Objective boundaries: The relationship between the GII and E.G., without delving into other political and social aspects.

2. Materials and Methods

The research is based on the analytical descriptive approach based on real data from official sources, such as the World Bank and China National Statistics Office as well as the WIPO Innovation ranking Foundation. Using the standard method using the ARDL distributed deceleration self-regression model .

Previous studies:

Among the most important studies dealing with this topic, we mention:

1. The Chen & Guan study found that there is a clear innovation gap between the developed eastern regions and the less developed western regions, posing challenges to balanced development policies.
2. CAI & Li noted that the creation of innovation zones and technology incubators helped attract foreign direct investment (FDI) and increase exports of technical products.
3. Shown by Zhang et al in technological forecasting & Social Change, innovation has become a key driver of China's transition from a low-cost to a knowledge-based economy.
4. Wang & Li explained that China has become a major player in global value chains by exporting advanced technologies, especially in the fields of renewable energy and artificial intelligence.

Most research suggests that innovation in China is no longer a development option but a strategic necessity to boost competitiveness and ensure continued

growth in the face of global competition. However, challenges such as regional inequality, intellectual property protection, and the need to raise the efficiency of institutional innovation remain important topics of academic and political debate.

The first axis: The theoretical and conceptual framework for innovative E.G.

First: general concepts of E.G. and innovation

This research builds on these concepts to understand how innovative factors interact with variables of China's E.G., and how national policies play a role in promoting this interaction to achieve sustainable innovative E.G..

1. E.G.: is the continuous increase in real GDP, and includes improving the quality of production and increasing productivity. It is also defined as a continuous increase in the market value of goods and services produced by a given economy over a specified period of time, often measured by an increase in real GDP. E.G. also includes improving the quality of production and increasing productivity in various economic sectors.
2. Innovation and Innovation Index: The development of new products and methods that lead to economic value – the Global Innovation Index is used as a performance measure. It is the development of new ideas, products and methods that create economic or social value, and includes technological and organizational innovations .

   It refers to the process by which new ideas or substantial improvements are developed in products, processes, or services with the aim of creating economic or social value. Innovation is not limited to the technological aspect, but also includes organizational and commercial innovations.
3. Innovative growth:is E.G. that depends on innovation and continuous technological development, and focuses on research and development, human capital, and effective institutions.

   «Innovative growth» refers to the process of expanding the productive capabilities of an economy by generating new knowledge, applying it to more valuable products, services, and technologies, and increasing the productivity of factors of production through technological progress and institutional learning. This concept is related to endogenous growth theories (endogenous growth) that position research and development (R&D), human capital, and innovative enterprises as central drivers of long-term growth. Therefore, measuring innovative growth requires looking at indicators such as R&D spending as a proportion of output, patents and their quality, labor productivity in high-tech sectors, and building local value chains in advanced industries.

   If innovative growth is a type of E.G. attributed to innovation and continuous technological development. This growth is considered one of the primary sources for improving productivity and competitiveness in the economy, and focuses on investing resources in research and development, developing human capital, and improving institutional frameworks.
4. The relationship between E.G. and innovation :

   The research is based on the endogenous growth theory (endogenous growth theory) which asserts that innovation is the result of deliberate policies and investments in research, development and education, innovation contributes to increased productivity of production factors, the creation of new industries and the spread of knowledge between sectors, and emphasizes that investment in innovation and research drives growth.

Second: An overview of innovative E.G. in China.

The Chinese government began adopting ambitious industrial policies such as the made in China 2025 initiative, which aims to upgrade the national

industry in areas such as semiconductors, robotics and electric vehicles, and later evolved toward a broader strategy to promote "new high-quality productive forces" and support basic research and market-oriented innovation. The authorities have also directed funding for strategic sectors, facilitated financial channels and incentives to accelerate the technology transition of companies, with policies to support university-private sector connectivity.

China's experience in pursuing "innovative E.G." is a dynamic model that combines strong industrial policies, increased investment in R&D, and an effort to build advanced industrial capacity. Preliminary results confirm improved innovation capabilities and the emergence of new high-value sectors, but the path to an integrated innovation economy requires institutional reforms, a balance between government support and market efficiency, and managing global chain risks. The balance between strategic economic goals and global bets will remain the cornerstone of how successful this shift will be over the next decade.

