Can Innovation Input Help Reduce the Income Inequality in China? — An Analysis Based on Panel Data of 21 Provincial Regions

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***Abstract*—Innovation has long been discussed as the driving force of income inequality, while the empirical results are mixed, and few studies focus on the role of innovation input. By using the panel data of 21 provinces in China, this paper analyzes the impact of the innovation input on income inequality. A robust negative relationship between innovation input and income inequality is supported by empirical results, which indicates that innovation input can help reduce income inequality in urban areas and is greater in provinces with a lower unemployment rate. While the income level of each province does not have a statistically significant mediating effect. Besides, the empirical evidence also suggests a prediction effect, where the innovation input of last year can narrow the income gap in the next year.**

***Index Terms*—Innovation input, innovation, income inequality, R&D.**

I. Introduction

Income inequality has always been a critical problem, especially for developing countries since it would hold back economic development [1] and lead to social instability [2]. China, as a representative developing country, has also been trying to solve this problem for years. Since the reform and opening up in 1978, China's economy has developed rapidly, the level of people's income has been greatly improved, and the per capita income has also begun to enter the ranks of upper-middle-income countries. However, this does not mean that everyone gets the benefits brought by rapid economic development, and some people are still in poverty. According to the data from the National Bureau of Statistics, the Gini coefficient of China has always been above 0.4 from 2003 to 2017, which means income inequality is still a concern.

Meanwhile, the innovation investment, which has been stressed by the Chinese government for the sake of technology development in recent years, has come into view. In 2012, China's innovation investment accounted for 1.98% of GDP, exceeding 1.96% of Europe for the first time. By 2018, the R&D investment of enterprises in China has exceeded 2% of GDP. More and more enterprises benefit from the state's investment in innovation, which also drives the development of many regions. Although there is no consensus on the role of innovation in explaining income inequality, many studies still attribute the widening wealth gap to the development of technology. However, few studies pay attention to innovation investment. Now that the innovation investment can undoubtedly affect the long-term economy, it should be taken into consideration whether the innovation investment would have an impact on income inequality in China.

This article aims to identify the impact of innovation input on income inequality in China. Despite most previous research about the wealth gap only focusing on one province or national level, this article can provide a more specific perspective by using the panel data of 21 provincial regions from 2010 to 2015. The finding of this paper not only extends the influence factor of the wealth gap in China but also helps to put forward the countermeasures to alleviate income inequality.

The rest of this paper is constructed as follows: related literature is provided in section 2. Section 3 presents the sample and models used in this research. Then section 4 gives a detailed discussion of the empirical results. Section 5 concludes.

II. Literature Review

A. Innovation Input and Innovation

Although few attempts have been made to directly link innovation input with income inequality, the relationship between innovation input and output has long been discussed. There are many types of innovation inputs, including human capital, patent protection, R&D spending and so on, and some literature concentrate on only one aspect. For example, Zhou and Luo (2018) [3] analyze the role of higher education input and reveal that this kind of input is the driving force of technological innovation. While similar research of Xia *et al*. (2021) [4] examine the performances of industry-university-research cooperation (IURC) and argue that there is an inverted U-shaped relationship between innovation talent input and the effectiveness of IURC.

However, the one that has attracted the most attention from researchers is the role of R&D. The R&D expenses not only lead to a higher level of specific innovation activities, such as patent and new-to-market sales [5], [6] but also has been proved to have a generally positive effect on innovation [7]. For the studies based on the data of China, many of them find that in-house R&D plays a significant role in industrial innovation [8], [9]. In another related literature, Guo *et al*. (2016) [10] indicate that manufacturing firms with government-subsidized R&D outperformed those without subsidies in China. While opposite results are also shown in some studies. For instance, Wu *et al*. (2020) [11] claim that R&D capital investment is negatively correlated with firms' performance in the present time, despite there being a positive influence in the later period. But no matter the empirical results suggest a positive or negative relationship, there is no

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denying that innovation input plays an essential role in innovation. This study aims to investigate the impact of innovation input on income inequality, thus relevant literature about the innovation-inequality nexus should also be discussed.

B. *Innovation and Income Inequality*

Numerous studies have analyzed the positive impact of innovation on income inequality. Law *et al*. (2020) [12] study the effect of innovation in developed countries and suggest that innovation aggravates income inequality instead of narrowing it. Asamoah *et al*. (2021) [13] also indicate that innovation plays an important role in widening the income gap, especially for those high-income countries. A similar result can be found in the study of Aghion *et al*. (2019) [14], where they state that innovation can cause top income inequality. Besides, Guo (2019) [15] examines the relationship between innovation and income inequality in Chinese city regions. Rather than pointing out a simple positive relationship, he concludes that there is a non-linear relationship, that is, the income inequality within city regions will increase first and then falls as innovation improves.

