National Innovation Capacity and Economic Growth: A Global Empirical Analysis

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Abstract. In recent years, building an innovative country has gradually become a hot topic in the international community. Relying on scientific and technological innovation to increase their core competitiveness has become an objective requirement of all economies. Therefore, starting from Schumpeter's theory, this paper takes 41 countries from 2011 to 2021 as samples to investigate the impact of national innovation capacity on their economic growth, the intermediary role of price level in the main relationship, and the heterogeneity of developed and developing countries after analyzing the pattern of innovation capacity of countries in the world. This paper uses the global innovation index and the CPI of various countries for empirical analysis. The empirical results show that countries with high GII scores are more likely to have a good economic growth; The lower consumer price level has a positive effect on the GII to influence the economic growth; Scientific and technological progress in developed countries is more conducive to economic growth. This study mainly discusses the impact of innovation ability on economic growth and adds content to relevant literature to help countries think about their innovation level and change ways.

Keywords: Global innovation index; Innovation situation analysis; Schumpeter; Price impact.

1. Introduction

1.1 Research significance and background

Schumpeter pointed out that the existing research mainly discusses the role of technological innovation in combination with technology and economy [1]. Today, innovation is the focus of comprehensive national strength competition. Whoever has an advantage in knowledge and scientific and technological innovation can take the initiative in development. At the same time, with the further deepening of economic globalization, the embryonic form of international division of labor has taken shape, that is, from the original world-wide division of labor pattern of "industrial Europe and U.S., raw materials Asia, Africa and Latin America" to the present "innovation in Europe and U.S., production and processing in Asia, Africa and Latin America "[2]. Although this division of labor has certain rationality and advantages for the market, it has suppressed the innovation ability of most economies to a certain extent, and even restricted their economic development.

This paper analyzes the relationship between the global innovation index (GII) and the economic growth of existing economies, further verify the emergence and changes of Schumpeter's theory and give corresponding construction countermeasures for the tripartite world with different innovation states.

1.2 Innovation capability performance of participating economies

The ranking of global innovation index scores further reflects the comprehensive innovation capacity of the selected economies. According to the collected data from 2011 to 2021, the global innovation presents the following trend characteristics:

1.2.1 European and American countries continuous a leading position and have strong sustainability

At present, innovation is mainly concentrated in U.S., and European countries. Among them, the U.S. has maintained the third place in the GII ranking for the third consecutive year. Led by the San Jose San Francisco cluster, it also has the largest number of top science and technology clusters in

the world (24). Among the top 10 GII countries, 7 are European countries, of which Switzerland has maintained the leading position in the global innovation field for 11 consecutive years.

The reason why European and American countries have such strong performance is mainly due to their cultural and political environment. First, these countries have opened courses such as innovation management (mainly discussing product and service innovation and process innovation). Under the far-reaching influence of Schumpeter's five innovations, its culture will hinder innovation less than other cultures, and will be more easily accepted and tried by entrepreneurs [3]. Secondly, the government attaches great importance to R & D and their industrialization, thus creating many national level R & D platforms and investing heavily in innovation. Finally, due to natural conditions, population size and other factors, when competing with other countries in the world, European and American countries will not have an advantage in the number of goods, their production costs are very high, and the scale of products cannot be expanded. They must rely on innovation to participate in the competition.

1.2.2 Some developing countries have entered a period of high-speed innovation

Fu, Pietrobelli, and Soete pointed that although emerging economies often find challenges to steadily improve their innovation systems, some middle-income economies have caught up with more developed economies in innovation [4]. The innovation performance in Asia has been the most dynamic in the past 10 years, narrowing the gap with North America and Europe. Among them, China, which has 19 leading global science and technology clusters, is the only developing country that ranks among the top 15. In addition, some middle-income economies such as Vietnam, India and the Philippines are catching up and changing the innovation pattern. At the same time, the economist pointed out that Chinese young entrepreneurs have the spirit of innovation and global vision and are leading a new round of world industry and consumption trends.

