The Nonlinear Effects of Public Education Expenditure on Income Inequality: A Panel Threshold Regression Analysis of 31 Provinces in China

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Abstract-The impact of the scale of public education expenditure on income inequality is affected by many factors, and generally speaking, there is a nonlinear relationship between the two macro variables. This paper constructs a panel threshold model by using China's provincial panel data from 2007 to 2020 to examine the nonlinear relationship between education expenditure scale and income inequality under different income inequality levels. The results show that when income inequality is low, public education expenditure will narrow the income gap, while when income inequality is high, public education expenditure will increase the income gap. Therefore, in areas where the income gap is too large, the input of education resources should be biased towards the vulnerable groups, and the government should provide employment opportunities for the economically vulnerable groups, broaden the channels for obtaining employment information, and provide employment security, which is conducive to playing the role of education expenditure in narrowing the income gap.

Keywords-Public Education Expenditure; Income Inequality; Threshold Effects; Human Resources; Wealth Stock

1. Introduction

Income inequality is a universal economic phenomenon that exists in various countries and regions and has a vitally important relationship with the stable operation of the economy and people's welfare. A high level of inequality in income distribution means minorities in an economy have more wealth in society, which will lead to serious differentiation and confrontation between the wealthy and the impoverished, eventually affect social security and stability. Excessive wealth accumulation in the hands of the rich will also seriously weaken the total social consumption capacity, thus reducing the total social output, which is detrimental to economic development. The primary distribution mode dominated by the market mechanism is often ineffective in regulating the inequality of income distribution. Therefore, how to deal with the problem of income inequality is an important topic for governments of all countries and areas. Public fiscal expenditure is considered to have a major role in reducing income inequality because it is the most important means for the government to intervene in the market. Among them, the research on the impact mechanism of education expenditure on improving and curbing income inequality has long been a source of debate in the field of education economics.

There have already been many related research results. However, after sorting out the relevant literature, we find that there is still a different perspective from the previous research need to be

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further studied. Earlier literature has paid more attention to the impact of exogenous variables on the linear relationship between public education spending and income distribution, and recent researches mainly focus on identifying which exogenous factors lead to the nonlinear impact of public financial expenditure on income inequality， but has ignored that the real effect of public education expenditure is also influenced by the current situation of income distribution itself. And this paper is dedicated to clarifying how the current status of income distribution affects the effect of public education expenditure in narrowing the income distribution gap.

2. Literature Review

Relevant research about the relationship between education and income can be traced back to 1955, when Kuznets, a preeminent American economist, first made this view that the improvement of residents' education level will improve the inequality of income distribution [1]. The academic circle of social science began to pay attention to the relationship between education and income distribution. After Schultz and Becker (1963) put forward the human capital theory [2], the possible path of the impact of education expenditure on income inequality was revealed. According to the theory, knowledge reserve, professional and technical ability, personal health and conduct quality are different kinds of capital that can help a person create high wealth, so people from poor backgrounds can improve their education level by investing in education, reduce the difference in human capital between them and the rich groups as much as possible, so as to achieve the goal of improving income inequality in the future, and reduce the income gap between the wealthy and the impoverished. The government can provide more educational opportunities and resources for the middle and lower classes of society to improve their ability to obtain income in the future by increasing the investment in national education. Sylwest (2000) verified it from an empirical perspective, and proved that more investment in education resources is a powerful means to reduce the income distribution gap through the regression of international panel data [3]. However, some scholars put forward completely opposite opinion, such as Byron and Manaloto (1990), who believed that the increase in public education expenditure would result in an increase in income distribution gap [4]. Jimenez (1986) believed that poor residents could not benefit from the increase in education expenditure because of resource misallocation [5]. Chen Binkai, Zhang Pengfei, Yang Rudai (2010) [6] and Lei Genqiang (2012) [7] found through their research on China's empirical data that because China's public education expenditure is biased towards cities, education expenditure has widened the income distribution gap between urban and rural residents.