3. Results

Innovation indicators: R&D, output and innovation

1. Research and development (R&D) spending: China has recorded strong growth in total R&D spending in recent years, with spending growth rates exceeding those of many advanced economies; OECD reports indicate strong growth in Chinese R&D spending in 2023 [10].
2. National Innovation Index: China's National Bureau of Statistics noted that the innovation index (to higher levels in 2024, reflecting a cumulative improvement in research capabilities and industrial application.
3. Overall E.G.: While sources of growth change, China ' s GDP continues to grow at rates different from periods of historical acceleration; World Bank databases showed growth rates below the peak of the past two decades, but China continues to register positive growth, supported by domestic expansion and investment in technology sectors [11].
4. China's place in global innovation indicators: Studies by research centers such as ITIF show that China is making rapid progress in advanced industries (such as electric vehicles, batteries and commercial nuclear power) and is approaching or surpassing some of the indicators of research and industrial performance over developed countries in specific fields [12].

Taken together, these indicators support the argument that China is not only increasing its research spending, but shifting that to new industrial capabilities that affect its E.G. structure.

Table 1. selected indicators of China's innovative growth

Ranking of the Global Innovation Index	R&D spending (% of output)	GII Global Innovation Index (0 -100)	GDP percentage of E.G.	GDP is billion yuan	GDP percentage of E.G.	The GDP is trillion dollars	The year
29	1.84	45.67	9.55%	47,157.3	9.55%	7.55	2011
29	2.06	48.95	8.00%	66,100.0	7.04%	11.06	2015
17	2.19	54.82	5.93%	79,500.0	6.75%	13.89	2018
14	2.40	55.3	3.10%	86,600.0	2.24%	14.69	2020
11	2.55	55.31	3.19%	97,000.0	2.95%	17.88	2022

10	2.65	56.3	3.93%	106,000,0	5.00%	18.27	2024

Source: Prepared by the researcher based on R&D data: China Bureau of Statistics (NBS) and OECD.
Innovation Ranking: WIPO and CountryEconomy.
Worldometers. China GDP 1960–2024. Retrieved from https://www.worldometers.info/gdp/china-gdp/
MacroTre.s. China GDP 1960–2024. Retrieved from https://www.macroTre.s.net/global-metrics/countries/CHN/china/gdp-gross-domestic-product
Statistics Times. China GDP (IMF Forecast). Retrieved from https://statisticstimes.com/economy/country/china-gdp.php

We note in Table 1 that China's indicators are constantly improving, the GDP, whether in US dollars or Chinese yuan, is constantly rising and the E.G. has been positive and for the global innovation index goes hand in hand with the stability of E.G. there and progress in the country's ranking of the index in 2011 and 2015 ad the same ranking does not indicate a lack of progress but to increase the number reporting States from 125 to 141. This reinforces the hypothesis that there is a positive correlation between innovation and growth [13].

From 2011 to 2024, the Chinese economy witnessed remarkable growth in real GDP and continued despite the challenges. this highlights the resilience of the Chinese economy during the research period and the fact that the rate of E.G. has been uneven but not negative, although it slowed significantly in the 2020 COVID -19 pandemic). this is evidence that technology dependence helped, followed by a strong recovery in 2021 [14], [15].

Gross domestic product (in current US dollar prices) continued to rise from 2011 to 2024, with the International Monetary Fund's 2024 estimate of around $18.27 trillion.

Third: The impact of innovation on China's E.G.

The main channels through which innovation contributes to China's growth can be summarized as follows:

1. Raising worker productivity and capital: Advanced technologies and automation that raise productivity in manufacturing and services.
2. Creating new high-value-added sectors: Electric vehicles, semiconductors, and industrial software.
3. Reducing foreign technical dependence: Replacing technological imports with local structures for innovation reduces geopolitical risks [16].

Stimulating private investment and the size of the domestic market: Innovation policies increase the incentives for investment in research and industrial application

Despite the gains, China faces several constraints that will weaken or complicate its full transition to an innovative economy: Rhodium/CSIS analyzes (RHODIUM).