Among the literature that researches the impact of innovation, many of them focus on some specific dimensions of innovation, such as patent protection. Chu (2010) [16] claims that the reinforcement of patent protection can lead to an increase in income inequality by raising the return on assets. This conclusion is confirmed by Chu and Cozzi (2018) [17]. But besides the effect of patent protection, they also observe an opposite impact of R&D subsidies, which can help reduce income inequality. Undoubtedly, the role of R&D is far from negligible when talking about innovation, even though the samples and methodology are different, many studies assert that the investment and incentives of R&D and its spillover effects need to be responsible for the widening income inequality [18]-[20].

While there is also much reverse empirical evidence. By using panel data for 29 countries, Benos and Tsiachtsiras (2019) [21] argue that innovation can reduce personal income inequality. Likewise, Abolfazl and Sara (2013) [22] indicate that better income distribution is usually found in those countries with more support for innovation. Contrary to some of the previously mentioned literature, the importance of R&D in narrowing income inequality is also verified [23]. More specifically, Featherstone (2021) [24] suggests that the Gini coefficient decreases by 2.72 % for every additional 1% of GDP spent on R&D.

Admittedly, different types of innovation can lead to different impacts on income inequality [25]. But theoretically speaking, innovation can take either a positive or negative sign [26], while it depends on some conditions. Adrián Risso and Sánchez Carrera (2019) [27] argue that the positive impacts of innovation on income distribution would occur when innovation is above a threshold value of 0.10% of GDP. Other literature believes innovation would cause the wage differential among skilled and unskilled labours and consequently lead to income inequality [18], but a strong spillover effect of R&D may avoid this wage differential [28]. However, Hornstein and Krusell (2003) [28] fail to find out how strong such spillovers are. In later studies, a more clear mechanism of how unskilled or less skilled labours would not be affected by technological change is illustrated by Iacopetta (2008) [29]. This author suggests that rapid technological change may not result in income inequality since the technological change can lower the price of equipment so that less skilled labours are able to employ sophisticated technologies. Likewise, Antonelli and Gehringer (2013) [30] also corroborate that innovation can reduce income inequality when there is rapid technological development since technological change raises total factor productivity and labour productivity, which increase the saving level and consequently lower the interest rate. Thus, income inequality is reduced due to the decrease in income gains from wealth and higher wages from the increase in labour productivity.

However, no doubt there is no consensus on the innovation-inequality nexus. By constraining the context of China, this paper contributes to linking innovation input with income inequality.

III. Methodology

This paper selects the sample of 21 provincial administrative regions in China from 2010 to 2015, including Beijing, Hebei, Inner Mongolia, Liaoning, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Henan, Hubei, Guangdong, Guangxi, Hainan, Sichuan, Guizhou, Xizang, Shaanxi, Ningxia and Xinjiang. These original data all come from the statistical yearbook of each province.

To measure the impact of innovation input on income inequality, we use a set of OLS regressions as follows:

$$Gini\ Coefficient_{it} = \beta_0 + \beta_1 EXRD_{it} + \beta_2 X_{it} + \eta_t + \varepsilon_{it}$$

where *i* and *t* denote the province and the year respectively. The term η_t is the year fixed effect.

The income inequality is measured by the Gini coefficient. Considering the urban-rural dual structure in China, this paper only selects the disposable income of urban residents to study the income distribution effect. The Gini coefficient after tax of urban residents in each province is calculated based on the data of per capita disposable income of urban residents in the statistical yearbook of each province. In some provinces, the ninth or seventh class groups are weighted to be fifth class groups. This paper classifies the income of individual income tax into three parts: first, the tax amount of wage and salary income; second, the tax on business income includes income from production and operation of individual industrial and commercial households and income from contracted or leased operations of enterprises and institutions; third, other income (tax amount of other income items except the first two categories). To avoid the influence of multicollinearity on the empirical results, and according to the consideration of data stationarity, this paper takes the logarithm of different types of tax as the core variable.

The core independent variable is innovation input, which uses the intramural expenditure on R&D of research institutes as a proxy. X_{it} are the set of controls, including the level of urbanization, the level of economic development, unemployment rate, the degree of marketization and the per capita disposable income of urban households as control variables for the regression model. These control variables are developed based on the work of Feng and Wu (2019) [31]. The level of urbanization is the proportion of the urban population to total population; the level of economic development is denoted by GDP per capita (trillion yuan); while the unemployment rate (%) and the per capita disposable income of urban households are from the statistical yearbook directly; the degree of marketization uses the proportion of the added value of the tertiary industry in the GDP. Table I shows the summary statistics for the whole sample.

