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Article

Income Inequality and Fertility Decline in China

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Abstract: This study examines the influence of income inequality on the declining fertility rate in China from the perspective of educational expenditure. We employ provincial panel data from the China Statistical Yearbook spanning 2011 to 2020 for empirical analysis. The findings indicate: (1) Income inequality exerts a significant negative effect on the fertility rate. (2) The income distribution gap significantly diminishes education expenditures; however, after introducing the interaction term, the impact on the fertility rate becomes significantly positive, suggesting that increased income inequality enhances the positive influence of education expenditure on the fertility rate. (3) Considering the threshold effect of income disparity, when the income gap is relatively small, it positively influences the fertility rate, as evidenced by the positive interaction term. (4) This study selects after-school tutoring expenditure as an instrumental variable because it is correlated with income and its educational resources are exogenous, satisfying the conditions for two-stage least squares regression. Tutoring affects the income gap but does not directly influence the fertility rate, ensuring the validity of our results. Finally, we evaluate the effectiveness of the two-child policy implemented in 2016 and conclude that its impact has been limited. Therefore, we recommend that the Chinese government focus on reducing the financial burden of education on families to potentially improve the fertility rate.

Keywords:Low Fertility; Income Inequality; Education Expenditure; Negative Population Growth

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1. Introduction

Low fertility is emerging as a global demographic phenomenon that attracts almost as much attention as aging. Extremely low or very low fertility, on the one hand, leads to a rapid decline in population; on the other hand, it causes a high degree of population aging. This is undoubtedly a demographic crisis that every country desires to avoid or solve. Since the 1970s, as more countries have completed their fertility transitions, fertility trends in the post-transition period have diverged. Some countries have maintained fertility just slightly below replacement levels, while many more countries have continued to decline to extremely low or even very low levels. The year 2022 marks a milestone in the history of China's population development. According to the National Bureau of Statistics, there were 9.56 million births in China in 2022, with a birth rate of 6.77 per cent. The death population was 10.41 million, and the mortality rate was 7.37 per cent. The total population was 1,411.75 million, decreasing by 850,000 compared to the end of the previous year, with a natural growth rate of -0.60 per cent. China has officially entered the era of negative population growth after the completion of the demographic transition. This is a watershed in the transformation of the direction of China's population development, signifying the shift from a positive population growth trend that has lasted for hundreds or even thousands of years to a long-term negative population growth. It is a major demographic event of the times and history.

Although the rapid decline(Figure 1) in the fertility rate offered sufficient "demographic dividend" for China's economic growth to mitigate the adverse impact of high population growth on the economy, this fertility rate change pattern also led China into an aging process that was ahead of the stage of economic development. Most of the existing studies have conducted descriptive statistical analyses on how population structure and population aging affect economic growth from the macroeconomic level, as well as on issues such as whether income inequality plays a role in the decision of residents' surplus, whether the inequality of distribution affects the fertility rate of a country, and what long-term impact the decline of the fertility rate and population aging will have on the economy of a country. Few have provided a systematic solution.

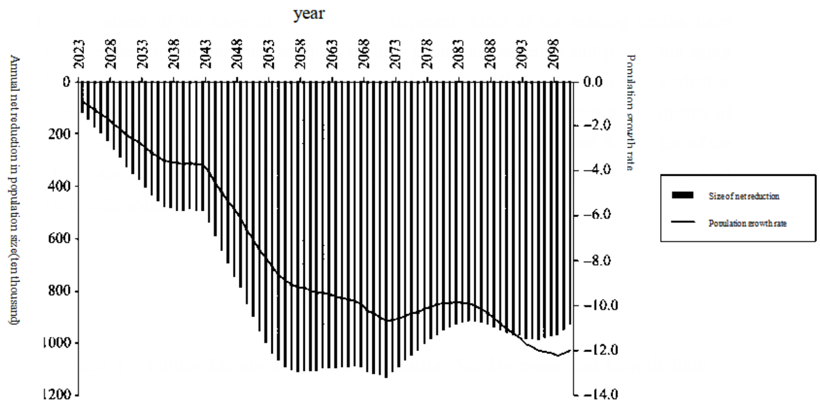

Figure.1 Future Trends in China's Population Net Decrease and Growth Rate

Globally, the total fertility rate (TFR) exhibited a declining trend across all regions after the 1960s. Specifically, sub-Saharan Africa, the Middle East and North Africa, South Asia, and Latin America and the Caribbean continue to experience ongoing declines in TFR without indications of reaching a nadir. In East Asia and the Pacific, while the decline has slowed, there has been no significant recovery in fertility rates. North America has shown short-term increases in fertility rates; however, this region's data is limited to Canada and the United States, which may not be fully representative. Conversely, Europe and Central Asia have experienced a rebound from low fertility rates, which has since stabilized.

