

Chinese Fertility and Economics Exploration based on Time and Space

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Abstract. Chinese fertility policy has changed from family planning to two child policy and even three child policy. China's fertility rate is declining year by year and its economy is growing rapidly. Based on the background, this paper studies the relationship between China's fertility rate and economy over time and across space, mainly focuses on the income effect of economy on fertility, and discusses the impact of national fertility policy on its relationship. This paper mainly uses the reproducible utility model of Gary S. Becker (1998) and applies the linear regression OLS model to analyze the fertility rate and per capita GDP over time and across space. According to the analysis, the fertility rate shows a downward trend with the growth of per capita GDP over time, but the rate of decline is gradually slowing down. Moreover, the impact of national fertility policy on the relationship between fertility and per capita GDP is relatively significant. Regionally, the highest fertility rate and the response of fertility rate to economic growth is in the western region, while the lowest is in the eastern region. This study reveals the income effect of China's fertility policy on the economic status of fertility. In the family planning stage, the income effect has a negative impact on fertility, while after the implementation of the second child policy, the income effect has no impact on fertility. This paper points out that the fertility policy should continue to be liberalized, so that the income effect has a positive impact on the fertility rate.

Keywords: Fertility; Income Effect; Fertility Policy; Regional Difference.

1. Introduction

1.1 The Variation in Fertility Over Time and Across Space

China has had a lot of variation in fertility across space and over time. Over time dimension, China has experienced more than 70 years of development since the founding of the people's Republic of China and Chinese fertility concept has been constantly changing. Also, the fertility concept in the eastern developed regions is more conservative than that in the western regions. From the demographic dividend period of "large number of people and great strength" to the population planning period of "eugenics and good parenthood", and then to the current two child and three child period of "advocating fertility." The fertility rate has also undergone tremendous changes. In terms of spatial distribution, as a country with a population of 1.4 billion and a land area of about 9.6 million square kilometers, Different cities of China in different development stage have different fertility regions, which can be roughly divided into Eastern China, Middle China and Western China.

In this paper, the fertility rate will be used to refer to the birth rate, which defined as the ratio of the number of births in a certain area in a certain period to the average number in the same period, expressed in thousands. The fertility rate in this data refers to the annual fertility rate.

From the national perspective, overall, the fertility rate has a downward trend over time. From 1950 to 2020, the average national fertility rate was 22.11 per 1000, and the standard deviation of the fertility rate in this seventy-one year was 9.35. From 1950 to 1957, the national fertility rate continued to be about 35 per thousand, while from 1958 to 1961, due to major natural disasters in China, the fertility rate fell sharply to about 20 per 1000. After the disaster, China's national fertility rate recovered and reached the historical maximum of 43.6 per 1000. After that, the fertility rate showed a relatively rapid downward trend in the 1970s. From the 1970s to 2000, China's fertility rate maintained a gentle downward trend. Since 2001, the trend of fertility rate has become more and more gentle, and there has been some slight rebound trend from 2010 to 2016. However, although the rate has decreased, the fertility rate still maintains a downward trend, reaching the lowest value of 8.52

per 1000 in 2020, breaking below 10 per 1000 for the first time. (Source: China National Bureau of Statistics).