TABLE I: DESCRIPTIVE STATISTICS OF VARIABLES

	Mean	Median	Min	Max	SD	N
Gini coefficient	0.29	0.28	0.23	0.43	0.03	122
Intramural expenditure on R&D (trillion yuan)	0.01	0.00	0.00	0.07	0.01	126
Level of urbanization	0.54	0.51	0.23	0.90	0.15	126
Level of economic development (trillion yuan)	0.00	0.00	0.00	0.00	0.00	126
Unemployment rate	3.27	3.35	1.20	4.40	0.68	126
Degree of marketization	0.02	0.01	0.00	0.05	0.01	126
Per capita disposable income of urban households (yuan)	24000.76	23001.00	13189.00	52962.00	7197.33	186

TABLE II: ESTIMATIONS OF OLS REGRESSIONS

	(1)	(2)	(3)	(4)	(5)
intramural expenditure on R&D (trillion yuan)	-1.292***	-1.359***		-1.331**	-2.350***
	(0.243)	(0.286)		(0.557)	(0.637)
the intramural expenditure on R&D of last year (trillion yuan)			-1.486***		
			(0.349)		
per capita disposable income of urban households (trillion yuan)				524619.756	
				(415722.654)	
intramural expenditure on R&D × per capita disposable income of urban households				9685489.696	
				(1.456e+07)	
unemployment rate					-0.027***
					(0.008)
intramural expenditure on R&D × unemployment rate					0.569**
					(0.255)
level of urbanization	-0.095***	-0.108***	-0.120**		
	(0.036)	(0.040)	(0.046)		
level of economic development (trillion yuan)	1111335.085***	1091737.484***	1180980.175***		
	(349886.261)	(270180.136)	(289975.895)		
unemployment rate	-0.017***	-0.018***	-0.020***		
	(0.004)	(0.006)	(0.007)		
degree of marketization	0.246	0.185	0.066		
	(0.223)	(0.254)	(0.284)		
per capita disposable income of urban households (trillion yuan)	-1.177e+06*	-605085.633	-642263.677		
	(666064.009)	(544349.047)	(588836.860)		
Province Fixed Effects	No	Yes	Yes	Yes	Yes
Observations	122	122	102	122	122
Adjusted R^2	0.289	0.309	0.322	0.103	0.284

IV. EMPIRICAL RESULTS AND DISCUSSION

A. Baseline Regression

In Table II, column (1) presents the baseline regression and column (2) shows the model that controls for year fixed effect. The coefficients of R&D expenses of the two models are both negative given the significance level of 1%, which indicate that an increase in innovation input can reduce income inequality in urban areas. This result could be explained by the conclusion of Antonelli and Gehringer (2013) [30], where they claim that innovation can narrow the wealth gap if technological development is rapid. Meanwhile, China is such a country with rapid technological development. According to the IP5 statistics reports, China has always had the highest number of patent filings worldwide from 2010 to 2015 (Fig. 1), and the worldwide patent granted is also among the highest (Fig. 2). Although theoretically more innovation input cannot be equal to more innovation, some empirical literature has already proved a positive relationship between innovation (like increase in the patent) and the input effect of R&D [32], [33].

Apart from the negative sign, an increase in the coefficient of R&D expenses is witnessed in column (2). One of the reasons could be the fixed effect, like national policies, which may vary over time but do not change across provinces. Because Chinese provinces do not like states in the US, they must obey the policies of the central government, it is likely the national policies could be an omitted variable. Besides, to account for heteroskedasticity and serial correlation of standard errors, the second model also clustered the standard errors in the regression.

B. Prediction Effect

The models in columns (1) and (2) only consider the effect of R&D expenses on the Gini coefficient of the same year. However, this expenditure may have a lagged effect or prediction effect, which means the intramural expenditure on R&D of last year may have impacts on the Gini coefficient of next year. This effect is crucial when making policy decisions in real life. By generating a new variable of the intramural expenditure on R&D, the model can estimate the prediction effect of the intramural expenditure on R&D on the Gini coefficient. As can be seen in column (3), the impact of R&D

expenses is greater than that in baseline regression and fixed effect regression, in other words, the intramural expenditure on R&D of last year has a greater effect on income inequality in urban areas. When there is an increase of one standard deviation in the intramural expenditure on R&D, the Gini coefficient will decline by approximately 0.519 on the significance level of 1%.

