Innovation and Economic Inequality——An Observation from the Global Innovation Index

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ABSTRACT
Innovation is widely acknowledged as an important propeller of economic development. However, innovation may not be the elixir for extreme contrast in wealth among different countries, and it might even exacerbate inequality. Using economic data of 128 countries from the World Bank and the Global Innovation Index, this paper observes severe inequality and a high threshold among different countries regarding innovation capability, innovation sustainability, and IP profiting. This also discusses the shortcomings of the GII index and the relationship between innovation and economic growth.

Keywords: *Innovation, Economic Growth, Global Economic Inequality, IP Protection, Global Innovation Index*

1. INTRODUCTION

Innovation has long been referred to as the "first and foremost power of economic growth". "Innovation", or "technological growth", is believed to be the root cause of long-term economic growth in both classical growth models and new economic growth models. As a result, governments worldwide have strived to stimulate the economic innovation capacity of nations. However, there are huge gaps between different countries regarding innovation capacity. Rich nations are often the head starters and leaders in innovation. Their technological advantages and institutional completeness are far beyond the reach of following-up countries. At the same time, these rich countries are also utilizing their advantages, often reflected on the numbers of patents and the strength and popularity of their products, to make more profits than the late developing countries, and rich countries can, in turn, reinvest more money into research and development (R&D) and gain more advantages on technology. This cycle is widening the gap between head starters and late developing countries and will result in global economic inequality. This article tries to figure out how elements of innovation capability impact economic development, how might these impacts work differently across countries, and how the gaps might be shortened.

2. LITERATURE REVIEW

Previous studies have shown many characteristics on the topic of innovation and economic and technological growth.

2.1. Extreme Inequality Exists in Global Economic Levels——Theoretical Approaches

Zhu (2002) analyzes the imbalances in the current world economic development: a) extreme poverty exists due to unfair distribution of profit in global development, and rich countries like the US and UK refuse to provide the minimum internationally agreed level of financial aid. b) internal inequality exists among rich and poor countries also exists: US is increasing its advantage against the EU and Japan, while China and India are leading the developing nations, but the South-South cooperation is developing slowly due to conflicts of interest and limitations of the technological capacity of developing countries themselves. c) the emergence of financialization makes the economy partly disconnected from the real sector [1]. Therefore, bubbles are easier to appear and more dangerous as most capital goes to speculative activities. Financial elites in rich countries are absorbing the world's wealth through financialization. Also, the strengthening of IP protection by technology leader countries is weakening the "diffusion effect" of the new economy, further stratifying the world in terms of technological capability.

Guo and Chen (1998) analyze the imbalanced growth situation in the world by the Growth Pole Theory and the

Circular Cumulative Causation Theory by Myrdal [2]. The authors acknowledge the existence of global economic inequality and claim that Perroux and Myrdal's theories were correct and are beneficial for economic development. The prerequisite for growth in this model is having governmental policies make the diffusion effect of fast-growing regions overcome the backwash effect (the adverse effect of the core region attracting people and economic activity away from peripheral areas and suppressing the peripheral areas from growing).

2.2. Roles of Innovation on Economic Development Differentiated——Empirical Evidence

2.2.1. National Differences

Niu and Zhao (2021) compare innovation policies in the US, Japan, and the EU and suggested that Chinese firms have a weaker technological base compared to Western countries [3]. Their research presents an important notion that huge differences exist between the innovation patterns among technology leading countries and their "followers". The followers can catch up only via building a similar innovation environment as in leading countries to maximize growth. Though it is growing fast on innovation, there are only a few top-ranking firms actively doing R&D and innovation. Also, China don't have a well-developed system of technological transfer. They suggest that the Chinese government should pass laws to encourage and build a complete innovation environment and integrate the relationship between firms, universities, and financial intermediates.

The research above shows that in developing countries, the action of innovating is only taken by a few firms, and an innovative atmosphere is not yet built. Therefore, governmental policy is needed for encouraging innovation actions.

The international technological transfer is a common way and good opportunity to reduce the gap between technology leaders and followers. However, Zhou and Zhang (2011) claim that economies with independent innovation abilities benefit significantly more from a stricter IP protection system [4]. They also conclude that undertaking countries in international outsourcing is inversely related to financial market efficiency: the higher the financial market's efficiency, the slower the undertaking country advances technologically. These all show that rich countries are building technology thresholds and increasing the global inequality in technology by outsourcing lower-end manufacturing and developing higher-end ones. At the same time, rich countries are using the financial market to extract funds from the global market to enhance the development of their high-tech firms.