1. restrictions in some basic industries such as advanced semiconductor design, where Chinese companies still rely on advanced foreign technologies and equipment.
2. dependence on government support: The risks of excessive stimulus or support to inefficient companies lead to a weakening of the efficiency of resource allocation.
3. institutional and governance issues: Intellectual property protection, transparency in statistics, and the legal environment reflect on the effectiveness of innovation and the depth of international cooperation. (Wired analysis).

4. geopolitical risks: Technology export restrictions from major countries and sanctions that could disrupt supply chains and cost Chinese companies higher prices to overcome restrictions.

The Second axis : Measuring the relationship between the Innovation and E.G. Index using China's distributed Slow Self-decline Model (2011-2024)

First: the search and characterization variables

In order to test the hypothesis of the research and achieve its objectives, the independent variable index of innovation and the dependency of E.G. was identified as follows:

GII The Global Innovation Index Independent variable

G-d E.G. Variable continued

According to the theoretical framework of the research, it assumes the test of the following functional relationship

$G_t = a + b\ GII_t + ui$

(GII) stands for innovation, and (G) stands for E.G..

Second, the test results

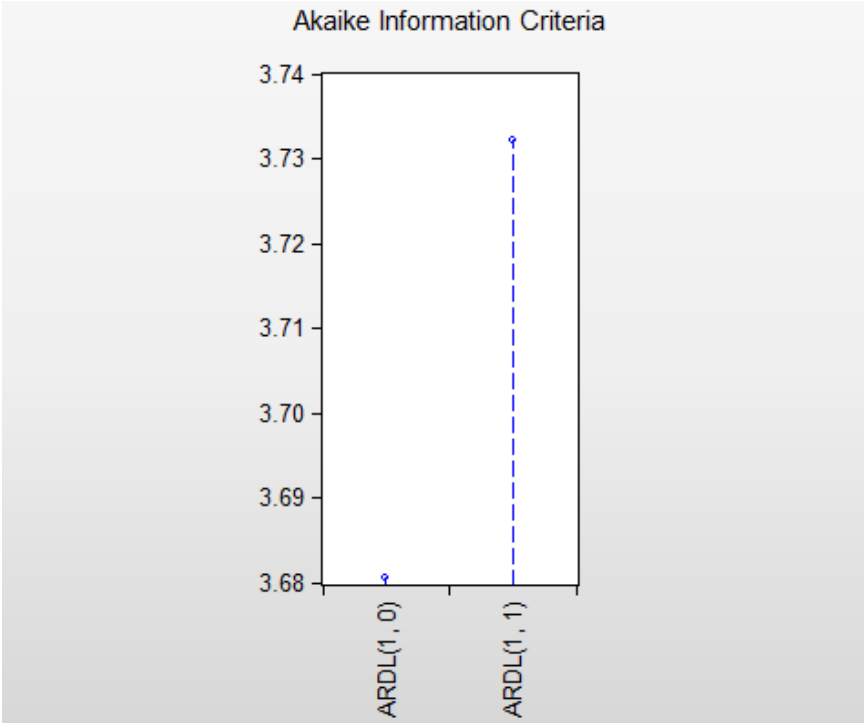
1. Unit root test

The Table 2. Unit root test (PP)

	Level		
		G-d	GII
Cons.	t	-3.5159	-0.9233
	Sig,	0.0255	0.7463
		**	N0
Cons. & Tre.	t	-19.0427	-1.1852
	Sig,	0.0001	0.869
		***	N0
No. Cons. & Tre.	t	-1.2303	2.3669
	Sig,	0.1891	0.9916
		N0	N0
	At First Difference		
		d(GDP)	d(GII)
Cons.	t	-19.4326	-3.0585
	Sig,	0.0001	0.0576
		***	*
Cons. & Tre.	t	-21.5152	-3.18
	Sig,	0.0001	0.1342
		***	N0
No. Cons. & Tre.	t	-9.6935	-2.1894
	Sig,	0	0.0328
		***	**

After testing the root unit of the search variables and through the table 2 we find that the variable gsettled at the level while the variable gii settled at the first difference with a sector and a general Tre., we go and determine the optimal slowing period as follows: "As shown in Figure 1, the optimal lag period for the ARDL model was identified as lag 1."