However, since these countries have only a leading position in certain aspects, their innovation sustainability is still questioned by the public. For example, Thailand, which is a leader in enterprise funded R & D, and New Zealand, which is developed in cell engineering and biotechnology, need to expand their innovation capabilities in an all-round way to achieve common growth between innovation and economic improvement.

1.2.3 Most third world countries encounter difficulties in innovation

The development of innovative technology has brought a transformative impact on world politics and economy, leading it to a more chaotic and unequal era, which has also led to a new round of development difficulties faced by underdeveloped or developing third world countries, and it is difficult to break through the existing scores in various innovation indexes. On the one hand, most third world countries lack talents, and a large number of low educated, low skilled labor force make the national economy and innovation development inefficient, further deepening the gap; On the other hand, the existing cheap labor is constantly replaced by innovative technologies, the advantages of labor-intensive industries are gradually disappearing, and the unemployment rate is increasing, which also exacerbates the instability of economic development.

2. Hypothesis Development

2.1 Innovation and economic growth

From the perspective of economics, economic growth can be divided into Smith type growth and Schumpeter growth, that is, economic growth needs the impetus of innovation [5]. Although Ghisellini, Cialani, and Ulgiati believe that GDP is more representative of the production system, the innovation system cannot be reflected in GDP [6]. This view does have a certain practical basis, that is, Chinese economic development since the reform and opening, many early manufacturing enterprises began business in the 1980s and 1990s and rapidly expanded their scale and went public. However, Qian and Moser have proposed that in the absence of an innovation environment, the

innovative achievements cannot be effectively protected by law and practice, which makes replication the most cost-effective choice in the market [7-8]. Additionally, since 1912, Schumpeter's theory of defining innovation as a qualitative breakthrough has been increasingly affirmed by all walks of life, that is, innovation drives industrial upgrading, and in turn improves work efficiency, promotes economic growth.

Hypothesis 1: Countries with high scores in the GII are more likely to have a good economic growth.

2.2 Innovation and price level

The essence of innovation (to bring better products and services to the society) determines that innovation can lower the price level in the long run, and when it drops to a certain extent, a new round of innovation will occur. Schumpeter pointed out that innovation means destruction at the same time, that is, in the constantly competitive market, the birth and popularity of new combinations also means the elimination of old combinations through competition [9]. When an economy enters the development cycle, innovation becomes a fundamental requirement for its internal renewal. Therefore, the price of old products in the market is bound to be lower, and the price of new products is bound to be at a high level in the initial stage.

However, Keynesianism also pointed out that falling prices are not conducive to the survival of capital and will further hinder social innovation and technological development. It is necessary to make the speed of money issuance exceed the speed at which science and technology are constantly innovated, that is, businessmen should expand production scale and increase production with the increase of raw material prices and go bankrupt with the decrease of profits caused by the discount of raw materials [10]. In addition, Drucker and others also put forward the assertion that all innovation is essentially a cost reduction of more than 30%, pointing out that when prices rise, people are eager to reduce prices, thus embarking on the journey of innovation [11].

Hypothesis 2: The lower CPI has a positive effect on the ability of national innovation to influence the economic growth.

2.3 Heterogeneity caused by national nature

At present, from the perspective of the innovation force between developed countries and developing countries, some scholars believe that the development of technology level is more beneficial to small countries. They pointed out that the underdeveloped developing countries generally have a large population, and when technologies are innovated, it is easy to greatly improve productivity and expand output through industrialization, forming competitive advantages in the world and promoting domestic economic development [12-13]. However, empirical analyses from 1990 to 2010 have denied this view. For example, Omri and Berman, Bound, and Machin has concluded that only in rich developed countries can technological innovation promote the sustainable development of national industries, but has no effect on low-income countries [14-15]. This also echoes the current technological innovation situation described above. Due to the rapid development changes in the past decade and the frantic catch-up of medium-sized economies in the level of technology or wealth, and the shortage of workers in developed countries, this debate has been thrown back to the public [16].