2.2.2. Regional Differences

Tang, Zhang, and Peng (2019) use data in China and the Cobb-Douglas Model to measure the contribution to economic development by fixed capital investment, employment, and patents [5]. Their study shows that the IP protection and innovation policies greatly stimulated the Chinese economy. However, regional inequality existed in terms of such contribution, and the effect of the innovation policies was more significant on mid-west provinces that were initially underdeveloped. Their result is consistent with the "catching-up effect" in underdeveloped countries: after receiving technological or financial aid, they often see a high economic growth quickly, creating a converging trend with developed countries in terms of economic performance. However, it remains unclear whether the converging trend can sustain itself.

Cheng (2019) studies the triangular relationship between IP protection, technological growth, and economic growth. From his regression of economic growth (GDP) data in China on several variables (IP protection, technological growth, labor, capital, foreign investment, and economic openness), he conclude that IP protection is significantly correlated with patent numbers and technological growth, which in turn improves GDP growth in China [6]. His claims that intellectual property protection might positively impact GDP growth via the transition of technological growth (patent numbers). He also finds that in more (economically) developed regions, IP protection and technological growth have a weaker impact on economic growth, whereas in poorer regions such impact is stronger.

Breau and Bolton (2014) present data from Canadian Cities and show that cities with higher innovation levels have an unequal income distribution. They urge for an equal distribution of innovation profits so that the innovative society can sustain longer without exaggerating social conflicts [7].

These researchers describe the fact that the impact of innovation is different between regions: the impact of innovation is less visible in prosperous regions than less prosperous ones. This reflects the “catching-up effects” or the “convergence”.

2.3. The Impact of IP Protection Policies——Theoretical Analysis

Kou, Li, and Shao (2021) challenge the traditional claim that strengthening IP protection in countries in the (political) South will benefit the northern countries because southern countries will no longer be able to save money in getting advanced technologies from northern countries, which can make more profit out of their technological advance [8]. They claim that if Southern countries have weak IP protection, countries in the North

will refuse to introduce advanced technology in an earlier stage but will tend to introduce some traditional technology first and secure the future profit of advanced technology. They also claim that firms in the North should not make whether owning advanced technology their private information, such information asymmetry will reduce the will of countries in the South to strengthen IP protection. They propose a "reversed U-shaped" function to represent the relationship between desired strength in IP protection and southern countries' ability to imitate.

Liu (2011) discusses an extended endogenous growth model on late-developing countries' technological growth models [9]. He claims that independent R&D investment is positively correlated with technological growth, and such investment (as well as the growth rate of technology) are both in "reversed U shape" with IP protection strength. That means a certain level of IP protection is necessary for late-developing countries, but a very high level of IP protection is not beneficial to late-developing countries, as their weak R&D capability will hinder their speed in technological growth. Increasing IP protection is beneficial for technological leader countries and increases the patent obstacles for late-developing countries. He claims that late-developing countries like China should keep their IP protection level at a suitable level until they have a higher technology level and independent R&D capability.

Qu (2016) also claims that an optimal IP protection strength exists, determined by various elements such as technological gap, imitation capabilities, proportion of imitative technology. She argues that a moderate level of IP protection is beneficial for the cumulation of human capital in the R&D department and can help the nation fully release "innovation system dividends" [10].

2.4. Summary

The above studies give a relatively comprehensive depiction of the world economic and technological inequality and the role of innovation in such phenomenon. However, there lacks a comprehensive international-level analysis in how innovation threshold is built and then enhanced the inequality of economic growth and technological growth and how effective the conventional index measures the influence of innovation on the economy, which this paper is trying to address.

3. DATA AND METHODOLOGY

This paper uses data from the World Development Indicators from the World Bank. This dataset includes a variety of indicators in the past decades: GDP, GDP per capita, numbers of resident and non-resident patent and trademark applications. Data were retrieved from the World Bank's World Development Indicators. The conventional measurement of the innovation capability of countries is given by the Global Innovation Index. All Data were retrieved in March 2023.

The main methodologies were regression and statistical visualization of data.