A more common perspective is that education expenditure and income inequality have a nonlinear connection. According to Knight and Sabot's (1983) theory, the expansion of education has both a structural influence and a compression effect within the context of the human capital mechanism. The structural impact of education expenditure will come first, which increases the size of highly educated groups, thus lead to an increase in income inequality. With the further increase of education expenditure, when the supply of a higher education labor force is higher than the market demand, these groups' earnings will decrease since the compression effect of school spending will outweigh the structural effect. At this moment, a certain amount of increased education expenditure will help to lessen economic inequality. [8]. Lai Desheng (1997) used transnational panel data to demonstrate that the impact of education expenditure on income distribution is related to the level of economic development. When the level of economic

development is low, the income distribution gap is widened, and when the economy develops to a high level, the income distribution gap is reduced [9]. Zhang Xiaofang (2021) believed that the relationship between the two depends on the level of government governance. When the government level reaches a certain threshold, increasing public education expenditure can alleviate the inequality of income distribution [10]. Through sorting out the previous literature, it can be found that the research conclusions are different due to the different years, regions and analysis models of the data selected by the research, but the theories based on the literature also have certain persuasiveness and practical significance, which can provide reference for practical decisions. The uncertainty of the relationship between education expenditure and income inequality also proves the complexity and diversity of the impact mechanism. Therefore, it is also necessary to constantly explore this field to improve relevant theories.

Based on a new perspective, this paper will investigate the relationship between education expenditure and income inequality under different income structures, explore whether the existing income distribution status in the region will affect the role of public education expenditure on the income distribution gap, and elucidate whether the relationship between the two is linear or nonlinear. It will be verified in the form of theoretical analysis and empirical analysis to fill the research gaps in this field.

3. Theoretical Analysis and Research Hypothesis

According to the analysis of human capital theory, we can draw a conclusion that improving the stock and quality of human capital of a specific group in a certain region can improve the overall earning capacity of the group and the economic development potential of the region. The investment in public education includes the cost of building schools; the cost of teaching infrastructure; the cost of teacher training; admission subsidies; etc. It is the main means of forming human capital. If public education funds can be more invested in economically underdeveloped areas with inferior teaching facilities and weak teaching staff, and education transfer payment to the poor can be increased considerably, the human capital stock of these poorer groups can be significantly improved, so as to narrow the human capital gap with the rich class, and reduce the ability to obtain remuneration between the two groups as much as possible, which ultimately plays a role in narrowing the income distribution gap.

However, in the impact mechanism, there are several important issues to be considered clearly. First, education expenditure may not benefit the economically disadvantaged groups to a greater extent. Many factors, such as different policy systems, the government's level of integrity, regulatory capacity, etc., can affect the effectiveness of education expenditure and the groups it ultimately benefits (Zhang Xiaofang, 2021) [10]. Second, the human capital is not only affected by public expenditure on education, but also by private investment in education. Families with large wealth stock will invest more in education, so that people from these families will have better personal quality and comprehensive ability, and are more likely to find high paying jobs in the job market. Besides, the marginal rate of return on education investment in the rich class will also be higher than that of other classes, especially the poor class. This is because the wealth owned by the rich class can provide resources that better match the promotion of personal human capital, for instance, they can easily obtain employment related resources and afford the high cost of job search, then fully play the role of income promotion brought by the promotion

of human capital. As a result, people from rich families will get a higher income increase than those from poor families. Therefore, when studying the impact of education expenditure on the income gap, it is necessary to consider the factors that affect the efficiency of education expenditure and the groups it benefits, as well as the factors related to the state of wealth distribution in different economic strata in the studied region.

This paper argues that the current situation of regional income inequality is a primary factor affecting the efficiency and effectiveness of financial expenditure on education. When the regional income distribution gap is too large, it means that compared to other class groups, the rich class group's families have much more wealth, which makes the rich class to invest more in private education and have a higher marginal rate of return on education. In addition, the large income gap reflects the low efficiency of government governance and intervention in the market. More education resources provided by education expenditure are concentrated in the hands of social elites, which is similar to the phenomenon of Elite Capture. In this case, public education expenditure will have a Matthew effect. With the increase of public education expenditure, income inequality will be aggravated. When the income distribution gap is small, it indicates that the gap between the wealth and soft power of each family in the region is small, and individuals can equally enjoy the benefits brought by public education expenditure. At this time, the marginal rate of return on education decreases with the increase of family wealth. That is, compared with families with strong economic strength, the same education expenditure will improve the quality of human resources of families with weak economic strength to a larger extent, and education expenditure will have a greater income effect on them.