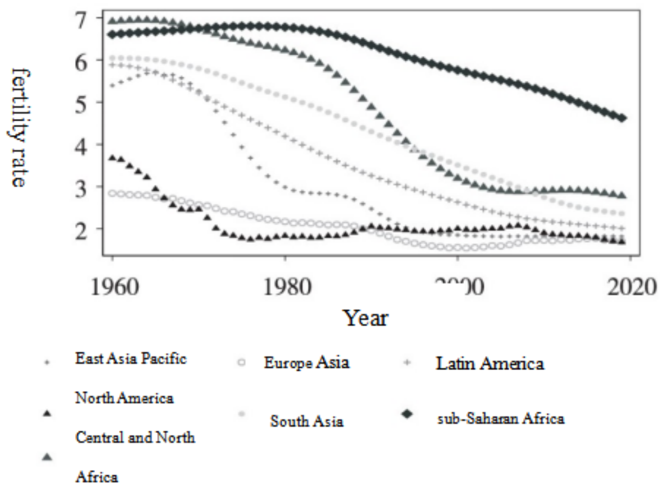

Figure.2 Fertility rates by region of the world

Some literature has analyzed the long-term effect of China's decreasing fertility rate on the economy from the aspect of the contradiction between labor supply and labor productivity. It is argued that with the decline of the working-age population in terms of both relative proportion and absolute number, the gap between labor supply and demand is bound to result in the increase of the wage rate as well as the adjustment of industrial and employment structures. During the period when the relationship between labor supply and demand undergoes a significant turning point, the rapid aging of the population and even the emergence of the "population fault" are certain to augment the burden of pensions, thereby weakening the impetus of economic growth. We hold the view that the "demographic fault" is sure to lead to a decrease in the proportion of labor supply in China over the next 20 years. This paper refers to the treatment of human capital investment and fertility rate decision in Dahan and Tsiddon (1998), constructs the optimal fertility rate decision and human capital investment model, and explores the impact of income inequality on fertility rate, human capital investment and labor productivity. At the same time, the provincial panel data of China from 2011 to 2020 are utilized to empirically test the conclusions of the theoretical part, thereby providing empirical support for population policy adjustment and demographic structure transition.

2. Literature review and hypothesis

Regarding the relationship between income distribution and fertility rate, existing literature primarily examines three key dimensions: Firstly, the impact of changes in the Gini coefficient on fertility rates during economic growth. The Gini coefficient, a widely recognized metric for measuring income inequality ranging from zero to one, reflects the overall equality of income distribution within a society. A lower Gini coefficient signifies greater income equality and smaller income disparities among social groups, whereas a higher Gini coefficient indicates greater income inequality and larger income gaps. Kuznets (1955) observed that income inequality follows an "inverted U-shaped" curve with economic development, initially increasing before decreasing. Lee's (1990) analysis of China's provincial data from the 1980s revealed a significant correlation between average income distribution and declining fertility rates. Some scholars argue that the relationship between the Gini coefficient and fertility rate is not linear. For instance, Repetto (1974) noted that in early stages of economic development, fertility rates were positively correlated with the Gini coefficient; however, as economies enter periods of rapid growth, the Gini coefficient continues to rise while fertility rates decline, leading to a negative correlation.Secondly, the literature explores the relationship between income distribution and fertility rates during demographic transitions. Dyson and Murphy (1985) posited that in the initial stage of demographic transition, rising income inequality correlates positively with increased fertility rates, whereas in the subsequent stage, decreasing income inequality correlates positively with declining fertility rates.Thirdly, studies analyze the underlying logic of fertility choices across different groups influenced by income distribution. Different groups experience varying income effects, which shape their fertility behaviors. Perotti (1996) suggested that differences in the relationship between income distribution and fertility rates reflect variations in opportunity costs. After analyzing macro-level data on social mobility, researchers (2003) found that disparities in family investments in human capital for offspring influence fertility decisions. In summary, changes in income distribution can have diverse impacts on fertility depending on the state and stage of social development.

With the advancement of human society, technological progress and the accumulation of material wealth have significantly enhanced people's quality of life. Consequently, fertility preferences have shifted from a focus on quantity to an emphasis on quality. Reproductive quality is determined by the impact of reproductive behavior on the family or individual, which is influenced by the balance between income and reproductive costs. When income remains constant, an increase in reproductive costs may reduce reproductive quality, whereas an increase in income can enhance reproductive quality when costs remain unchanged. Reproductive costs encompass not only direct expenses but also opportunity costs, including time, energy, and resources invested in raising offspring, as well as the effects on personal and family life. The pursuit of higher reproductive quality involves allocating more resources to nurture superior offspring without compromising the continuous improvement of the family's or individual's quality of life. Therefore, reproductive costs are a social construct that will continue to rise with societal development. As people increasingly prioritize reproductive quality, especially the developmental outcomes of their offspring, reproductive costs are likely to increase at a faster rate than other living expenses, leading to a higher proportion of reproductive costs in total household expenditure. For instance, more time and effort are devoted to child-rearing, and additional funds are allocated for better education. This trend not only reduces overall societal fertility willingness but also contributes to the gradual transition into a low-fertility society, where reproductive behavior is increasingly constrained by family income.

Reproductive behavior is influenced by income levels. Families may find it difficult to afford the reproductive costs associated with their desired number of children, leading them to either abandon or reduce their fertility intentions. The average reproductive cost in a society often aligns with the average family income, meaning that the growth of reproductive costs tends to match or even outpace the growth of residents' income. Thus, the income that constrains reproductive behavior refers to relative rather than absolute income. In modern society, income disparities are prevalent. High-income families generally face fewer income constraints on their reproductive behavior, while low-income families are more constrained by income limitations. Reducing income constraints for low-income families can promote overall fertility rates by increasing their fertility intentions, while enhancing income constraints for low-income families can lead to further reductions in fertility rates. On one hand, the reproductive behavior of high-income individuals increases the average social reproductive cost, and greater income inequality imposes stronger income constraints on low-income families. On the other hand, because low-income families' reproductive behavior is income-constrained, a higher proportion of low-income families means more families cannot realize their potential reproductive intentions due to financial limitations. Therefore, during the low-fertility stage, widening income inequality and an increasing proportion of low-income groups further inhibit fertility rate increases, while narrowing income inequality and decreasing proportions of low-income groups promote fertility rate increases.

Based on this analysis, this paper proposes Hypothesis H1: In the low fertility stage, the equalization of income distribution will reduce the proportion of low-income families and tighten the constraints of income on their reproductive behavior, thus inhibiting the recovery of the overall fertility rate. The Gini coefficient is significantly negatively correlated with the total fertility rate.

3. Theoretical model and hypothesis

The growth of the labor force refers to the growth of the labor force possessing certain knowledge, skills, and qualities. The accumulation of knowledge and the improvement of the quality of the labor force should rely on the inherent characteristics of the labor force itself, and knowledge and the labor force itself should not be separated. Individual workers will fully consider the cost and future income of educational investment, thereby choosing an optimal level of knowledge accumulation. Human capital investment is inherent in the individual decisions of workers. In this paper, labor productivity is endogenous to the optimal human capital input, and labor productivity is approximately replaced by human capital investment to investigate the influence of income distribution inequality on fertility and labor productivity within a unified theoretical framework.