4. RESULTS AND DISCUSSION

This part tries to give a comprehensive description of international inequality in innovation capabilities and technological thresholds. It also discusses the credibility of the conventional innovation index and the effort to reduce inequality via aids.

4.1. Discovering Inequality and Thresholds

Rich countries are head-starters and are often among those first-generation industrialized countries. These countries have accumulated considerable amounts of wealth in the process of industrialization. They have developed for a longer time than countries that started industrialization later. The main difference in our discussion between first movers and trailers is that the first movers are often the definers of the environment and the leaders of technology. Tech-leaders often have the following characteristics: 1) huge investment in research and development in terms of human and financial resources. 2) A larger number of patents and technological properties brings these countries considerable income by selling those patents to other users. 3) Because of their good foundations of innovation and technology, these tech-leader countries are more likely to be stronger innovators, which means they are more likely to produce more innovations.

Table 1 International R&D Shares. *Source:* ANBERD database, OECD.

Country	R&D shares 1991	R&D shares 2005
US	45%	35%
Japan	20%	15%
Germany	11%	7%
France	6%	4%
UK	5%	4%
China	1%	8%
Other	12%	28%

Table 1 shows that technology leaders have huge advantages on total R&D shares around the world. For example, the United States occupies around 40% of the world's R&D shares, whereas all developing countries only occupy less than 15%. Such inequality in research investment leads to but one outcome: technology leaders will never cease getting farther and farther ahead, where trailers will see a great divergence between themselves and the leaders. Something like "snowball effect". Table 1 shows that from 1991 to 2005, the developing countries are occupying more and more in the world share of

research and development investment, meaning that developing countries are starting to catch up on research activities. Though it does not follow that these countries will eventually manage to catch up, a converging trend between leaders and trailers is a positive signal.

In addition, the R&D advantages often convert into patent outputs. In general, higher investment means more patent numbers output each year.

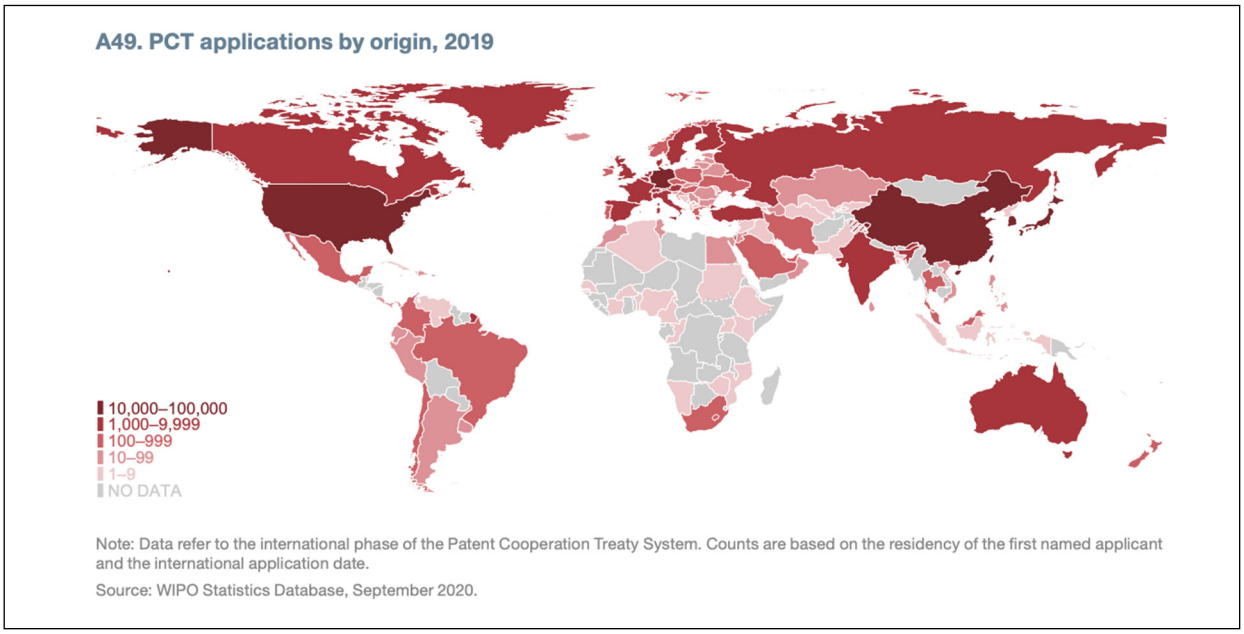

Figure 1. Patent Cooperation Treaty System Application by origin, 2019. *Source:* WIPO Statistics Database, September 2020.

