

The Impact of Fiscal Investment in Education and the Structure of Investment on Urban–Rural Income Disparities: A Study Based on Quantile Panel Regression

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Abstract. This study investigates the impact of government education expenditure and its structural composition on urban–rural income inequality in China, using provincial panel data spanning from 2004 to 2023. The empirical results reveal that increased per-student education spending plays a significant role in narrowing the income gap between urban and rural populations. However, a disproportionately large allocation to higher education tends to widen income disparities, indicating an urban bias in the distribution of educational resources. Mechanism analysis further demonstrates that human capital development serves as a key transmission channel linking education finance to income inequality. The study also uncovers strong regional heterogeneity: the income-equalizing effects of education spending are more evident in eastern provinces, while central and western regions exhibit weaker or inconsistent outcomes, likely due to institutional and structural limitations. These findings underscore the importance of rebalancing education budgets between basic and higher education and adopting regionally tailored fiscal strategies to promote equitable income distribution and inclusive economic development.

Keywords: Education Finance; Educational Investment Structure; Urban–Rural Income Inequality; Human Capital; Quantile Panel Regression.

1. Introduction

The tension between efficiency and equity constitutes a central challenge as China's economy enters a new development stage. Over recent decades, rapid economic growth substantially enhanced social efficiency, while the 'common prosperity' and 'rural revitalization' strategies under the 14th Five-Year Plan yielded notable phased achievements. Nevertheless, income disparities remained pronounced, especially under urban-rural dualistic structure. Although China's Gini coefficient declined to 0.357 by 2021, yet remained close to international warning threshold of 0.4, indicating that persistent inequality could hinder both economic momentum and the realization of common prosperity.

Public expenditure, especially education funding, plays a pivotal role in addressing these disparities. The scale and structure of education finance determine the accessibility and quality of public educational resources, shaping human capital accumulation and income distribution. Despite continuous growth in education budgets, regional and administrative imbalances persist, highlighting the need for fiscal optimization to ensure equality of opportunity from the outset.

This study employs provincial-level panel data from 2004 to 2023 and applies a two-way fixed effects model to evaluate the impact of the scale and the structure of public education on urban-rural income disparities. Quantile panel regression further examines structural optimization effects across different income levels. The analysis aims to provide empirical evidence for the allocation and structural adjustment of educational finance, offering policy insights to narrow urban-rural income gaps and advance common prosperity.

2. Literature Review

2.1. Theoretical Foundations: Efficiency and Equity

Imbalanced educational development is a key factor driving urban-rural income disparities in China, accounting for roughly one-third of the total gap [1]. Education can affect income distribution through three main channels. First, human capital theory suggests that education investment enhances skills and knowledge, which, as productive factors, influence individual income levels [2]. This theory is widely adopted by scholars both domestically and internationally. Second, fiscal education spending may generate implicit subsidies during redistribution, potentially exacerbating income disparities among groups [3]. Third, access to high-quality and equitable education can shape intergenerational human capital accumulation, thereby influencing income mobility across generations [4].

Within China's dualistic urban-rural economic structure, the accumulation and returns of human capital differ markedly. Urban households can accumulate human capital at low cost due to a combination of public education support and marginal family investment, while rural households face inadequate fiscal support and are compelled to bear high private costs to compensate for limited educational resources. Research indicates that educational expansion may initially widen income inequality when educated labor is scarce, but as the supply of education meets demand, disparities can gradually decrease [5, 6]. Over the long term, urban residents are better positioned to leverage public education benefits for their children, whereas rural residents, facing uncertain educational returns, tend to invest in short-term high-yield activities, creating a "fiscal bias → educational gap → income divergence → intergenerational persistence" Matthew effect [7].

2.2. The Role of Government Expenditure on Education in Income Distribution

Fiscal intervention is considered a crucial lever for breaking this cycle. By reducing rural education costs and improving investment efficiency, fiscal policies can simultaneously enhance equity and efficiency. Empirical studies show that the "Notice on Deepening the Reform of the Funding Guarantee Mechanism for Compulsory Education in Rural Areas" significantly lowered direct educational costs for rural households, increased women's human capital investment, and encouraged additional educational investment in their children [8].