3.1 Production model

To further elucidate the influence of income distribution inequality on labor productivity, this paper incorporates labor productivity into the model and considers the impact of income distribution inequality. We further hypothesize that the children of skilled laborers obtain higher income from skills than those of unskilled laborers. Thus, we can assume that the level of human capital input in each period remains unchanged, all of which are$\theta w_{s\cdot t}$. Moreover, the children of skilled laborers receive an improvement of human capital of H_s units in each period. The level of human capital improvement that skilled children obtain from their parents isH_{us} $H_s > H_{us}$,and does not vary with time; Y_{Ut}represents the output level of the unskilled sector, $w_{U,t}$and $L_{U,t}$represent the wage level and labor supply of the unskilled sector respectively. Hence, the production rainfall of the unskilled sector can be written as follows:

$$Y_{U\cdot t} = w_{U\cdot t} L_{U\cdot t} \quad (1)$$

The production of the skilled sector requires the participation of capital and skilled labor And, therefore, the production function of the skill sector can be expressed as:

$$Y_{s\cdot t} = A_t(H_{t-1}) K_t^{\alpha} H_t^{1-\alpha} \quad (2)$$

Where, $Y_{s\cdot t}$ represents the total output of the skill department, K_t and H_t are respectively the capital input and the supply quantity of the skilled labor force of the skill department. A_t stands for the productivity level of the skilled sector and is a function of the skilled human capital in the previous period. Assuming that the total human capital in each period H_t is the transformation of the unskilled labor force in the previous period and the weighted average of the skilled labor force, $H_t=N_{us}H_{us}+N_s\ Hs$ is given. Similar to the above assumption, the interest rate level is externally generated as *r*. Under the condition of perfect competition in the capital market, the interest rate level can be expressed as:

$$r = \frac{\partial Y_{s\cdot t}}{\partial K_t} = Y_{k\cdot t}^{s} = \alpha A_t K_t^{\alpha-1}\, t\, H_t^{1-\alpha} = \alpha A_t \left(\frac{H_t}{K_t}\right)^{1-\alpha} \quad (3)$$

$$w_{s,t} = \frac{\partial Y_{s,t}}{\partial L_{s,t}} = \frac{\partial Y_{s,t}}{\partial H_t} = (1-\alpha) A_t K_t^{\alpha} H_t^{-\alpha} = (1-\alpha) A_t \left(\frac{H_t}{K_t}\right)^{-\alpha}$$

$$= (1-\alpha) A_t \left(\frac{r}{\alpha A_t}\right)^{\frac{-\alpha}{1-\alpha}} = (1-\alpha)\left(A_t\right)^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{r}\right)^{\frac{\alpha}{1-\alpha}} \quad (4)$$

$$w_{u,t} = \frac{\partial Y_{u,t}}{\partial L_{u,t}} \quad (5)$$

Wages of unskilled labor and skilled labor in each period The proportion of sex income can be expressed by the proportion of formula (4) and formula (5)：

$$\frac{w_{s,t}}{w_{u,t}} = (1-\alpha)(A_t)^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{r}\right)^{\frac{\alpha}{1-\alpha}} \quad (6)$$

3.2 Consumption model

Domestic three representative consumers through the consumption of the second phase of goods Raising children and keeping the next installment of the estate, getting the current utility,

Therefore, the utility function of representative consumers in the current period can be expressed as:

$$U_t = \gamma \ln(C_{t+1}) + \beta \ln(N_{t+1}) + \delta \ln(B_{t+1}), \quad \gamma + \beta + \delta = 1 \quad (7)$$

Where, C_{t+1} represents the consumption in the second period; N_{t+1} represents the number of children raised in the next period; B_{t+1} represents the physical heritage resources retained by consumers in the current period for their children in the next period; and $\gamma\ \beta\ \delta$ respectively represent consumption, the number of children, and the marginal utility brought by leaving inheritance to consumers in the current period. It is assumed that the total income of consumers in the next period is I_{t+1}, and the total income of consumers in the next period is spent on the consumption, child rearing and bequeathing in kind in the second period. However, different consumers have different investment in children's education and the return on human capital obtained by their children. Therefore, the budget constraints of the three types of consumers in the second period can be written as:

$$C_{i,t+1} + \varphi N_{i,t+1} H_{j,t+1} w_{k,t+1} + B_{k,t+1} = I_{i,t+1} \quad (8)$$

$$C_{i,t+1} + \varphi N_{i,t+1} w_{k,t+1} + B_{k,t+1} = I_{i,t+1} \quad (9)$$

Among them, $C_{i,t+1}$ represents the consumption of the third-class consumers in the second phase; $N_{i,t+1}$ represents the number of children of third-class consumers in the second phase; $I_{i,t+1}$

represents the income level of different consumers in the second phase; $w_{k,t+1}$ represents the wage income of unskilled and skilled labor force in the second phase; $B_{k,t+1}$represents the physical inheritance of different skilled workers to the next generation; $H_{j,t+1}$ represents the human capital investment of children by different skilled workers in the last period; φ represents the proportion of child-rearing expenditure. Under the conditions of budget constraints (8) and (9), the maximizing utility function (7) can be used to construct the Lagrangian function.

$$\Phi_t = \gamma \ln(C_{t+1}) + \beta \ln(N_{t+1}) + \delta \ln(B_{t+1}) + \Lambda_t \left(I_{i,t+1} - C_{i,t+1} - \varphi N_{i,t+1} W_{i,t+1} - B_{i,t+1}\right)$$
(10)