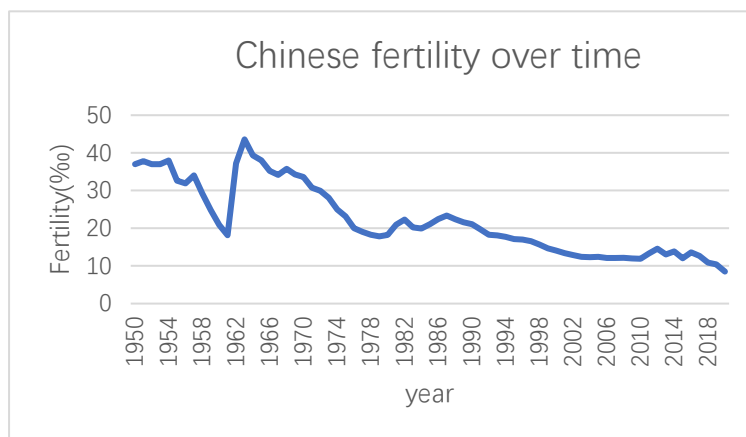


Figure 1. Chinese fertility over time

From the spatial distribution perspective, represented by the average fertility rate of 31 provinces of mainland from 2000 to 2019, on the whole, China's fertility rate increases from east to west over time. In the eastern provinces, taking the coastal areas as an example, the average fertility rate such as Beijing is 7.76, in Liaoning Province is 6.76, which is the lowest in China, and for Guangdong Province, the average fertility rate is 12.2. The fertility rate range in the eastern region is from 6.76 to 12.45, the highest one is Shandong Province. For middle provinces, the average fertility rate in Henan in the past 20 years is 12.07. In the western region, taking Xinjiang in Northwest China and Tibet in Southwest China as examples, Xinjiang has an average fertility rate of 15.40 and Tibet has a high average fertility rate of 16.49, making it the province with the highest fertility rate in China. However, there are also provinces with relatively low fertility in the West, the land in Sichuan Province is as low as 10.06, which is even lower than that in some eastern provinces. The interval of the western region is from 10.06 to 15.40. The average value of the eastern provinces which is 9.86 is lower than the average value of the western region which is 13.4. From the data, we can demonstrate that the average fertility rate in the west is higher than that in the East. (Source: China National Bureau of Statistics).

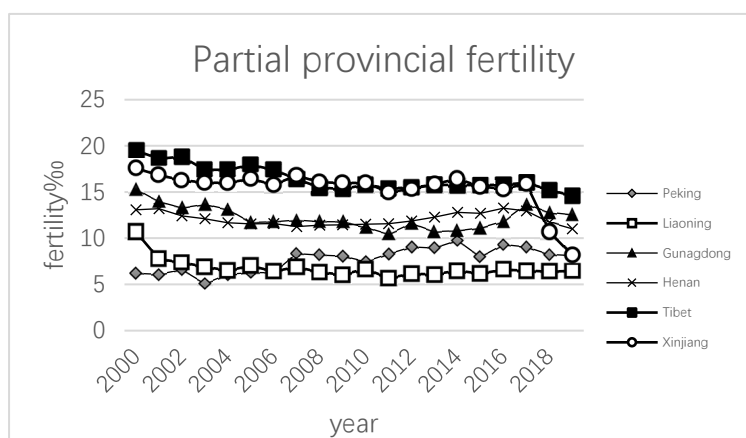


Figure 2. Trends in Partial provincial fertility

1.2 Fertility Policies Over Time

China has had changing national fertility policies over time. They can be roughly divided into four stages: encouraging fertility from 1949 to 1953, advocating family planning from 1954 to 1977,

strictly implementing family planning policy from 1978 to 2001, and the gradual relaxation of family planning since 2002. The details of the four stages are shown in the table below:

Table 1. Fertility policies

Stage	Policy
1949-1953 Stage of encouraging fertility	Birth control and induced abortion are strictly limited at this stage.
	The concept that more people is power is deeply rooted in the hearts of the people, which led to population greatly exceeding expectations in the first census in 1953.
1954-1977 Stage of advocating birth control	In 1971, the State put forward that "one cannot be less, three are more, and two are just right"
	In December 1973, the policy of "late, rare and less" was put forward in the first national family planning work report meeting.
1978-2001 Stage of strictly implementing the family planning policy	In March 1978, "the state advocated and promoted family planning" was written into the Constitution for the first time and strictly implemented throughout the country
	In October 1978, the report on the first meeting of the family planning leading group of the State Council issued by the Central Committee clearly stated that "it is recommended that a couple should have the best number of children and the maximum number of children should be two"
	In September 1980, the CPC Central Committee issued the "open letter of the CPC Central Committee to all Communist Party members and members of the Communist Youth League on controlling China's population growth", which marked the beginning of further tightening China's fertility policy and transforming the "two coincidences" in the 1970s into a policy of strictly controlling the birth of a second child and one-child
	In April 1984, the No. 7 document of the central government proposed to "open a small mouth and block a big mouth". The conditions for giving birth to a second child in rural areas can be appropriately relaxed, and it was strictly prohibited to exceed the planned second child and multiple children.
2002- Stage of gradually liberalizing family planning	In 2002, the government launched the "two children only" policy, that is, to promote one child, some second children are allowed after approval, and it is strictly prohibited to exceed the planned two children and more children
	In November 2013, the decision of the CPC Central Committee on several major issues of comprehensively deepening reform issued by the foreign ministry mentioned that "adhere to the basic national policy of family planning and start the implementation of the policy that couples with only one child can have two children", which marked the formal implementation of the policy of "two children alone"
	At the Fifth Plenary Session of the 18th CPC Central Committee in 2015, the population and family planning law was revised to "the State advocates one couple having two children" and the policy of "comprehensive two children" was launched
	In 2016 two-child policy
	2020, three children policy

1.3 The Relationship between Fertility and Economics Conditions

The purpose of this study is to explore the relationship between China's economy and fertility over time and across space. Based on the study of family economics, we use the reproductive utility model of Gary S. Becker (1998) and mainly focuses on the income effect of economic status on fertility

without involving the price effect. Therefore, the fertility rate and per capita GDP are used as key variables.