Hypothesis 3: Scientific and technological progress in developed countries is more conducive to economic growth.

3. Research Design

3.1 Sample selection

This paper selects 41 countries in the world from 2011 to 2021 as the research sample. The selected countries include 22 developed countries and 19 developing countries, the proportion is confirmed according to the average proportion of two different countries participating in the election over the

past 16 years. Data of individual countries are missing in individual years, but through investigation, this paper believes that it will not affect the research results. In addition, this paper also performs 5% quantile Winsorize processing on all sample data to make the results more accurate.

3.2 Variable definition

Current Year's GDP: The Gross Domestic Product (GDP) of each country is selected as the explained variable. Wheelan pointed out that although it has doubts about measuring the happiness index, it is the best measure of economic progress recognized by many economists [17].

Global Innovation Index Score: This paper selects the global innovation index founded in 2007 as the explanatory variable of this paper [18]. The index is a detailed quantitative tool, consisting of 2 primary indicators, 7 secondary indicators, 21 tertiary indicators, 81 tertiary indicators. Oturakci pointed out that the current index is often used by economists to analyze regional and structural analysis, and the measures given in the annual output report have been widely adopted by governments [19].

Control Variable: To increase the stability of the study, after analyzing the studies, this paper uses various quantitative economic factors widely used in empirical analysis in recent ten years as control variables to verify the research results [20]. Table 2 below shows a list of all variables used.

Table 1. Total Score Composition of GII

Total Score of Global Innovation Index			
Innovation Input			Innovative Output
System	Commercial Maturity	Infrastructure	Knowledge and Technology Output
Human Capital and Research	Market Maturity		Creative Output

Table 2. List of Variables in This Paper

Variable	Index	Definition	Data Sources
Explained Variable	lnGDP	Logarithm of current year's GDP	WIPO
Explanatory Variable	BII	Global innovation index score	CSMAR
Control Variable	CPI	Consumer price inflation index	CSMAR
	lnHuman	Logarithm of total population	CSMAR
	lnExport	Logarithm of commercial exports	Trade Map
	lnImport	Logarithm of commodity imports	Trade Map
	Unemploy	unemployment rate	EPS
	Govern	Proportion of general government expenditure	EPS

3.3 Model design

There are two models in this paper. Model 1 is the basic regression equation of this paper, of which explanatory variable is the logarithm of the GDP price of the country and region in the current year (lnGDP); Model 2 is the robustness test equation of Model 1, which is interpreted as the logarithm of GDP prices of countries and regions in the next year (L. lnGDP). The core explanatory variable is GII, which measures the comprehensive innovation capacity of selected countries, such as the number of patent applications and innovation performance. and β1, β2 also indicates the direction and extent of the impact of the GII score on the country's GDP. The explanatory variables and control variables of the two equations are consistent, and both are expressed as Contral, which is listed as Table 2.

$$\ln GDP_{it} = \alpha + \beta_1 BII_{it} + \beta_2 Contral + \varepsilon \quad \text{(Model1)}$$

$$L.\ln GDP_{it} = \alpha + \beta_1 BII_{it} + \beta_2 Contral + \varepsilon \quad \text{(Model 2)}$$

4. Empirical Analysis

4.1 Descriptive Statistics

The results of relevant variables are as follows:

Table 3. Descriptive Statistical Results

Variable	Mean	Std. Dev.	Min	Max	Observations
lnGDP	6.227	1.400	3.728	8.926	410
BII	45.310	11.554	24.830	62.470	410
CPI	145.804	95.784	93.784	472.742	410
lnHuman	17.300	1.429	15.378	20.920	406
lnExport	24.645	1.426	21.659	26.871	386
lnImport	25.787	1.269	23.330	27.882	407
Unemploy	0.058	0.044	0.000	0.171	410
Govern	0.323	0.172	0.000	0.563	410