By calculating the first derivative of consumption, labor supply and legacy in kind on both sides of equation (10), the consumption level, labor supply and legacy in kind of the three types of consumers in the next period can be obtained as follows:

$$C_{s,t+1} = \gamma I_{s,t+1}, N_{s,t+1} = \frac{\beta}{\varphi H_{s,t+1} W_{s,t+1}} I_{s,t+1}, B_{s,t+1} = \delta I_{s,t+1} \quad (11)$$

$$C_{us,t+1} = \gamma I_{us,t+1}, N_{us,t+1} = \frac{\beta}{\varphi H_{us,t+1} W_{s,t+1}} I_{us,t+1}, B_{us,t+1} = \delta I_{us,t+1} \quad (12)$$

$$C_{u,t+1} = \gamma I_{u,t+1}, N_{u,t+1} = \frac{\beta}{\varphi W_{u,t+1}} I_{u,t+1}, B_{u,t+1} = \delta I_{u,t+1} \quad (13)$$

It is assumed that parents divide in-kind bequests equally among each child, while Each child's bequest is simply a function of the second period's bequest:

$$\left(\frac{B}{N}\right)_t \equiv b_t = \left(\frac{\delta\varphi}{\beta}\right) w_{i,t} i = u, s \quad (14)$$

Individuals are assumed to live for two periods in the life cycle, period I. At the end of the period, individuals receive bequests from their parents, and individuals in the current period decide whether to advance or not. By investing in human capital, individuals acquire *E* amount of human resources during their life.Capital is then put to work as a skilled labor force at the end of the first period,When income is w_s and individuals do not invest in human capital, at the end of the first period Remains an unskilled worker; Human capital of skilled workers to their children Investment is always greater than unskilled labor, while human capital investment is assumed Entry is a fixed share of skill wages, that is, $H_t = \theta w_{s \cdot t}$, in the first period.At the end, individuals who choose human capital investment need to pay for it.Enter the cost of education, while the cost of education is higher for low-income unskilled workers.The mover needs to borrow money from the bank to pay for education, so it may be low income.The interest rate of borrowing from the bank is ***i,*** which is higher than the exogenously given capital margin.The yield is ***r***. Then, the income level of the second period consumer will appear.Here are three situations:

$$I_{u,t+1} = \left[w_{u,t} \left(1 + \frac{\delta\varphi}{\beta}\right)(1+r) + w_{u,t+1} \right] \quad (15)$$

$$I_{us,t+1} = \left\{ H_{us,t+1} w_{s,t+1} + \left[\left(\frac{\delta\varphi}{\beta}\right) w_{u,t} - \theta w_{s,t} \right](1+i) \right\} \quad (16)$$

$$I_{s,t+1} = \left\{ H_{s,t+1} w_{s,t+1} + \left[\left(\frac{\delta\varphi}{\beta}\right) w_{s,t} - \theta w_{s,t} \right](1+r) \right\} \quad (17)$$

3.3 education expenditure model

The second period income levels of the three different types of consumers are substituted into the effect.With function (7), the indirect effect of various consumers in the second period can be obtained.Level of use:

$$U_{u,t} = \ln\left[w_{u,t} \left(1 + \frac{\delta\varphi}{\beta}\right)(1+r) + w_{u,t+1} \right] + \varepsilon_{u,t+1} \quad (18)$$

$$U_{us,t} = \ln\left\{ H_{us,t+1} w_{s,t+1} + \left[\left(\frac{\delta\varphi}{\beta}\right) w_{u,t} - \theta w_{s,t} \right](1+i) \right\} + \varepsilon_{s,t+1} \quad (19)$$

$$U_{s,t}=\ln\left\{H_{s,t+1}w_{s,t+1}+\left[\left(\frac{\delta\varphi}{\beta}\right)w_{s,t}-\theta w_{s,t}\right](1+r)\right\}+\varepsilon_{s,t+1} \tag{20}$$

Of which, $\varepsilon_{u,t+1}=\gamma\ln(\gamma)+\beta\ln(\beta)+\delta\ln(\delta)-\beta\ln(\varphi w_{u,t+1})$; $\varepsilon_{us,t+1}=\gamma\ln(\gamma)+\beta\ln(\beta)+\delta\ln(\delta)-\beta\ln(\varphi H_{us,t}w_{s,t+1})$; $\varepsilon_{s,t+1}=\gamma\ln(\gamma)+\beta\ln(\beta)+\delta\ln(\delta)-\beta\ln(\varphi H_{s,t+1}w_{s,t+1})$.

Substituting Equations (15) to (17) into the utility function (7), three can be obtained.The indirect utility functions of different consumers are as follows:

$$U_{s,t}=\ln(I_{s,t+1})+\varepsilon-\beta\ln(\varphi H_{s,t+1}W_{u,t+1})$$
$$U_{us,t}=\ln(I_{us,t+1})+\varepsilon-\beta\ln(\varphi H_{us,t+1}W_{s,t+1})$$
$$U_{u,t}=\ln(I_{u,t+1})+\varepsilon-\beta\ln(\varphi w_{u,t+1})$$

Of which $\varepsilon=\gamma\ln(\gamma)+\beta\ln(\beta)+\delta\ln(\delta)$, Therefore, skilled workers will always invest in education to enhance human capital, rather than.The condition for skilled labor to invest in human capital is when Equation (19) is large In Equation (18), the input in education of unskilled labor can be defined

The bound condition is:

$$\Theta=\ln\left\{H_{us,t+1}W_{s,t+1}+\left[\left(\frac{\delta\varphi}{\beta}\right)w_{u,t}-\theta w_{s,t}\right](1+i)\right\}+\varepsilon_{s,t+1}$$
$$-\left\{\ln\left[w_{u,t}\left(1+\frac{\delta\varphi}{\beta}\right)(1+r)+w_{u,t+1}\right]+\varepsilon_{u,t+1}\right\}$$

After a simple arrangement, it can be obtained

$$\Theta=H_{us,t+1}W_{s,t+1}+\left[\left(\frac{\delta\varphi}{\beta}\right)w_{u,t}-\theta w_{s,t}\right](1+i)-\left[w_{u,t}\left(1+\frac{\delta\varphi}{\beta}\right)(1+r)+w_{u,t+1}\right]\left(\frac{H_{us,t+1}W_{s,t+1}}{w_{u,t+1}}\right)^{\beta} \tag{21}$$