Over time, China's economy has no repeated situation of fertility and been maintained a growth trend, but the growth rate shows a downward trend with the progress of time. From 1952 to 2020, the GDP per capita increased from the 119 yuan in 1952 to 72000 yuan, of which the average value was 11299.3 and the standard deviation was 19331.89 (Source: China National Bureau of Statistics). At the same time, as mentioned above, China's birth rate has decreased over time. We aim to examine that whether the decline of China's fertility rate is related to China's economic growth and whether this relationship is related to China's fertility policy.

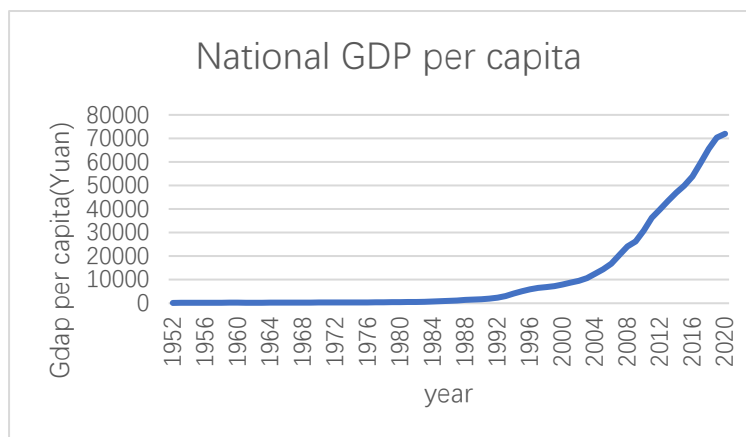


Figure 3. Trends in national GDP per capita

In terms of space, we have seen that the fertility rate in eastern China is significantly different from that in Western China, showing lower fertility in the East and higher in the West. According to China's economic situation, the average per capita GDP of the eastern region, such as Beijing, Shanghai, and Guangdong were 84151-yuan, 83291-yuan, 45901 yuan, and the eastern region had 52092 yuan respectively. The rang is from 25684 to 8415], the minimum value appeared in Hebei and the maximum value was Beijing. In the western region, the average per capita GDP in 20 years is 27225 yuan in Xinjiang, 21526 yuan in Tibet, and the total average per capita GDP of the western region is 24511 yuan, and the range in the western region is [17487, 34105], the former appears in Gansu and the latter in Chongqing. (Source: China National Bureau of Statistics). It can be seen that the economy of the eastern region is more developed than that of the western region. From this conclusion, while discussing the relationship between time, this paper will also explore the relationship between China's economy and fertility over space.

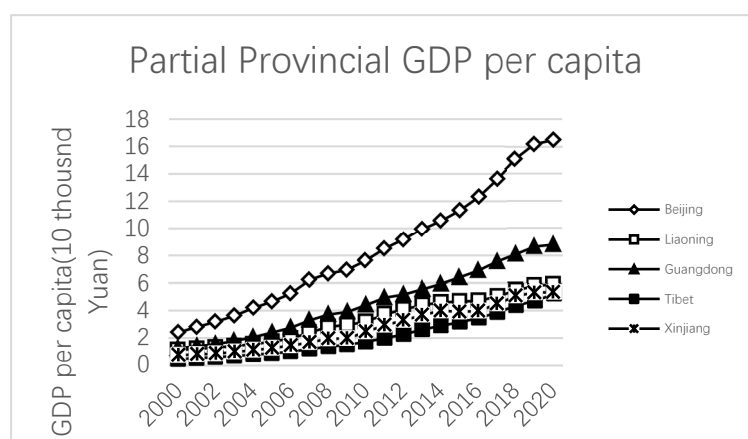


Figure 4. Trends of Partial Provincial GDP per capita

2. Literature Review

Analyzing the country's fertility rate and relationship with economic conditions which can infer further changes and guide subsequent policy changes is significant.

Some scholars have studied the fertility trend over time in China and the reasons for this trend, Guo Zhigang (2011) [1] finding that the population estimation and prediction from 1990 to 2010 overestimated the number of births and underestimated the degree of population aging. And Wang Hui et al. (2019) [2] reviewed the change process of population in New China in the past 70 years which shows that the current population aging problem is mainly caused by the low fertility. A small number of scholars have also studied the distribution of fertility in China across geographical factors. Wang Liangjian et al. (2015) [3] summarized the overall spatial distribution law of county total fertility in China through the quadrant map method which infer the northeast and eastern coastal areas are the lowest, and the southwest and South China are the highest. And Li Jianwei et al. (2018) [4] also showed that the degree of population aging and total dependency ratio in rural and underdeveloped areas in the central and western regions were significantly higher than those in urban and developed areas in the East.