Figure 1. specifies the delay period



In the form (1), the optimal slowing period for the model is lag 1 .

2. The ARDL model of common integration

Table 3. Results of the ARDL Model of common integration

Variable	Coeff.	STDR.	t	Sig,*
G (-1)	-0.549097	0.254469	-2.157817	0.0563
GII	-0.438822	0.125235	-3.503983	0.0057
C.	32.67110	7.725472	4.229011	0.0017
Rsquared	0.55	**Adjusted Rsquared**		0.46
Fstatistic	6.150	**DW TEST**		2.32

Table 3 presents the outcomes of the self-regression model of the distributed deceleration, indicating that the explanatory power of R-squared was 0.55. The independent variable in the estimated model accounts for 55% of the variance in the dependent variable, while 45% is attributable to external factors. The Adjusted R-squared value is 0.46, and the F-statistic is 6.150, which is significant at the 5% level. Therefore, we reject the null hypothesis and accept the alternative hypothesis, indicating the model's validity [17], [18].

3. Boundary testing

Table 4. testing boundaries (Bounds Test)

Test Stat.	**Value**	**K and K**
F- Stat	**21.00952**	**1**
Signi.	**I0 Bound**	**I1 Bound**
5%	**4.94**	**5.73**

Table 4, which shows the results of the boundary test, we find that the value (F-statistics) calculated was (21.00952), which is greater than the small and large values at the level of 5%, so the impact of innovation on E.G. is significant in the long term.

4. Test the problem of self-correlation and heterogeneity of contrast

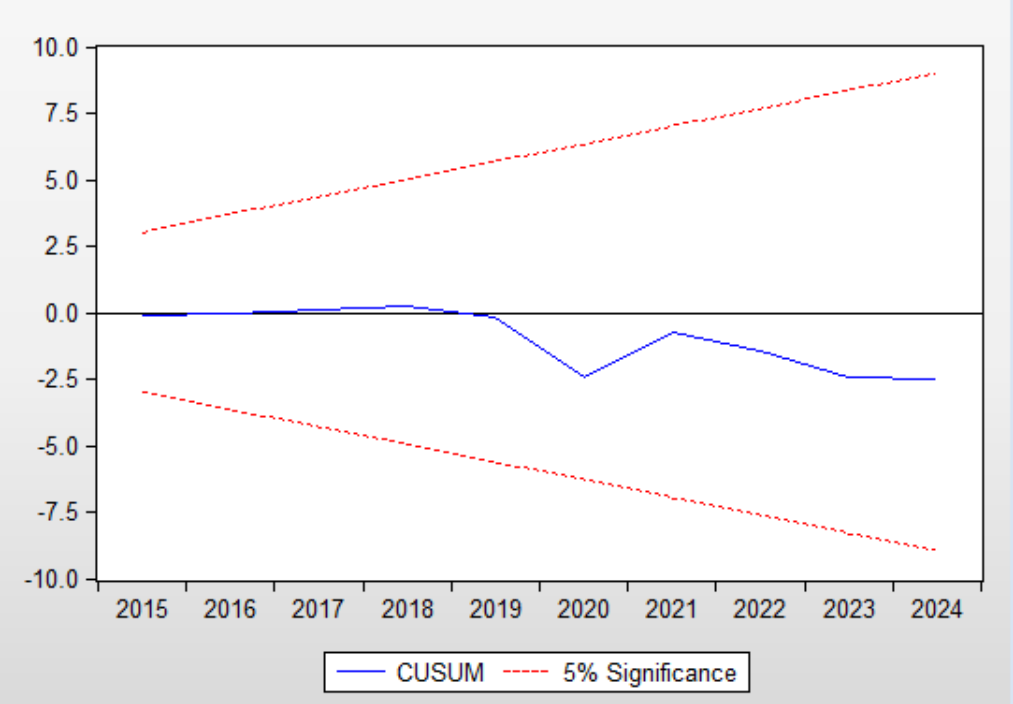
Table 5. Test serial correlation and heterogeneity of variance

Breusch-Godfrey Serial Correlation LM Test			
F- statistic	0.326410	Prop . F	0.7307

Obs*Rsquared	0.980797	Sig, Chi-Square	0.6124
Heteroskedasticity Test: ARCH			
F-statistic	0.032832	Sig, F.	0.8598
Obs*Rsquared	0.039269	Sig, Chi-Square	0.8429

Table 5 and the Breusch-Godfrey Serial Correlation LM Test indicate that the model is robust and devoid of autocorrelation, since the Chi-Square value is not significant at the 5% level. The model was determined to be devoid of the heterogeneity of variance issue, as shown by the Heteroskedasticity Test: ARCH, which was likewise not significant at the 5% level, see Figure 2.