Equation (17) can be used to obtain the relationship between the current residents and the next generation in the steady state.The critical condition of children's human capital input is:

$$\Pi=\begin{cases}\dfrac{w_u(2+r)\left(\dfrac{H_{us}W_s}{w_u}\right)^{\beta}+w_s[H_{us}-(1+i)\Theta]}{(1+i)-(1+r)\left(\dfrac{H_{us}W_s}{w_u}\right)^{\beta}} & \text{when } \Theta>0\\ 0 & \text{when } \Theta\le 0\end{cases} \tag{22}$$

Given the case of ***β=0*** in Equation (18), it can be obtained that exogenous factors are considered.Under the fertility rate decision, income distribution inequality and human capital investment Relationship:

$$\Pi=\begin{cases}\dfrac{w_u(2+r)+w_s\left[H_{us}-(1+i)\theta\right]}{i-r} & \text{when } \Theta>0\\ 0 & \text{when } \Theta\le 0\end{cases} \tag{23}$$

Further define the inequality of income distribution at the steady state as domestically high.The ratio of the income gap between low-skilled labor, namely $\mathrm{INE}=\dfrac{w_s}{w_u}$,.It can be seen from Equation (23):

$$\frac{\partial\Pi}{\partial \mathrm{INE}}=\begin{cases}\left(\dfrac{H_{us}-(1+i)\theta}{i-r}\right)w_u & \text{when } \theta>0\\ 0 & \text{when } \theta\le 0\end{cases} \tag{24}$$

Obviously, suppose that the domestic loan interest rate is higher than the deposit interest rate, i-r>0, and it can be seen from Equation (21) that the basic human capital investment conditions are met $H_{us}-(1+i)\theta>0$, then Equation (24) shows that the inequality of income distribution plus.Drama will increase the critical value of human capital investment, and at the same time, increasing human capital investment will increase the burden of low-income families, leading to a decline in the fertility rate, namely |i-r| the smaller, $\frac{\partial \Pi}{\partial \text{INE}}$ the larger. We argue that income is unequally distributed.The intensification will stimulate low-skilled workers to achieve high future after receiving education.The expectation of skill wages, in turn, will increase the amount of human capital input, thus.Raising domestic labor productivity levels; Human capital investment will increase the burden of low-income families, which will enhance the positive promotion effect of income inequality on labor productivity to a certain extent. Therefore, we put forward the following propositions:

Hypothesis 2: Inequality in income distribution will dampen household expenditure on education and thus fertility.

3.4 Fertility decision model

The number of family planning for the three types of children in the current period can be written as follows: The first type of workers, who are unskilled labor in the current period, are still unskilled workers without human capital investment in the second period:

$$N_{u,t} = \frac{\beta}{\varphi w_{u,t}} I_{u,t}$$

$$= \frac{\beta}{\varphi w_{u,t}}\left[w_{u,t-1}\left(1+\frac{\delta\varphi}{\beta}\right)(1+r)+w_{u,t}\right] = \frac{\beta}{\varphi}\left[\frac{w_{u,t-1}}{w_{u,t}}\left(1+\frac{\delta\varphi}{\beta}\right)(1+r)+1\right] \quad (25)$$

The second type of laborer -the current period is skilled labor, the second period investment in human capital is still skilled labor:

$$N_{s,t} = \frac{\beta}{\varphi w_{s,t}} I_{s,t} = \frac{\beta}{\varphi w_{s,t}}\left\{H_{s,t}w_{s,t} + \left[\left(\frac{\delta\varphi}{\beta}\right)w_{s,t-1} - \theta w_{s,t-1}\right](1+r)\right\}$$

$$= \frac{\beta}{\varphi}\left[\frac{w_{s,t-1}}{w_{s,t}}\left(\frac{\delta\varphi}{\beta}-\theta\right)(1+r)+H_{s,t}\right] \quad (26)$$

The third type of laborer -unskilled labor in the current period, second invest in human capital to become skilled workers:

$$N_{us,t} = \frac{\beta}{\varphi w_{s,t}} I_{us,t} = \frac{\beta}{\varphi w_{s,t}}\left\{H_{us,t}w_{s,t} + \left[\left(\frac{\delta\varphi}{\beta}\right)w_{u,t-1} - \theta w_{s,t-1}\right](1+i)\right\}$$

$$= \frac{\beta}{\varphi}\left[\frac{w_{u,t-1}}{w_{s,t}}\left(\frac{\delta\varphi}{\beta}\right) - \theta\frac{w_{s,t-1}}{w_{s,t}}\right](1+i)+H_{us,t} \quad (27)$$

As can be seen from Equations (25) to (27), there is no skill transition .The number of births of workers and unskilled and skilled workers in the previous and current periods.The ratio of income is relevant because the level of wage income in the previous period determines.The amount of human capital input in the current period is determined. Ignoring the time subscript.We can conclude that the inequality of income distribution in the steady state affects the three types of labor.The effects of fertility are respectively.

$$N_u = \frac{\beta}{\varphi}\left[\left(1+\frac{\delta\varphi}{\beta}\right)(1+r)+1\right] \quad (28)$$

$$N_s = \frac{\beta}{\varphi}\left[\left(\frac{\delta\varphi}{\beta}-\theta\right)(1+r)+H_{us}\right] \quad (29)$$

$$N_{us,t} = \frac{\beta}{\varphi}\left[\frac{w_u}{w_s}\left(\frac{\delta\varphi}{\beta}\right)-\theta\right](1+i)+H_{us} \quad (30)$$

From the number of births of the three types of workers in the steady state expressed in Equations (28), (29) and (30), the inequality of income distribution only has an impact on the number of births of the unskilled labor in the early stage to the skilled labor in the current period, while the total number of births of skilled workers can be written as:

$$N_s^T = N_s + N_{us} = \frac{\beta}{\varphi}\left[\left(\frac{\delta\varphi}{\beta}-\theta\right)(1+r)+H_{us}\right] + \frac{\beta}{\varphi}\left[\frac{w_u}{w_s}\left(\frac{\delta\varphi}{\beta}\right)-\theta\right](1+i)+H_{us} \quad (31)$$