Figure 1 shows the average number of patent applications by country. Generally, developed countries, rich countries, and countries with better economic performance do better in this statistic, whereas poorer countries in middle Asia, southeast Asia, Africa, and Latin America do significantly worse. This figure implies that rich countries are creating more patents and building a higher technology threshold. This trend is worrying as it would be more and more difficult for trailers to catch up.

In terms of patent number growth rates, data show that developed countries are generally growing steadily. On the other hand, trailer countries often have high growth rates. The fact that developing countries in Asia and Africa have relatively high growth rates is good news, whereas countries in South America are not doing as well as their African and Asian counterparts is relatively worrying.

Rich countries have a highly profitable system based on their advanced innovation and patent system: they charge foreign users a huge amount of money on accessing their patent products.

However, Rich countries are also more likely to spend more money buying patents from other countries in their production processes: as the players in a strictly protected IP system, players have to pay the price to stay in the game.

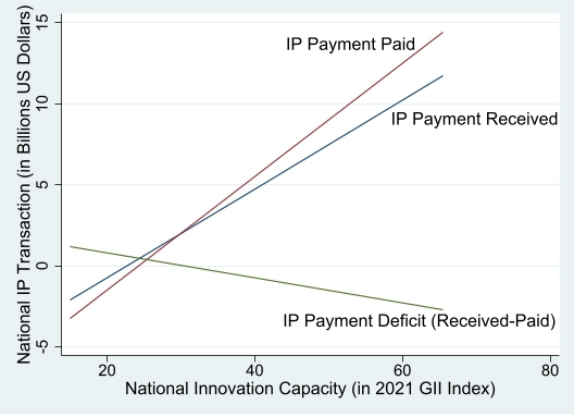

Figure 2. Trend Line of IP Transactions Countries of Different GII Index Values. *Data Source:* GII Index & WIPO Statistics Database, Retrieved March 2023.

Figure 2 shows that countries with higher innovation index values tend to pay and receive more money on IP payments. However, as index values increase, the "IP payment deficit" (IP profit minus cost) increases, making it harder for poor countries to further increase innovation capability. This graph above indicates the diverging trend on innovation: only rich countries are capable of more innovation and by affording a larger IP payment deficit as they advance the innovation capacity ladder. On the other hand, countries with weaker financial situations would find it harder to do the same, and here lies the threshold of innovation.

4.2. The Impact of Innovation

A few simple data explorations examine the relationship between the GII index, which represents countries' innovation capabilities, and their respective economic conditions.

The GII analysis data since 2013 show positive correlation coefficients between GDP and GII index at about 0.3, as well as GDP per capita and GII index about 0.7. A high wealth level is closely correlated with high GII ratings because of several reasons: a) the innovation environment in rich countries are more pervasive and encouraging, shown by a larger number of innovating firms and a higher GII rating of government-industry-university cooperation strength. b) Technology basis and human capital level of the labor force on average in these countries are generally higher. c) Higher investment on R&D (both from the government and the private sector) increases the chance of realizing innovative ideas. d) A more sophisticated financial market means a better chance of fundraising and relative easiness of starting new businesses. e) A higher GDP per capita means a wealthier consumer population and a welcoming market for new products, meaning a higher possibility of innovative products to become financially sustainable.

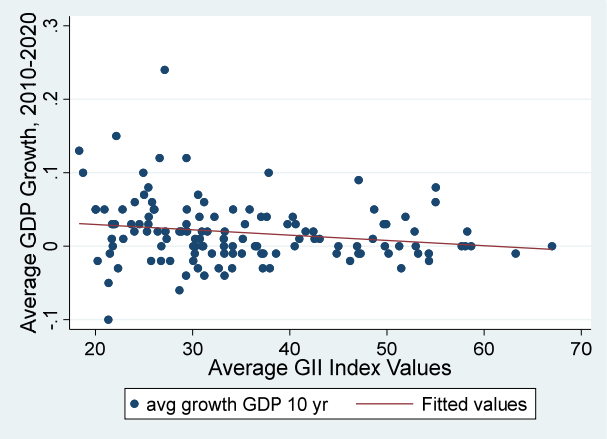

Figure 3. Average GDP Growth of Countries with Different GII Values in the Last Decade. *Data Source:* GII Index & WIPO Statistics Database, Retrieved March 2023.