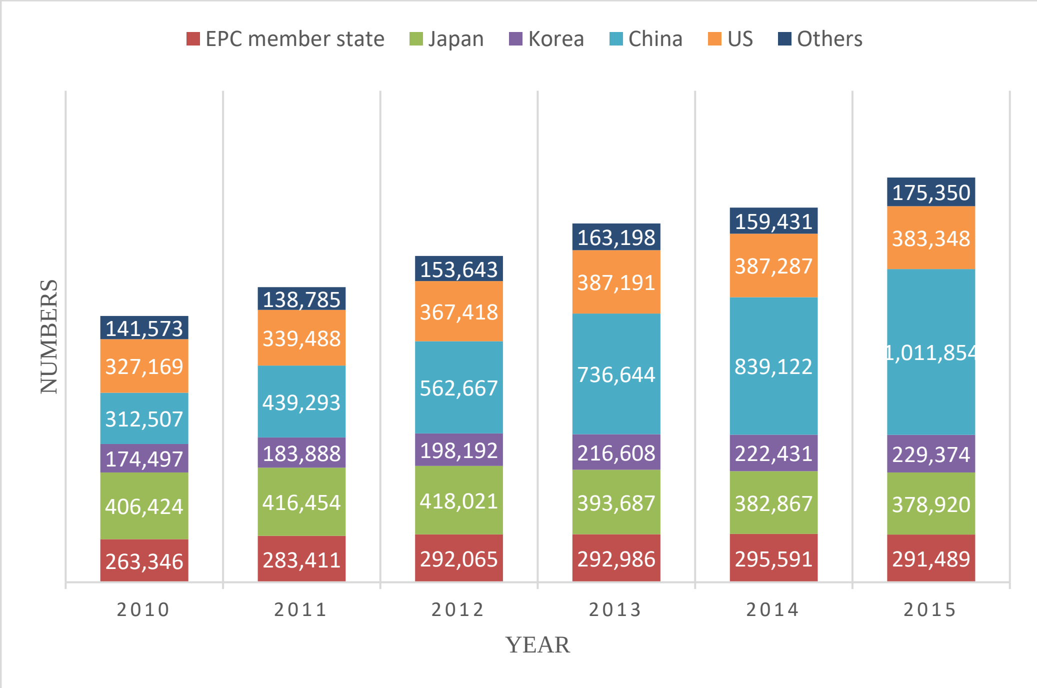

Fig. 1. Worldwide patent filings-origin. Source: IP5 statistics reports.

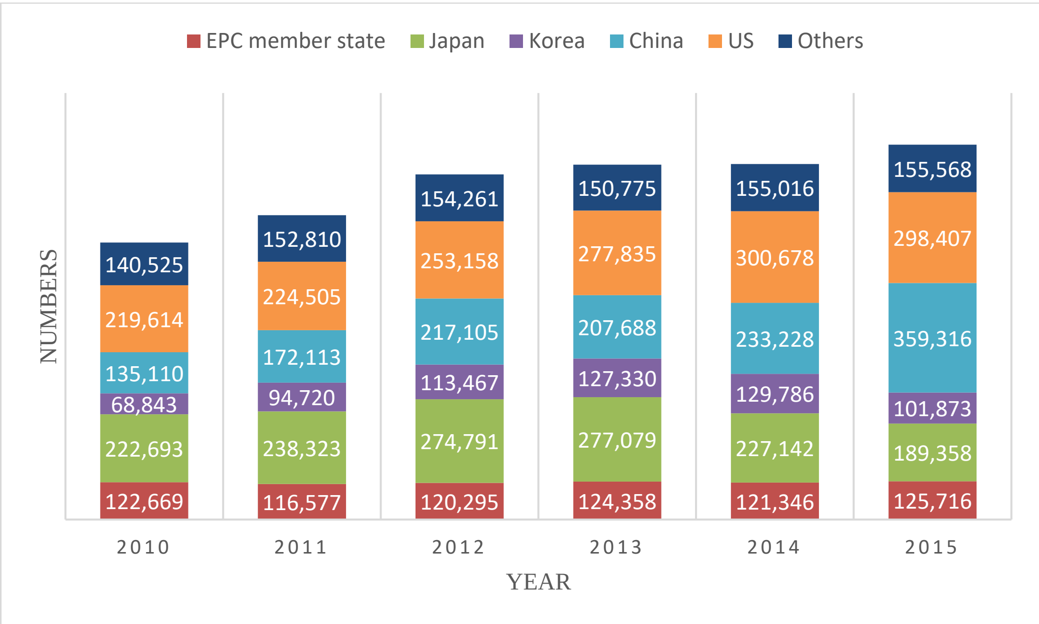

Fig. 2. Worldwide patent granted-filing bloc. Source: IP5 statistics reports.