In summary, this paper proposes the following research hypothesis:

H1: There is a threshold effect of public education expenditure on income inequality. When income inequality is low, public education expenditure will reduce income inequality, and when income inequality is high, it will increase income inequality.

4. Model specification and data source

In order to verify the correctness of the theoretical analysis, this paper uses panel data from 31 provinces in China from 2007 to 2020 to build a threshold regression model to study the nonlinear relationship between public education expenditure and income inequality. We take the single threshold model and double threshold model as examples, and the specific forms are as follows:

Single threshold regression model:

$$\mathrm{LNGINI_{it}} = \beta_0 + \beta_1 \mathrm{GEDU_{it}} \cdot \mathrm{I(GINI_{it} < \gamma)} + \beta_2 \mathrm{GEDU_{it}} \cdot \mathrm{I（GINI_{it} > \gamma）} + \theta \mathrm{X_{it}} + \varepsilon_{it} \quad (1)$$

Double threshold regression model:

$$\mathrm{LNGINI_{it}} = \beta_0 + \beta_1 \mathrm{GEDU_{it}} \cdot \mathrm{I(GINI_{it} < \gamma_1)} + \beta_2 \mathrm{GEDU_{it}} \cdot \mathrm{I（\gamma_1 < GINI_{it} < \gamma_2）} + \beta_3 \mathrm{GEDU_{it}} \cdot \mathrm{I（GINI_{it} > \gamma_2）} + \theta \mathrm{X_{it}} + \varepsilon_{it} \quad (2)$$

In the above two equations, the explanatory variable is the logarithm of the Gini coefficient, the core explanatory variable is the proportion of public education expenditure in GDP, and the threshold variable is the Gini coefficient. I is indicator function, γ represents unknown specific

thresholds. In the single threshold model, it divides the model into two parts, and in the double threshold model, the whole model is divided into three linear parts. ε_{it} is a random error term, X_{it} represents a set of control variables, including GDP per capita, urbanization level, public social security expenditure scale and public health expenditure scale, these variables are all related to explanatory variables and explained variables simultaneously. Among them, GDP per capita is a variable representing the level of economic development, according to the Kuznets curve, there is a certain nonlinear relationship between the level of economic development and the degree of income inequality. Therefore, it is necessary to introduce the variable of economic development level. GDP per capita is used to control the impact of demographic changes caused by changes in the total population on the degree of inequality. The level of urbanization is expressed by the proportion of the urban population to the total population. Research literature shows that the improvement of urbanization is conducive to narrowing the gap between urban and rural income distribution, which will indirectly affect the overall income gap of residents. Both of public social security and health expenditures have significant impacts on closing the income gap among residents because social security and health funds generally subsidize economically disadvantaged groups. So, they need to be controlled in regression analysis to reduce the estimation error caused by endogenous problem. This paper uses the ratio of public health expenditure to total financial expenditure and the ratio of social security expenditure to total financial expenditure to express their expenditure scale. The definitions, symbols, and values of variables are as follows:

Table 1 Definition of research variables

Variables	Symbol	Explanation
Explained variable	LNGINI	Logarithm of Gini coefficient of residents' income
Threshold variable	GINI	Gini coefficient of residents' income
Explanatory variable	GEDU	Ratio of public education expenditure to GDP
Control variables	LNAGDP	Logarithm of the ratio of GDP to total local population
	URBAN	Proportion of urban population in the total population
	HEA	Proportion of public health expenditure in total expenditure
	SEC	Proportion of public social security expenditure in total expenditure

The data of Gini coefficient of Chinese provinces used in this paper is calculated through the method proposed by Tian Weimin (2012) [11]. The specific steps are: first, calculate the Gini coefficient of urban and rural residents in each province by using the income data of urban and rural residents in the provincial statistical yearbook, then calculate the overall income Gini coefficient of the province according to the urban-rural decomposition method introduced by Sundrum (1992) [12]. The following is specific formula:

$$\mathrm{GINI} = p_c^2 \frac{I_c}{I} \mathrm{GINI}_c + p_r^2 \frac{I_r}{I} \mathrm{GINI}_r + p_c p_r \frac{|I_c - I_r|}{I} \quad (3)$$