The impact of education fiscal expenditure depends not only on total funding but also on the structure of spending. Existing literature highlights three perspectives:

The central role of basic education: Basic education, particularly compulsory education, is essential for narrowing urban-rural disparities, as quality improvements directly increase the returns for lower-income groups [1]. Studies show that investments in preschool, compulsory, and general secondary education since 2013 have substantially reduced regional and urban-rural income gaps [9]. International evidence supports this view; for example, in Indonesia, expanded access to basic education increased rural human capital levels, effectively narrowing the urban-rural divide [10].

The unique value of vocational education: Investment in secondary and tertiary vocational education has a significant effect on reducing income disparities, even more so than general education. Regression analyses and instrumental variable approaches confirm that vocational education spending substantially lowers urban-rural income gaps [11, 12].

Regional heterogeneity in higher education: The effects of higher education vary considerably across regions. In western China, where higher education resources are scarce, expansion may exacerbate inequality due to unequal opportunities; in eastern, market-oriented regions, misalignment between education and labor market demand can diminish income gains. Moreover, within eastern provinces, differences in resource allocation can create a siphoning effect, reinforcing internal disparities [10, 13].

2.3. Limitations of Existing Research and Methodological Innovations

Most studies employ OLS regression to analyze income disparities, yet Theil indices typically display right-skewed distributions, violating the normality assumption and potentially reducing estimation efficiency. In contrast, quantile regression does not rely on normality assumptions and can robustly capture the nonlinear effects of educational spending across different levels of income disparity. Empirical results indicate that education expenditure has the strongest impact at 30% quantiles of income gap distribution, while the moderating effects in eastern and western regions are more pronounced at higher quantiles [14].

Building on this insight, we adopt a quantile panel regression framework combined with heterogeneity analysis to systematically examine the dynamic effects of government expenditure on education and its structure across different quantiles and regions. This approach overcomes the limitations of traditional static, region-based analyses, providing policy-relevant evidence that accounts for both structural and regional heterogeneity in addressing urban-rural income disparities.

3. Methodology

3.1. Model Specification

To assess the impact of government expenditure on education and investment structure on income gap, this study first adopts a two-way fixed-effects panel model (1):

$$Theil_{it} = \beta_0 + \beta_1 \times \ln_edu_{it} + \beta_2 \times str_edu_{it} + \gamma \times Control_{it} + \alpha_i + \lambda_t + \epsilon_{it} \quad (1)$$

where i and t denote province and year, respectively. $Theil_{it}$ is the Theil Index. $\ln_edu_{it}$ is the logarithm of per-student education expenditure, and str_edu_{it} denotes the education investment structure. $Control_{it}$ represents a set of control variables, including fiscal support intensity, degree of openness, urbanization level, and industrialization level. The model includes province-fixed (α_i) and year-fixed (λ_t) effects, with ϵ_{it} as the disturbance term.

We employ human capital (*HumanCapital*) as the core instrumental variable to uncover the underlying mechanism through which government expenditure on education and its structural composition influence income disparities. We measure human capital using the ratio of higher education enrollment to total population.

3.2. Variable Description and Data Source

This study draws on data from the China Statistical Yearbook, the China Education Finance Statistical Yearbook, the China Macroeconomic Database, and the annual national education expenditure implementation reports published by the Ministry of Education, the National Bureau of Statistics, and the Ministry of Finance. It examines the relationship between the scale and the structure of government expenditure and urban-rural income inequality across 30 provinces in China from 2004 to 2023. The variable definitions and data collection process are as follows.