Where, N_s^T represents the number of children of skilled workers in the steady state. Substituting the definition of income distribution inequality into Equation (31) and taking the first-order partial derivative of Equation (24), we can obtain:

$$\frac{\partial N_s^T}{\partial INE} = \frac{\varphi}{\beta} \cdot \frac{\beta}{\delta\varphi} = \frac{1}{\delta} < 0 \quad (32)$$

As can be seen from equation (32), income gap will reduce fertility rate. We believe that rising inequality in income distribution has two effects on fertility. First, the income gap is too large, and low-income families who are unwilling to accept education and human capital investment will choose to reduce their fertility to obtain higher family income in the future, and thus the fertility rate will decline. Second, after income distribution inequality intensifies, low-income families willing to accept human capital investment will also reduce the number of children to control family expenditure. Therefore, the intensification of income distribution inequality has a inhibitory effect on the overall fertility level of the society. Therefore, we put forward the following proposition:

Hypothesis 3: Increasing inequality of income distribution will produce threshold effect. When the income distribution gap is small, families spend less on education, which has no obvious negative inhibitory effect on fertility. However, with the widening of income gap, families spend more on education, which has a strong inhibitory effect on fertility.

4. Measurement method and data description

4.1 Model specification and descriptive statistics

In order to test the impact of Gini coefficient and education expenditure on fertility rate（fig 3） and their interaction effect, this paper constructs the following measurement model.This study utilizes the China Statistical Yearbook database, which encompasses valid data from all provinces, autonomous regions, and municipalities directly under the Central Government for the period of 2011 to 2020. It shows that Hypothesis 1 is valid.

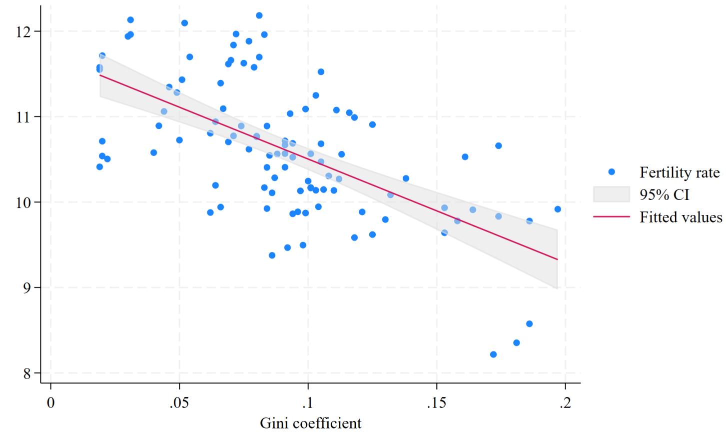

Figure.3 Gini coefficient and fertility rate

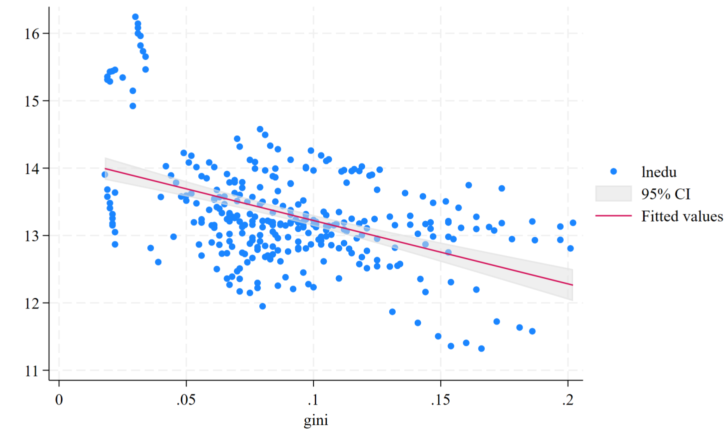

Figure.4 Gini coefficient and Education expenditure

Figure 4 shows that the widening income gap has a negative impact on education expenditure, and as the income gap widens, education expenditure declines. It shows that Hypothesis 2 is valid.

Among them, Table 1 shows the descriptive statistics, including the main explained variable, the Fertility Rate and the explanatory variable, Fertility usually refers to the average number of children born to women in a given age group over a given period of time. In the China Statistical Yearbook, Fertility can be measured by the Total Fertility Rate (TFR), which indicates the total number of children a woman is expected to have during her childbearing years. The natural growth rate is the ratio of the difference between the number of births and deaths in a given period to the average population in that period. According to the China Statistical Yearbook 2024, China's natural population growth rate in 2023 is -1.48 per thousand, indicating that China's population has experienced negative growth, that is, the number of deaths has exceeded the number of births. Gini coefficient is an important index used to investigate the difference of income distribution among residents in the world.GDP（gdp per capita），primary industry （Proportion of added value of primary industry）,financial industry （Proportion of added value of financial industry）Proportion of opening up（Ratio of imports and exports to gdp）Advances in technology（Logarithm of the number of patent applications）Unemployment rate、Edu（Logarithm of education expenditure）、Productivity（Productivity of labor）. The missing data is interpolated linearly.

China implemented the universal two-child policy in 2016, and since this paper uses the data from 2011 to 2020, in order to exclude the impact of the fertility policy on the regression results, this paper adds the year control effect in the model setting. Therefore, this paper establishes a two-way fixed effect model of province and time to investigate the impact of income gap on fertility intention. Productivity in the model represents labor productivity. Previous studies on labor productivity mostly used per capita GDP or per capita GDP of full-time employees (Hein and Tarassow, 2010; Paniagua et al., 2011), but GDP per capita cannot reflect the full picture of labor productivity, so some people use the total factor productivity indicator to replace labor production.Rate (Bussiere et al., 2005). So this study adopts total factor productivity.