4.2 Correlation analysis

According to the results as follows, we can observe the correlation coefficient between lnGDP and BII is 0.530, which is significant at the level of 1%, which is the first to verify that GII is significantly related to economic growth. In addition, it should be noted that the correlation coefficient between BII and CPI is -0.295, which is significant at the level of 1%, which verifies our hypothesis H2, that is, lower consumer price levels have a positive effect on the ability of national innovation to affect economic growth. And is in line with Wan, Williamson, and Yin that low factor prices are conducive to innovation [21]. On the one hand, innovation helps reduce input and improve productivity; On the other hand, advanced equipment and processes reduce costs, thus further reducing the price level.

Table 4. Correlation Analysis

	lnGDP	BII	CPI	lnHuman	lnExport	lnImport	Unemploy	Govern
lnGDP	1							
BII	0.530***	1						
CPI	-0.061	-0.295***	1					
lnHuman	0.622***	-0.235***	0.173***	1				
lnExport	0.817***	0.700***	-0.153***	0.321***	1			
lnImport	0.929***	0.595***	-0.111**	0.502***	0.867***	1		
Unemploy	-0.003	0.181***	-0.213***	-0.224***	0.022	-0.036	1	
Govern	0.341***	0.610***	-0.294***	-0.178***	0.455***	0.339***	0.629***	1

4.3 Heteroscedasticity test

This paper uses White test to verify whether the regression equation has heteroscedasticity, to ensure that the regression parameter estimation has good statistical characteristics. Table 5 shows that the Chi2 value of Model 1 white test is 221.73, and the P Value is 0.0000; The Chi2 value of Model 2 white test was 188.52, and the P Value was 0.0000. The results show that Model 1 and Model 2 should reject the original hypothesis of hemovigilance and accept the alternative hypothesis of heteroscedasticity. That is, Model 1 and Model 2 in this paper have heteroscedasticity. So, this paper will use the method of introducing robust standard error to solve the heteroscedasticity problem.

4.4 ADF test

Through the ADF test, the P-value of all the above variables is 0.0000, which can reject the original hypothesis, that is, all variables in this paper are stationary sequences.

Table 5. ADF test

Variables	Statistic	P-value
lnGDP	141.5855	0.0000
BII	204.0971	0.0000
CPI	140.9134	0.0000
lnHuman	227.4381	0.0000
lnExport	252.3769	0.0000
lnImport	195.1504	0.0000
Unemploy	165.4437	0.0000
Govern	135.1732	0.0000

4.5 Basic regression and robustness test

From the regression results in Table 7, we can observe that the regression coefficient between lnGDP and BII is 0.0334, and the T value is 10.05, which is significantly positive at the level of 1%, which verifies our H1 from the statistical point of view, that is, countries with high GII scores are more likely to have a good economic growth. This result is also consistent with our conclusion in the literature review.

As Windrum and García-Goñi pointed out, innovation drives economic growth, and the innovation of production technology and the change of production methods play a supreme role in the process of economic development [22]. An economy can promote orderly economic adjustment through a series of science and technology policies, establish a complete innovation ecosystem, and enable the national economy to enter a higher speed of development.

Among the other variables, the unemployment rate is worth mentioning. The regression coefficient of Unemploy is 1.1188, which indicates that the unemployment rate is positively related to the economic growth that is, as the economic level rises, the unemployment rate of the society will rise. On the one hand, modern society tends to replace ordinary labor with more intelligent equipment innovation to reduce costs and liberate labor, resulting in unemployment of ordinary labor; On the other hand, according to the short-term Phillips curve, the government can make a trade-off between inflation and unemployment. To promote stable socio-economic development and scientific and technological progress, many governments will adopt measures to increase the unemployment rate. At present, the unemployment rate has not caused great trouble to the level of social productivity and is still in an acceptable range.