Based on Gong Xiqiang's research, we employ the Theil index to measure income inequality [14]. As a relative indicator, the Theil index is not affected by regional population size or absolute income levels, thereby enabling direct comparisons across time periods and population groups of varying scales. The calculation formula is presented in Model (2):

$$Theil = \sum_{j=2}^2 \left[\left(\frac{I_{ij,t}}{I_{i,t}} \right) \times \ln \left(\frac{\frac{I_{ij,t}}{I_{i,t}}}{\frac{P_{ij,t}}{P_{i,t}}} \right) \right] \quad (2)$$

Where i denotes the province, t the year, and j ($j=1$ for urban data; $j=2$ for rural data). I represent per capita disposable income for urban or rural areas, while P represents the corresponding population category. The Theil index ranges from 0 to 1, with value closer to 0 indicating a smaller urban-rural income distribution gap.

Government expenditure on education(*ln_edustu*). Drawing on research by Wei Ping, this study selects per-student education expenditure as the core explanatory variable to measure local governments' investment in educational resources [15]. The logarithmic specification mitigates heteroscedasticity and allows regression coefficients to directly capture the output elasticity of education investment, thereby enhancing the model's economic interpretability. This variable is expected to have a negative sign. The calculation formula is presented in Model (3):

$$\ln_{edustu} = \ln \left(\frac{\text{local government education expenditure}}{\text{student enrollment}} \right) \quad (3)$$

Structure of Education Investment (*str_edu*). Following Liu Xinrong and Zhan Lingfang, this variable captures the share of fiscal resources allocated to higher education [16]. A higher ratio reflects stronger structural preferences for higher education in regional resource allocation. The expected coefficient is positive. The calculation formula is shown in Model (4):

$$str_{edu} = \frac{\text{Per Student Expenditure on Higher Education}}{\text{Per Student Expenditure on Vocational Education} + \text{Per Student Primary \& Secondary Education Expenditure}} \quad (4)$$

We employ human capital (HumanCapital) as the core instrumental variable to uncover the underlying mechanism through which government expenditure on education and its structural composition influence income disparities. We measure human capital using the ratio of higher education enrollment to total population.

To account for other potential influences, we follow existing literature and include the following control variables: fiscal support intensity (FiscalSupport), degree of openness (Openness), urbanization level (City), and industrialization level (Industrialization). Table 1 summarizes all variables and their definitions.

Table 1. All variables and their definitions

Variable	Definition	Obs	Mean	SD
Theil	Income inequality	620	0.102	0.051
<i>ln_edustu</i>	Log of local gov. education expenditure per student	620	11.336	0.921
<i>str_edu</i>	Higher ed. expenditure per student / (Basic ed. + Vocational ed. expenditure per student)	620	2.051	0.762
<i>ln_pubsinsupport</i>	Local gov. budget expenditure / Regional GDP	620	0.257	0.187
<i>city</i>	Urban population / Total population	620	0.551	0.150
<i>openness</i>	Total import & export (USD) / Regional GDP	620	0.298	0.345
<i>industrialization</i>	Industrial value-added / Regional GDP	620	0.329	0.095
<i>humancapital</i>	College enrollment / Total population	620	0.188	0.007
<i>ln_edu</i>	Log of local gov. education expenditure per person	620	9.475	0.830

3.3. Statistic Analysis

We conduct empirical analyses using Stata software. The data preprocessing procedures are as follows: First, to mitigate the influence of extreme values, continuous variables undergo winsorization at the upper and lower 1% levels. Second, all indicators are subjected to a logarithmic transformation to maintain data structural stability and minimize the impact of heteroskedasticity on empirical analysis results.

4. Empirical Analysis

4.1. Benchmark Regression

Column (1) and (2) of Table 4-2 report the fixed-effects regression results with and without control variables, respectively. It can be observed that per-student education expenditure (*ln_edustu*) has a significant negative effect on the income inequity, and this effect remains robust after adding control variables. The coefficient for education investment structure (*str_edu*) is significantly positive, indicating that increasing the proportion of higher education investment widens the income gap. Among the control variables, public fiscal support, urbanization, openness, and industrialization level all significantly contribute to narrowing the income gap.