We use Equation (33) to test Hypothesis 1, Where $Birth_{it}$represents ***Fertility Rate*** and $\boldsymbol{gini}$ represents inequality in income distribution. IC_{ipt} represents other control variables, and μ_p and ν_t represent fixed and time effects, respectively.

$$Fertility\ Rate_{it} = \alpha + \beta gini + \gamma \sum IC_{ipt} + \mu_p + \nu_t + \varepsilon_{pt} \qquad (33)$$

Equation (34) is used to test Hypothesis 2:

$$Fertility\ Rate_{it} = \alpha + \beta_1 Edu\left(ginip_{pt} < ginip_0\right) + \beta_2 Edu(Uginip_{pt} > ginip_0) + \gamma \sum IC_{ipt} + \mu_p + \nu_t + \varepsilon_{pt} \qquad (34)$$

Table 1 Descriptive statistics

Variable	N	Mean	SD	Min	Max
gini	310	0.091	0.04	0.018	0.202
Fertility Rate	310	10.563	1.012	2.565	12.926
Theil index	310	0.090	0.039	0.018	0.202
GDP	310	16.801	0.865	15.390	19.684
primary industry	310	9.8	5.233	0.3	25.8
financial industry	310	0.071	0.03	0.026	0.196
Opening up	310	0.269	0.287	0.008	1.464
Advances in technology	310	7.143	1.925	0	12.023
Une	310	9.717	0.941	4.927	16.75
Edu	310	13.087	0.775	9.906	16.246
Productivity	310	0.331	0.268	-0.011	1.747

4.2 Basic regression analysis

Unit root test. In order to avoid spurious regression, it is first necessary to conduct panel unit root tests on the data to test the stationarity of the variables.An empirical test of the impact of inequality in income distribution on fertility. The empirical results in Table 2 show that under the panel unit root test, all series do not have unit root and are stationary variables because.Therefore, we directly conduct regression test after taking log values of each variable. The results show that the urban-rural income gap has a negative inhibitory impact on the fertility rate, which is significant at the 99% confidence level.

Table 2 Regression of basis

	(1)	(2)	(3)
	Fertility Rate	***Fertility Rate***	***Fertility Rate***
gini	-12.135***	-14.327***	-7.072***
	(1.725)	(2.562)	(1.095)
Edu		0.724***	0 .817***
		(0.050)	(0.057)
financial industry		-0.001	-0.001***
		(0.001)	(0.000)
GDP			-0.198**
			(0.089)
Opening up			-0.213
			(0.168)
Productivity			-0.519***
			(0.157)
_cons	11.717***	12.236***	1.367
	(0.168)	(0.407)	(0.865)
N	102	102	102
Adj. R^2	0.37	0.37	0.83

Note: *The figures in the brackets are the standard errors adjusted by Robust, and *, ** and *** indicate p<0.1, p<0.05 and p, respectively*

Table 3 Introduce the cross multiplication term

	(1)	(2)	(3)
	Fertility Rate	***Fertility Rate***	***Fertility Rate***
gini	-71.254***	-61.316***	-42.571***
	(12.581)	(11.193)	(10.586)
Edu	0.375***	0.722***	0.894***
	(0.070)	(0.120)	(0.120)
gini *Edu	5.061***	4.324***	2.859***
	(0.932)	(0.843)	(0.808)
GDP		-0.253**	-0.312***
		(0.110)	(0.106)
Opening up		0.911	0.761
		(0.571)	(0.533)
Productivity		-0.237*	-0.213*
		(0.123)	(0.111)
Une		0.051	0.043
		(0.059)	(0.062)
primary industry		0.013***	0.008*
		(0.005)	(0.004)
technology			0.030
			(0.032)
financial industry			-4.990***
			(1.166)
_cons	5.929***	4.180***	3.398***
	(0.984)	(1.000)	(1.221)
N	102	102	102
Adj. R^2	0.82	0.85	0.87

Note: *The figures in the brackets are the standard errors adjusted by Robust, and *, ** and *** indicate p<0.1, p<0.05 and p, respectively*

Table 3 introduces the interaction term, which is the interaction term of logarithm of urban-rural income gap and education expenditure. First, the coefficient is significant. At 99% confidence level, the impact of urban-rural income gap on fertility is still significant, and the coefficient decreases with the increase of control variables, but the sign and significance do not change. Therefore, the increase in education expenditure will have a significant impact on the fertility, and the influence coefficient is significantly positive.

4.3 Robustness tests and threshold effects

In order to carry out robustness analysis (Table 4), firstly, this paper excludes provincial capitals and municipalities directly under the Central Government. Finally, the data are winnowed at the level of 5%. In summary, Hypothesis 1 is proved.

Table 4 Robustness test

	(1)	(2)	(3)
	Cities directly under the provincial capital are excluded	The core explanatory variables are replaced	5% windup
gini	-13.269***		-13.268***
	(1.944)		(1.943)
Theil index		-1.187***	
		(0.181)	
Other control variables	Yes	Yes	Yes
Time and the Individual	Yes	Yes	Yes
_cons	11.846***	13.662***	11.846***
	(0.207)	(0.486)	(0.207)
N	86	86	86
Adj. R^2	0.85	0.83	0.85

Note: *The figures in the brackets are the standard errors adjusted by Robust, and *, ** and *** indicate p<0.1, p<0.05 and p, respectively*

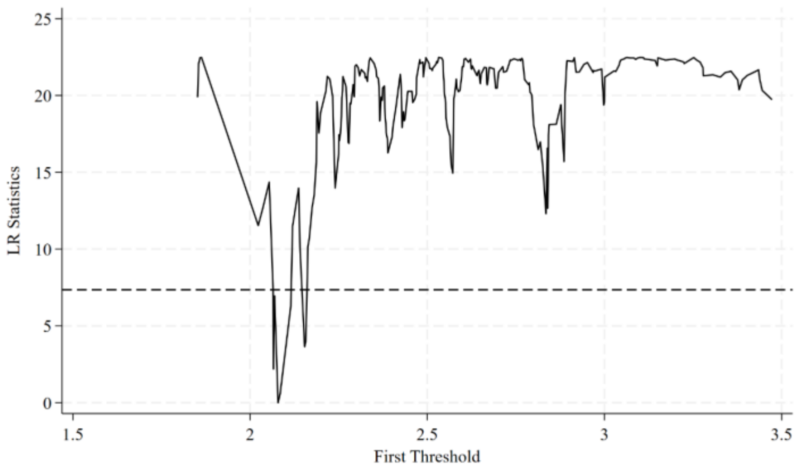

Figure.5 Threshold regression test diagram

Considering that the level of income gap can promote the increase of fertility rate to a certain extent, because low-income families have a single investment channel and can only invest in education, there will be a threshold effect. In light of the presence of a threshold effect, as illustrated in Figure 2, a threshold effect test was conducted. The results indicate the existence of a single threshold effect.