Table 6. White Test

Model	Chi2 Value	P Value
Model1	221.73	0.0000
Model2	188.52	0.0000

The explanatory variable of this paper is the GII, which is the only detailed indicator of innovation performance that can be used as the comprehensive innovation capacity of countries around the world and as a policy reference. For other similar index like the EU innovation index published with the series of reports of the EU Innovation Capability Scoreboard, the Silicon Valley index pioneered by joint venture Silicon Valley and the world knowledge competition index published from time to time by the Robert Hutchins Association of the United Kingdom since 2002, are all having problems like small scope, incomplete data. So they all cannot be used as a substitute variable for robustness test. Therefore, as in Model 2 described above, we take the GDP of the next year as the explained variable of the current year, while other variables of the current year remain unchanged. That is, the national innovation in this year can continue to affect the next year.

According to the results of Model 2, the regression coefficient between L.lnGDP and BII is 0.0373, which is significantly positively correlated at the level of 1%. Consistent with the results of Model 1.

Therefore, this paper believes that the regression results in this paper have passed the robustness test and are scientific to a certain extent.

Table 7. Basic Regression Results

	Model1	Model2
	lnGDP	L.lnGDP
BII	0.0334***	0.0373***
	(10.05)	(10.44)
CPI	0.0002	0.0002
	(0.72)	(0.63)
lnHuman	0.4416***	0.4663***
	(16.00)	(16.04)
lnExport	0.0656*	0.0388
	(1.75)	(0.94)
lnImport	0.5115***	0.4933***
	(11.11)	(9.42)
Unemploy	1.1188***	1.2248**
	(2.60)	(2.47)
Govern	0.3994*	0.4721*
	(1.75)	(1.84)
_cons	-17.9696***	-17.4844***
	(-38.16)	(-34.07)
R^2	0.921	0.918
adj. R^2	0.920	0.916
AIC	378.0221	330.2664
BIC	409.5645	360.3376
F	926.5672	739.3429
N	381	317

4.6 Heterogeneity analysis and robustness test

In addition, the relationship between GII and economic growth and other variables was tested in developed and developing countries respectively, and the results are shown in Table 8. We can see that the regression coefficient of lnGDP and BII in developed countries is 0.0375, which is significantly positively correlated at the level of 1%, while the regression coefficient of lnGDP and BII in developing countries is 0.0120, which is significantly positively correlated at the level of 10%. This verifies our H3, that is, scientific and technological progress in developed countries is more conducive to economic growth, which also confirms our previous literature findings. The interpretation of this result is as follows:

First, the prerequisite for technological progress is talent, technology, and financial support. Developed countries have all along provided a large amount of scientific research funds for technological research, while many developing countries have fallen into the middle-income trap, and their national scientific research funding intensity has been below 1.3% for a long time. And countries like South Korea that can invest a high proportion in R & D have successfully transformed into developed countries and enjoyed the benefits brought by scientific and technological progress.

Secondly, the leading industries in developing countries are low-end OEM and resource export. It is difficult for small countries without sufficient market scale to compete with large countries with large reserves of basic industrial level in high-tech and sophisticated technologies, and even less can they absorb the dividends brought by technological progress.

According to the results of Model 2, the regression coefficient of L.lnGDP and BII in developed countries is 0.0120, which is significantly positively correlated at the level of 10%, while the

regression coefficient of L.lnGDP and BII in developing countries is 0.0217. It is consistent with the results of Model 1 and verifies the reliability.