4.2. Robustness Tests

To access the robustness of the benchmark results, we re-estimated the model by replacing per-student education expenditure with per capita education expenditure (*ln_edu*). As shown in Column (3) of Table 2, the signs and significance levels of the core variables align with the benchmark regression, confirming robustness.

Table 2. Results

VARIABLES	(1) Without Control Var.	(2) With Control Var.	(3) Robustness Test
<i>ln_edustu</i>	-0.039*** (0.012)	-0.015* (0.009)	
<i>ln_edu</i>			-0.015* (0.008)
<i>str_edu</i>	0.007*** (0.003)	0.006*** (0.002)	0.007*** (0.002)
<i>ln_pubfinsupport</i>		-0.030* (0.016)	-0.030* (0.016)
<i>city</i>		-0.075** (0.031)	-0.078** (0.030)
<i>openness</i>		-0.042*** (0.008)	-0.041*** (0.008)
<i>industrialization</i>		-0.042* (0.025)	-0.041 (0.025)
Constant	0.491*** (0.113)	0.328*** (0.084)	0.297*** (0.064)
Observations	620	620	620
R-squared	0.858	0.900	0.900
Number of id	31	31	31
yearfix	YES	YES	YES
idfix	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Quantile regression and Mechanism analysis

5.1. Quantile Regression

Figure 1 depicts the quantile distribution of the Theil index, revealing a right-skewed distribution. This indicates that most provinces exhibit relatively low urban-rural income disparities, though a few displays high disparities. To examine the heterogeneous impact of educational investment across different disparity levels, this study further employs quantile panel regression for estimation.

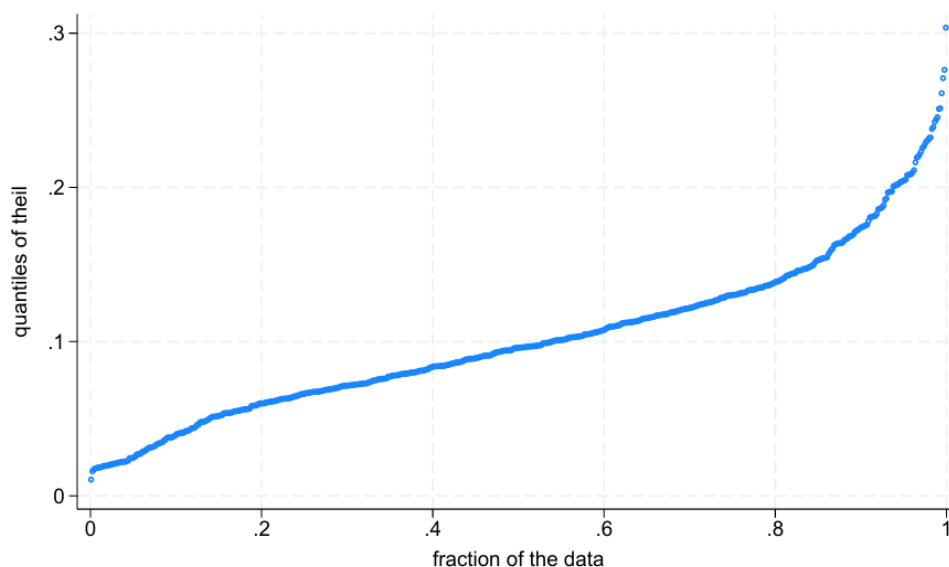


Fig. 1 Quantile Distribution of The Theil Index

Table 3 reports the quantile regression results for four quantiles (25%, 50%, 75%, and 90%). The coefficient of per-student education expenditure (*ln_edustu*) is significantly negative at the 1% level across all quantiles, with the absolute magnitude peaking at 75% quantile. This suggests that the gap-narrowing effect of education funding is strongest in regions with greater income disparities. The coefficient of the higher-education expenditure share (*str_edu*) remains consistently positive, ranging from 0.00408 to 0.00511, with larger values at both lower and higher percentiles, implying that its gap-widening effect is more pronounced in regions with either small or large disparities