Table 5 Threshold regression

	(1)	(2)	(3)
	Fertility Rate	***Fertility Rate***	***Fertility Rate***
Edu（***Theil***＜0.154）	-1.400***	-3.203***	-3.169***
	(0.529)	(0.909)	(0.914)
Edu（***Theil***＞0.154）	-0.908*	-2.653***	-2.665***
	(0.526)	(0.906)	(0.910)
GDP		1.938**	1.954**
		(0.890)	(0.904)
Opening up		3.227	3.937
		(4.270)	(4.313)
Productivity		-5.332***	-5.153***
		(1.447)	(1.461)
Une			0.005
			(0.228)
technology			11.511
			(22.933)
financial industry			3.040
			(3.089)
_cons	17.742**	9.119	6.967
	(6.994)	(8.914)	(10.651)
N	310	310	310
Adj. R^2	0.68	0.85	0.88

Note: *The figures in the brackets are the standard errors adjusted by Robust, and *, ** and *** indicate p<0.1, p<0.05 and p, respectively*

Table 5 reports the threshold regression results, from which we can see that when the Theil index is lower than 0.154, the impact of education expenditure on the fertility rate is significantly negative, with a large value and a high degree of influence. To sum up, Hypothesis 2 is established, and the income gap will inhibit the fertility rate by affecting the family's education expenditure.

4.4 Test for endogeneity

Table 6 considers the endogeneity problem, that is, there is endogeneity between the income gap and the fertility rate, so this paper uses the instrumental variable method to solve the endogeneity problem through the two-stage least squares estimator. This paper selects the after-school tutoring expenditure as the instrumental variable, because the after-school tutoring support is related to income, and the educational resources of after-school tutoring are exogenous, which meets the conditions of instrumental variable.

Table 6 Two-stage least squares

	(1)	(2)	(3)
	Fertility Rate	***Fertility Rate***	***Fertility Rate***
gini	-32.316***	-52.596***	-38.009**
	(10.298)	(17.022)	(18.660)
Tutoring expenses	-3.826***	-2.594**	-2.638**
	(0.963)	(1.011)	(1.061)
primary industry		-0.047	-0.075
		(0.066)	(0.065)
financial industry		-40.460***	-35.332***
		(12.861)	(12.434)
Edu			0.145
			(0.445)
_cons	9.414***	14.194***	10.877
	(1.131)	(2.057)	(6.972)
N	310	310	310
Adj. R^2	0.09	0.09	0.11

Note: *The figures in the brackets are the standard errors adjusted by Robust, and *, ** and *** indicate p<0.1, p<0.05 and p, respectively*

4.5 Further Analysis

This paper further examines the implementation of the universal two-child policy introduced in 2016. It is evident that the impact of this policy has been limited. Consequently, this study introduces the concept of a "fertility trap," which refers to a situation where the fertility rate is persistently low and fertility policies have minimal effect.

Table 7 Consider the role of the universal two-child policy

	(1)	(2)	(3)
	Fertility Rate	***Fertility Rate***	***Fertility Rate***
gini	-12.771***	-8.676***	-9.148***
	(1.801)	(1.344)	(1.885)
post2016	-0.154	-0.153	0.019
	(0.132)	(0.098)	(0.117)
GDP		0.579***	0.645***
		(0.065)	(0.062)
Edu		0.244	0.203
		(0.814)	(0.793)
Productivity		-0.476***	-0.356**
		(0.128)	(0.137)
primary industry			0.023**
			(0.009)
financial industry			-4.848***
			(1.810)
Opening up			0.287
			(0.314)
_cons	11.857***	1.781*	0.637
	(0.215)	(0.992)	(0.954)
N	102	102	102
Adj. R^2	0.37	0.67	0.70

Note: *The figures in the brackets are the standard errors adjusted by Robust, and *, ** and *** indicate p<0.1, p<0.05 and p, respectively*

5. Main conclusions

By incorporating endogenous fertility decisions and education expenditures within an overlapping generations partial equilibrium framework, this paper examines the impact of income inequality on fertility rates in China. Empirical testing is conducted using provincial panel data from the China Statistical Yearbook spanning 2011 to 2020. The key findings are as follows: (1) Income distribution inequality exerts a significantly negative influence on fertility rates, which can be attributed to increased education expenditures. To enhance income, low-income families opt to invest in education under limited investment channels, leading to higher education costs and consequently lower fertility rates. (2) Considering the threshold effect of income disparity, when the income gap is relatively small, it has a positive impact on fertility rates, as indicated by the positive interaction term. (3)This paper selects the after-school tutoring expenditure as the instrumental variable, because the after-school tutoring support is related to income, and the educational resources of after-school tutoring are exogenous, which meets the conditions of instrumental variable for two-stage least squares regression. Tutoring influences income disparity but does not directly affect fertility rates, ensuring the validity of the results. Finally, this paper evaluates the effectiveness of China's two-child policy introduced in 2016, concluding that its impact was minimal. This leads to the concept of a "fertility trap," where extremely low fertility rates render government policies and measures to boost fertility ineffective. This paper posits that the government should adopt a family education expenditure perspective to reduce both educational expenses and fertility costs, thereby more effectively stimulating the fertility rate.

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