Figure 2. Stability test of the ARDL model for innovation and economic growth in China



Stability test

Through Figure 2, it becomes clear to us that the model is stable because the graph lies within the upper and lower limits .

5-ECM Error Correction Model Estimation

Table 6. Error Correction Form

Short-term error correction form ECM				
Variable	**Coeff.**	**STDR.**	**t**	**Sig,**
D(GII)	-0.438822	0.125235	-3.503983	0.0057
Cointeq(-1)	-1.549097	0.254469	-6.087571	0.0001
Long-term error correction form ECM				
Variable	**Coeff.**	**STDR.**	**t**	**Sig,**
GII	-0.283276	0.061828	-4.581683	0.0010
C.	21.090413	3.237934	6.513540	0.0001

Table 6 indicates a long-term equilibrium connection between G and GII, since the error correction factor is significant at the 5% level, signifying a substantial rate of adjustment in the long run. This signifies that the outcomes of innovation do not manifest in a short timeframe; instead, they need an extended duration for adaptation and cost reduction.

4. Conclusion

1. The calculated F-statistic value was (6.150), which is significant at the level of 5%, meaning that the model is significant, meaning we reject the null hypothesis and accept the alternative hypothesis. This proves the research hypothesis that there is a soft relationship between innovation and E.G., and we note that the explanatory power Rsquared was (55R2=0.) That is, the independent variable in the estimated model explains 55% of the changes in the dependent variable, and 45% is due to other variables outside the model.
2. The impact of innovation on E.G. has an impact in the long term.
3. By analyzing the relationship between innovation indicators and E.G. in China, it becomes clear that the transition to a knowledge- and technology-based economy was not a coincidence, but rather the result of long-term strategic policies. China has not only transferred technology from abroad, but has also focused on building a strong domestic base for research and development, which has been reflected in increased patents and the expansion of high-tech industries, thus raising growth rates.
4. Innovation played a dual role: on the one hand, it enhanced productivity and raised the competitiveness of Chinese products in global markets, and on the other hand, it contributed to diversifying sources of growth and reducing dependence on traditional sectors such as low-value manufacturing.
5. China still faces challenges related to distributing the benefits of innovation across different regions, and reducing the gap between developed urban areas and less developed rural areas.
6. Investing in human capital and scientific research is the cornerstone for achieving sustainable E.G. capable of adapting to the changes of the global economy.

5. Recommendations

The researcher suggests the following to promote sustainable innovative growth:

1. Enhancing investment in research and development and long-term financing, China should continue to increase spending on scientific research, focusing on strategic areas such as artificial intelligence, renewable energy and medical technologies, ensuring that it maintains its global position in innovation.
2. Reducing the regional gap in innovation: It is important to develop special programs to support less developed regions, by establishing research centers in rural areas and linking them to networks of major universities and laboratories, to ensure a more equitable distribution of the fruits of innovation. 3- Developing the legislative environment and improving the environment for intellectual property protection and governance, reviewing laws related to intellectual property rights and tightening their protection, in a way that motivates companies and individuals to invest in developing new ideas and products.
3. Strengthening international cooperation, openness to global research partnerships, and exchanging experiences with leading countries in innovation will contribute to accelerating the process of technological development and adopting best practices.
4. Focus on human capital, investing in quality education and continuous training for workers in technical sectors, to ensure the presence of competencies capable of leading the innovation process in the future.
5. Linking innovation to sustainability, encouraging innovations that promote sustainable innovative E.G. and reduce environmental impacts, to ensure that E.G. is compatible with environmental and social goals.
6. China's experience in innovative E.G. is a dynamic model that combines government policies and investment in research and development to build advanced industrial capabilities. Linking growth to sustainability through environmentally friendly innovation.

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