Table 3. Quantile Regression

	(1) 25%	(2) 50%	(3) 75%	(4) 90%
<i>ln_edustu</i>	-0.00924*** (0.000188)	-0.00974*** (0.00000597)	-0.0104*** (0.00000570)	-0.0101*** (0.00000372)
<i>str_edu</i>	0.00511*** (0.0000600)	0.00408*** (0.00000640)	0.00474*** (0.00000191)	0.00480*** (0.00000392)
<i>pubfinsupport</i>	0.0595*** (0.000727)	0.0648*** (0.0000258)	0.0669*** (0.0000377)	0.0633*** (0.0000319)
<i>city</i>	-0.156*** (0.000771)	-0.159*** (0.0000750)	-0.150*** (0.0000373)	-0.154*** (0.0000423)
<i>openness</i>	-0.00305*** (0.000332)	-0.000528*** (0.0000193)	-0.00253*** (0.00000829)	-0.00326*** (0.00000796)
<i>industrialization</i>	0.00442*** (0.00108)	0.00557*** (0.0000557)	0.0104*** (0.0000423)	0.00769*** (0.0000199)

5.2. Mechanism Analysis

We employ a mediation model to analyze the role of human capital in linking education fiscal expenditure, its structural composition, and income inequality. Table 4 reports the regression results using a three-step procedure.

Column (1) indicates that, without mediating variables, per-student education expenditure (*ln_edustu*) significantly reduces the Theil Index, whereas the higher-education investment share (*str_hedu*) significantly increases income inequality. Column (2) shows that per-student expenditure has a significant positive effect on human capital (*HumanCapital*), while a higher share of higher-education investment exerts a slight inhibitory effect, possibly reflecting a crowding-out of human capital formation at the basic-education stage. Column (3), which includes both explanatory variables and human capital, shows that the coefficient of the latter is significantly negative at the 1% level.”

These findings suggest that human capital accumulation constitutes a key mediating channel through which government spending on education influences income inequality. Per-student education expenditure narrows the gap both directly and indirectly by enhancing human capital, whereas a higher share of higher-education investment widens the gap directly and may also exacerbate inequality indirectly by crowding out foundational human capital. Hence, optimizing both the scale and structure of education investment while strengthening human capital accumulation is crucial for fostering income equity between urban and rural areas.

Table 4. Mechanism Analysis Results

	(1) theil	(2) humancapital	(3) theil
humancapital			-1.061*** (0.320)
ln_edustu	-0.0153*** (0.00480)	0.00234** (0.000947)	-0.0128*** (0.00458)
str_hedu	0.00680*** (0.00135)	-0.00116*** (0.000228)	0.00558*** (0.00125)
pubfinsupport	-0.0300* (0.0171)	-0.00558*** (0.00216)	-0.0359** (0.0167)
city	-0.0753** (0.0297)	0.00974 (0.00658)	-0.0650*** (0.0248)
openness	-0.0424*** (0.00449)	0.00996*** (0.000976)	-0.0319*** (0.00442)
industrialization	-0.0421*** (0.0113)	-0.00325 (0.00219)	-0.0456*** (0.0115)
_cons	0.336*** (0.0491)	-0.0112 (0.00964)	0.325*** (0.0490)
N	620	620	620
R ²	0.969	0.946	0.970
adj. R ²	0.966	0.941	0.967

5.3. Heterogeneity Analysis

Table 5 and Table 6 report estimation results from the Two-way fixed effects model and quantile panel regression models disaggregated by region, revealing significant regional and conditional heterogeneity in the impact of education fiscal policies.

In the two-way fixed effects regression, the gap-reducing effect of per-student education expenditure and the gap-widening effect of the share of higher education investment are statistically significant only in the eastern region, while they are insignificant in the central and western regions. This may reflect difference in economic stages and factor market maturity between regions. The eastern region possesses the market conditions necessary to effectively convert educational investment into human capital enhancement, which in turn manifests as income changes.