In equation (3), p_c and $p_r$represent the proportion of urban and rural residents respectively, GINI represents the Gini coefficient of the overall income of residents in each province, GINI_c and GINI_r represent the Gini coefficient of the income of urban and rural residents respectively, I represent the income per capita of each province, I_c and I_r represent the income per capita of urban and rural residents respectively. The data about education expenditure, urban population,

GDP, health expenditure and social security expenditure is all from the China Statistical Yearbook from 2008 to 2021. The descriptive statistics of variables are shown in the Table 2:

Table 2 Data descriptive statistics

	Obs	Mean	Median	Std. Dev.	Min	Max
GINI	434	0.428	0.428	0.045	0.35	0.51
GEDU	434	0.043	0.036	0.023	0.018	0.168
LNAGDP	434	1.353	1.368	0.565	-0.243	2.798
URBAN	434	0.554	0.543	0.142	0.215	0.896
HEA	434	0.071	0.071	0.016	0.038	0.121
SEC	434	0.13	0.131	0.035	0.055	0.276

5. Analysis of Empirical Results

Next, this paper uses stata16.0 software to conduct panel threshold regression analysis on China's provincial panel data from 2007 to 2020. Before the regression analysis, we need to determine the number of thresholds. We estimate single threshold model, double threshold model, and triple threshold model, respectively. The obtained statistics, p-values, and critical values under the significance levels of "natural sampling" are shown in Table 3:

Table 3 Threshold existence test

Threshold test	F statistic	P-value	Critical value		
			1%	5%	10%
Single	595.53***	0.000	14.484	10.255	8.827
Double	284.26***	0.000	16.291	11.990	9.691
Triple	100.21	0.7567	241.127	215.225	194.415

The outcomes shown in Table 3 demonstrate that when the model is set as a single threshold model or a double threshold model, the p value of the corresponding model is 0.000, which indicates that the model is highly significant at the 1% significance level, while when the triple threshold model is used, the F statistic is not significant. Therefore, a double threshold model is required. The threshold value and its 95% confidence interval estimated by using the double threshold model are shown in Table 4:

Table 4 Estimated threshold variables

	Estimated threshold	95% confidence interval
γ_1	0.3874	[0.3869, 0.3874]
γ_2	0.4538	[0.4460, 0.4541]

It can be seen from the results in Table 4 that the model is divided into three intervals by two threshold values. Through the likelihood ratio function of threshold regression, we can know the process of threshold value acquisition and confidence interval construction. The dashed line

represents the approximation of the 95% confidence interval. Figure 1 shows the likelihood ratio function:

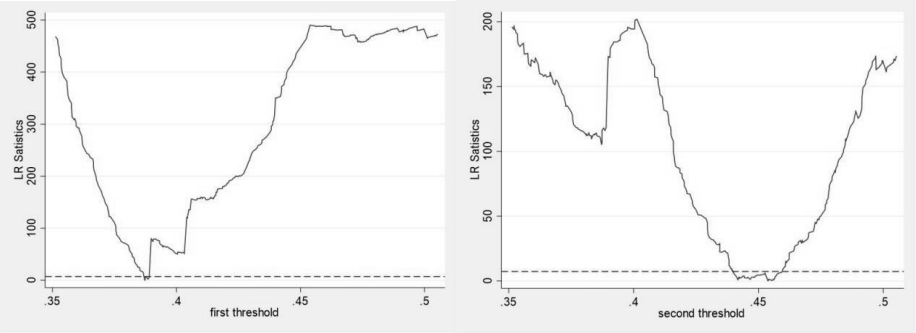

Figure 1. The likelihood ratio function graph of threshold model

Table 5 shows the regression results of the double threshold model and the regression results of fixed effects. Under the fixed effect model, the degree of income inequality in China's provinces is positively correlated with public education expenditure, with a coefficient of 1.6337, but only significant at the 10% significance level. From the results of the threshold regression model, we can know that due to the different degrees of income inequality, there are significant differences in the impact of public education expenditure on residents' income distribution. When the Gini coefficient is at a low level (less than 0.3874), the Gini coefficient decreases by about 4.03% for every 1% increase in the ratio of education expenditure to GDP; When the Gini coefficient is at a middle level (between 0.3874 and 0.4538), the impact of education expenditure on income distribution is not significant, and the coefficient value is also small. When the Gini coefficient is at a high level (greater than 0.4538), every 1% increase in the proportion of public education expenditure to GDP will increase the Gini coefficient by about 1.72%, and the coefficient value is significant at the significance level of 1%, but the positive correlation between the two is weaker than the negative correlation. Since the two thresholds are distributed at the two ends of the international warning value 0.4 of the Gini coefficient, it can be considered that when the regional income distribution gap is less than the first threshold, it is "reasonable", while when it is greater than the second threshold, it is "excessive". The regression result of the threshold model basically proves the correctness of the research hypothesis. That is, in the range with a low Gini coefficient, public education expenditure will further reduce the income gap, while in the range with a high Gini coefficient, public education expenditure will increase the income distribution gap.

Looking at the impact of non core explanatory variables on explained variables, we find that in the threshold model, GDP per capita and urbanization level have no significant impact. A possible reason is that GDP per capita and urbanization level measure overall economic development level and population structure, and their changes have little relationship with the distribution structure of residents' income. However, the impact of public health expenditure on the explained variables in the fixed effect model is negative, and it becomes positive in the threshold regression model, and the coefficient values have not passed the significance test, so it can be determined that the correlation between public health expenditure and income inequality is weak or uncertain. Only public social security expenditure has a negative effect on the degree of

income inequality, and it is significant at the 5% significance level, which is consistent with our expectations.

Table 5 Estimate results of the fixed effects and panel threshold regression model

Variables	(1)	(2)
	Fixed effect	Threshold model
GEDU	1.6337*(1.90)	-4.0298***(GINI<0.3874)(-7.73) -0.5915(0.3874<GINI<0.4538)(-1.15) 1.7238***(0.4538<GINI)(3.48)
LNAGDP	-0.0700*(-1.98)	-0.0353(-1.63)
URBAN	0.6682**(2.35)	0.1457(0.95)
HEA	-1.1418(-1.31)	0.4414(1.16)
SEC	-0.3996(-1.68)	-0.3078**(-2.02)
Constant	-1.0667***(-9.90)	-0.8571***(-14.39)
R-squared within	0.0271	0.7600
F-test	2.60**	179.19***
observations	434	434

Note: Significant at the level of 1%, 5%, and 10% is denoted by the symbols ***, **, and *, respectively. The figures in parentheses are t-statistics of each coefficient

6. Conclusion

This paper studies the nonlinear relationship between public education expenditure and income inequality by building a double threshold regression model using China's provincial panel data between 2007 and 2020. It is found that when the level of income inequality is within a reasonable range, public education expenditure will reduce the inequality of income distribution; when income inequality is high, public education expenditure will aggravate income inequality. When the degree of income inequality is between "reasonable" level and "excessive" level, the correlation between the two is not obvious. This result examines the income distribution effect of public education expenditure from the perspective of regional household wealth structure, indicating that the role of public education expenditure is also limited by private resources and wealth stock, which is also the main contribution of this paper.

Hence, when relevant departments decide to ameliorate the income distribution gap of residents through public education investment, they cannot simply expand the scale of education expenditure. The expenditure structure, specific expenditure methods, and systems and policies related to the use and management of education funds should be carefully designed, taking a variety of factors into consideration. The enlightenment of this study on the design of public education policy is that: in areas with a small resident income gap, relatively more balanced public education investment can be carried out; in areas where the situation of income distribution is serious, it is necessary to optimize the structure of education expenditure, bias the expenditure towards basic education, focus on providing more educational opportunities and resources for vulnerable groups with a higher proportion of the population, provide more channels for these economically vulnerable groups to obtain employment information, employment opportunities, and improve employment security system, etc. To sum up, public funds should be used to assist households

with less wealth stock in order to help exert the positive effect of the increase of human capital on the income of these families, so as to reduce the income distribution gap.

In general, this paper has found a new key factor affecting the income distribution effect of public education expenditure, but focuses more on using data and econometric model to verify the potential effect that may exist. The theoretical analysis and demonstration content supporting the empirical results are still not detailed and complete enough. The logical analysis from this perspective needs to be further deepened to better explain and explore the impact mechanism.

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