Table 8. Robustness test

	Developed Countries	Developed Countries	Developing Countries	Developing Countries
	lnGDP	L.lnGDP	lnGDP	L.lnGDP
BII	0.0375***	0.0406***	0.0120*	0.0217***
	(8.51)	(8.29)	(1.68)	(2.92)
CPI	0.0003	0.0002	0.0003	0.0003
	(0.43)	(0.19)	(1.06)	(0.90)
lnHuman	0.5733***	0.5705***	0.2423***	0.3171***
	(16.09)	(14.19)	(5.44)	(6.81)
lnExport	0.1412***	0.0833	0.0722	0.0433
	(2.71)	(1.40)	(1.19)	(0.67)
lnImport	0.3050***	0.3513***	0.7457***	0.6513***
	(4.97)	(4.86)	(11.32)	(8.26)
Unemploy	0.6892	1.6435*	1.5224**	1.1271
	(0.92)	(1.91)	(2.36)	(1.54)
Govern	0.9762***	0.9068***	-0.2880	-0.0443
	(5.04)	(3.62)	(-0.70)	(-0.10)
_cons	-17.1131***	-17.0147***	-19.6355***	-18.3007***
	(-25.06)	(-22.00)	(-22.77)	(-18.76)
R^2	0.934	0.931	0.897	0.884
adj. R^2	0.932	0.928	0.893	0.878
AIC	144.3746	129.7657	193.6150	179.9730
BIC	171.2273	155.1296	218.6542	203.5631
F	415.1200	331.1456	316.5684	235.7651
N	212	176	169	141

5. Conclusion

This paper studies the impact of innovation level on economic growth from an empirical point of view, examines the impact of price level on innovation, and the heterogeneity between developed and developing countries after analyzing the GII ranking and various indicators in the past decade. The main findings are as follows: Countries with high GII scores are more likely to achieve good economic growth. For example, Switzerland, which has ranked first in the global innovation index for 10 consecutive years, has a high proportion of private funded R&D expenditure and knowledge intensive employment, which has helped it achieve great success in business. Low CPI has a positive impact on the ability of national innovation to affect economic growth. This is because with the rise of CPI, the society is prone to inflation, which will also affect the development of the stock market, and the real wages of residents are also decreasing. The economic growth of developed countries depends more on their scientific and technological development level than that of developing countries. At present, European and American countries rely more on capital intensive industries and technology intensive industries, while Asian, African and Latin American countries rely more on labor-intensive industries. Switzerland, Finland, the United States and other European and American countries continue to maintain a leading position in various innovation fields and have strong sustainability; Some developing countries, such as China, have entered a period of high-speed innovation, but there are not enough advantageous fields; Most third world countries, such as India and Pakistan, face difficulties in innovation and are difficult to change the status quo through independent capacity. Based on the above empirical and analytical results, the following policy recommendations are proposed.

First, each country can refer to the GII's evaluation criteria to develop its own innovation capacity in combination with its unique national conditions, to promote the development of its national economic growth. At the same time, the country needs to control its monetary policy, the price level according to the Schumpeter's theory of long and short economic cycles, further stimulate the development of science and technology, and promote its economic growth to reach a dominant position in the international community in the long run. In addition, developing countries can also improve the level of technological innovation for sustainable development and ecological sustainability through closer cooperation between universities and industries and increased investment in R & D. This can also help these countries get out of the "middle-income trap".

Secondly, for European and U.S., the existing scientific research system has been maintained in a very stable circulation system. The only deficiency is that the industrialization scale caused by the insufficient population scale is small, which leads to the problem that it is difficult to expand the economic growth. These weak areas can be strengthened through immigration and other means.

Third, for developing countries and some relatively backward economies, while further improving their weaknesses, they need to focus on participating in the activities of global economic institutions to maximize the influence on agenda setting.

Finally, for the vast number of backward third world countries, the top priority is to introduce advanced technology, attract investment and improve the comprehensive national quality. This can be achieved by transforming the old educational model, increasing the investment and strength in the cultivation of social creativity, and improving the treatment of innovators. At the same time, an innovative country needs an innovative environment. Under the influence of this environment, the national innovation consciousness and ability will be greatly enhanced.

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