Table 5. Heterogeneity Analysis—based on two-way fixed effects

	(1) East	(2) Middle	(3) West
ln_edustu	-0.0189** (0.00786)	0.00438 (0.00769)	-0.00742 (0.0158)
str_edu	0.00488** (0.00188)	0.000713 (0.00154)	-0.000248 (0.00457)
pubfinsupport	-0.00534 (0.0338)	-0.0128 (0.0215)	0.0175 (0.0311)
city	-0.0602* (0.0304)	-0.0770* (0.0386)	0.0340 (0.0986)
openness	-0.0221*** (0.00664)	-0.0221 (0.0248)	-0.0434* (0.0212)
industrialization	-0.0694 (0.0459)	0.00910 (0.0197)	0.0250 (0.0287)
_cons	0.337*** (0.0713)	0.113 (0.0720)	0.247 (0.164)
N	220	160	240
R ²	0.880	0.973	0.950
adj. R ²	0.864	0.968	0.944

Quantile regression further reveals how effects vary across different levels of inequality. In the eastern regions, the effect of per-student education expenditure diminishes as quantiles increase, while the share of higher education investment consistently and significantly widens income gaps. In the central regions, the effect of per-student education expenditure is most pronounced at high quantiles, yet the share of higher education investment remains significant—likely because higher education provides crucial upward mobility for local low-to-middle-income groups and mitigates talent outflow. In the western region, the coefficient sign for the share of higher education investment fluctuates it is significantly negative at the 25th quantile (-0.0113), significantly positive at the 50th quantile (0.00507), and turns negative again at the 75th quantile (-0.00309). Meanwhile, per-student expenditure shows the most pronounced effect at high quantiles, indicating significant internal disparities and greater policy importance in regions with high income gaps.

Table 6. Heterogeneity Analysis—based on quantile regression

		(1) 25%	(2) 50%	(3) 75%	(4) 90%
East	ln_edustu	-0.00944*** (0.0000262)	-0.00412*** (0.0000141)	-0.00278*** (0.00000077)	-0.00278*** (0.00000077)
	str_edu	0.00633*** (0.00000920)	0.00514*** (0.00000510)	0.00522*** (0.00000104)	0.00522*** (0.00000104)
Middle	ln_edustu	-0.0131*** (0.00291)	-0.0122*** (0.00106)	-0.0196*** (0.00192)	-0.0196*** (0.00192)
	str_edu	-0.00903*** (0.00122)	-0.00749*** (0.00263)	-0.00257*** (0.000971)	-0.00257*** (0.000971)
West	ln_edustu	-0.00734*** (0.00151)	-0.00471*** (0.000739)	-0.0180*** (0.00149)	-0.0180*** (0.00149)
	str_edu	-0.0113*** (0.00233)	0.00507*** (0.000954)	-0.00309*** (0.000233)	-0.00309*** (0.000233)

6. Conclusion

This study investigates the impact of government expenditure on education and its structural composition on urban-rural income disparity, drawing on provincial panel data from 2004 to 2023. The results indicate that per-student education spending significantly narrows the income gap, while excessive concentration of resources in higher education tends to widen it. Mechanism analysis highlights human capital as a key mediating channel. Heterogeneity analysis further reveals that the effects are strongest in eastern provinces, whereas in central and western regions they remain insignificant or unstable, reflecting disparities in economic development and fiscal capacity.

Policy implications are twofold. First, resource allocation should strike a balance between higher and basic education, avoiding overemphasis on tertiary institutions. Second, rural and less-developed regions should prioritize strengthening basic education infrastructure and teacher quality, supported by enhanced fiscal transfers and targeted programs, to ensure more equitable human capital accumulation.

This research contributes by distinguishing between the quantity and structure of education expenditure and by uncovering regional heterogeneity, thereby advancing the understanding of how fiscal education policies affect income distribution. Nonetheless, reliance on provincial-level secondary data limits the analysis of micro-level mechanisms. Future studies could combine survey data, household-level information, or case studies with advanced econometric methods to provide more granular and policy-relevant insights.

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