Figure 3 shows the average GDP growth goes down as innovation capability goes up, though with considerable variations among countries. This reflects the theory described in the classical economic models that rich countries have reached their "steady states" and may have a lower GDP growth rate than developing countries. Besides, the classical models also predict a "positive investment shock" might reduce the economic output and consumption in the short run. Though the economy will return to a higher steady state level of output in the long run, it is still costly for a developing country to heavily invest in innovation in the short run. The lack of imminent financial incentive is the main reason that developing countries might find it difficult to invest for innovation. Therefore, it remains a question whether poor countries, on average, really have any chance to breach the threshold on their way to converging towards the rich countries.

4.3. The Effectiveness of International Aids

Because of the dire contrast between technology leaders and trailers, international aid has been one of the most widely used methods of decreasing the divergence between technology leaders and trailers. The graph above shows the impact of the net (aid received minus the interest paid) official development assistance fund granted to a country on the innovation index of that country (Data show that countries ranking higher were less likely to receive aid, whereas countries with lower ranks were more likely to receive aids).

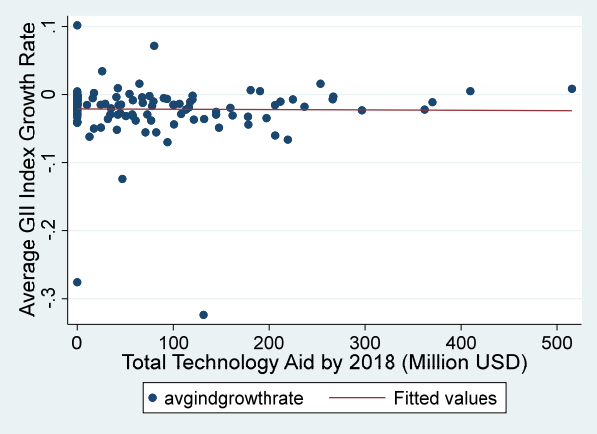

Figure 4. Average GII Index Growth Rate, 2017-2021 vs. Total Technology Aid in Million US Dollars by 2018. *Data Source:* GII Index & WIPO Statistics Database, Retrieved March 2023.

Figure 4 shows that the trend between aid received and index growth is unclear. A few countries receive high development assistance but still perform badly in terms of innovation strength growth. The general trend of the GII growth rate is also below zero, showing an overall decreasing trend of the GII index. The underlying problem might include that the fund was not distributed fairly and efficiently enough and wasted in corruption, excessive administrative costs, or other irrelevant programs. Also, assistance in the form of funds is not the most efficient way in increasing the innovation strength of countries because for the innovation environment to be improved, the overall business environment must be improved, and government policies should also be adjusted to be more friendly. In most cases, innovation is not entirely a matter of money.

4.4. On the Global Innovation Index

The Global Innovation Index is the measure of innovation capability by countries. This index is

measured by a series of criteria measuring innovation input and output. The input score measures the easiness to invest, innovate, start businesses in a country, whereas the output score measures the friendliness and strength of a country to export and trade their innovative products and make a profit. However, the innovation index is somewhat flawed in that the total index is calculated as the mathematical average of the input and output scores, which is in many cases not a good depiction for a universal interpretation of innovation pattern.

Moreover, the GII is also not perfect in that many countries are not on their list, and most of those countries are underdeveloped countries and poor countries. This means the lowest-tier countries were excluded from the global innovation environment. Such selection might be the best way to produce a viable statistic report, but it is never the best way to help reduce the inequality in global innovation.

5. CONCLUSION

Overall, there exist significant inequalities in innovation strength and economic growth among countries. Tech-leaders are occupying larger shares on innovation investment and patent growth and are building thresholds via IP protection policies. Data also show that innovation indexes are correlated more with GDP per capita level and less with short-term GDP growth, making it a difficult decision for poor countries to catch up at a price of short-term economic performance. Other than that, international aids aiming to help countries improve innovation strength have not shown as significant an impact as intended. Finally, the conventional way of calculating and ranking innovation capabilities of countries might be inaccurate in revealing the truth. With various problems lying along the way, constant and consistent international effort is needed in creating a better global innovation environment.

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