Since innovation is a long-run process, it takes time from emergence to implementation. Firstly, as for technology, even though an organization received its R&D funds from the government and decided to invest in new technology, its products may still rely on the previous technology. Besides, the installation of new equipment also takes time. Secondly, despite that the organization invests a large amount of money to recruit talents or experts, it also needs time to find the best person.

C. Mediating Effect

The Gini coefficient is closely related to the level of income. It is likely that the R&D expenses may first affect the income level, which then affects income inequality. To figure out whether the effect of the R&D expenses on the Gini coefficient would increase with the level of income, an interaction term is generated.

From column (4), the interaction term takes a positive sign, however, it is statistically insignificant. This means that there may be no mediation effect of the income on the intramural expenditure on R&D. The effect of the intramural expenditure on R&D on the wealth gap is unrelated to the change in income. While this result may seem contradictory to the previous conclusion since income inequality is highly correlated with income level. If the R&D expenses cannot affect the income level, then it also cannot smooth the income gap. However, it should be noted that the income level here means the absolute level of income in each province, and it is not the comparative level between the rich and poor. More specifically, one province could have a relatively low per capita income level, but the wealth gap within this province may not be as large as other richer provinces. Thus, this empirical result presents that innovation input is less likely to affect income inequality through the absolute level of income in each province.

Based on this result, another model is constructed to test the mediating effect of a different channel with the R&D expenses, that is, the unemployment rate. According to column (5), the coefficient of the interaction term is positive at the significant level of 5%. This suggests that the impact of R&D expenses on income inequality is smaller in places that have a higher unemployment rate. One possible mechanism could be the accumulated human capital. Especially for certain workers, they learn skills when working, but unemployment will affect the accumulated experience that workers learn, which then causes wage differentials [34]. Hence, the higher the unemployment rate, the weaker the impact of the R&D expenses on income inequality.

V. Conclusion

With the rapid economic development in China, the problem of income inequality draws more and more attention. While many scholars assert that innovation should be blamed for widening income inequality. Nonetheless, whether improving the innovation input can help reduce income inequality is still under debate.

Under the situation of China, this paper quantifies the effect of innovation inputs on income inequality in urban areas, which is denoted by the intramural expenditure on R&D of research institutes and the Gini coefficient respectively. By using panel data of 21 provincial regions from 2010 to 2015, empirical results indicate a negative relationship between innovation input and income inequality. The innovation input not only reduces income inequality of the same year but also has a prediction effect for the decrease in the next year due to the lagged effect of innovation input. The mediating effect of income level and the unemployment rate is also analyzed. While the effect of R&D expenses on income inequality is unrelated to the income level of each province, but the unemployment rate does have a mediating effect on innovation input, where the impact of the R&D expenses is smaller in places with a higher unemployment rate. This is because some workers accumulate skills and experience during work, while unemployment can disturb this accumulation and cause wage differentials.

The mechanism of this negative impact of innovation inputs on income inequality could be complicated since many previous studies stated the technological change could lead to more severe inequality. According to the paper of Antonelli and Gehringer (2013) [30], the mechanism of the impact of technology can be separated into two. If the technological change is sporadic and slow, the innovation would benefit the innovator only due to the formation of an entry barrier. However, the situation in China is different, where the technological change is rapid. The rapid development of technology would increase labour productivity, and consequently, the level of savings grows. These savings create more available investment capital and make the interest rate decrease. Then, the decreased interest rate leads to a systematical distribution of income between the rich and the poor. Because the development of technology in China is fast and the innovation inputs continue climbing, the second mechanism overweight the first one. Therefore, the innovation inputs reduce the wealth gap in China. This paper is consistent with the conclusions.

However, several limitations of this paper should be aware. Firstly, due to the limited sample, this paper only examines 21 provincial regions in China for a six-year period. One could make the conclusion more convincing by using a larger sample of data. Secondly, the innovation input is measured by the intramural expenditure on R&D of research institutes, while future studies could include more indicators and examine the individual impact of each type of innovation input. Lastly, since a non-linear relationship is founded in the innovation-inequality nexus, it is likely that the relationship between innovation input and income inequality may be also non-linear. Thus, more studies are still needed to find out the exact relationship.

Conflict of Interest

The author declares no conflict of interest.

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