Some scholars have analyzed the relationship between China's economic situation and the trend of fertility. On the one hand, fertility affects economic development under certain circumstances, Wang Wei (2017) [5] proposed that under the realistic parameters of today's China, the aging of the population has had a negative impact on household savings, human capital investment and economic growth. On the other hand, economic conditions also affect the trend of fertility, the research of Wang Weiguo et al. (2019) [6] shows that the negative substitution effect of fertility and the positive income effect of life expectancy play a decisive role in developing countries and with the improvement of the level of economic development, Du Yang (2005) [7] also showed, the positive marginal effect of the decline of fertility and the extension of life expectancy in China is receding and changing to a negative marginal effect. At the same time, some scholars have also studied the relationship between fertility and economic status in different regions of China, Yu Xiao et al. (2010) [8] concluded that the higher level of economic and social development in the eastern region (including mega cities) has significantly reduced the total fertility rate, while this effect is not obvious in the economically backward central and western regions. And Wang Jinying (2005) [9] analyzed the difference of women's total fertility rate in various regions. On the one hand, it comes from the difference of policy level, on the other hand, the level of social and economic development has a significant impact on this difference.

Combined with Chinese national conditions, many scholars believe that China's fertility policy has played a significant role on fertility and economic situation, Jiao Peng et al. (2019) [10] found that corresponding to the adjustment of population policy, China's population structure has experienced the coexistence of minority and aging after the continuous expansion of the working age population and creating a large population dividend. As for the economic situation, Guo Kaiming et al. (2013) [11] believed that with the continuous deepening of China's labor market reform, the impact of one-child policy on economic growth will gradually change from promotion to inhibition. However, Wang Wei (2017) believed that after relaxing the family planning policy, if the fertility rate does not rebound significantly, it will be conducive to economic growth. For the fertility policy in the last ten years, Wang Jinying (2016) [12] proposed the "comprehensive two child" fertility policy has slowed down the decline of the total population and labor force population to a certain extent, but the forecast results also show that the decline trend of the total population has not changed. Li Xiang (2020) [13] further considered that the implementation of the current two-child fertility policy or the further liberalization of the fertility policy can promote the fertility rate in the range of 1.5-1.8, which can promote the maintenance of high economic growth, and therefore, under the current low fertility background, after the adjustment of fertility policy, the moderate growth of fertility is conducive to economic growth.

The key issue is to select the appropriate indicators of economic and fertility in models. Some scholars have studied the model of altruistic parents in choosing fertility, Willis, Robert J (1973) [14]

deems altruistic parents choose fertility and consumption by maximizing a dynastic utility function. And we will use for reference the analysis model of fertility utility model, (Gary S. Becker (1973) [15]; Gary S. Becker (1976) [16]; Gary S. Becker (1991) [17]), *which holds that the demand for children depends on the relative price and total income of children, and divides the utility of economic conditions on fertility into price effect which is negative effect and income effect. The income effect have negatively correlated with fertility at low income level, and irrelevant or positively correlated while at high income level. At the same time, he also proposed that the reason for the negative correlation between income and fertility is that the quantity and quality of children affect each other, that is, the effective value of children increases with the increase of income.*

This paper has marginal contribution in three aspects. Firstly, this paper comprehensively analyzes the relationship between national fertility and economic status over time and across space. Secondly, this paper analyzes and compares the national fertility policy with the fertility rate and economic situation in the same period of time. Third, the time span of this paper is relatively wide. The data of the early stage of family planning, the one-child policy and the liberalization of the two-child policy are put together for an overall comparative analysis.

3. Research Design

3.1 National Relationship between Fertility and Economics Variable Over Time

This part is conducted to explore the linear relationship between fertility and GDP per capita at the national level, therefore, we estimate the effect of GDP per capita using OSL regression model for equation (1), where the birth rate in thousand for the i year which is $fertility_i$ is related to the GDP per capita for the i year and a stochastic error term μ_i which has mean 0 and is independent of GDP per capita. The variables, listed in the appendix A, includes 69 components from year 1952 to year 2020.

$$fertility_i = \beta_0 + \beta_1 * GDP \text{ per capita}_i + \mu_i \quad (1)$$

In the calculation, it is found that the regression between national fertility and per capita GDP at the time level is more suitable for exponential regression than linear regression. Therefore, this paper further makes the exponential regression between national fertility and per capita GDP on the basis of linear regression using an exponential regression model for equation (2) where the birth rate in thousand for the i year which is $fertility_i$ is related to the GDP per capita for the i year and a stochastic error term e_i .

$$fertility_i = \beta_0 * (GDP \text{ per capita}_i)^{\beta_1} + e_i \quad (2)$$

3.2 National Relationship between Fertility, Economics Variable and Timing Fertility Policy

Second, in order to compare the relationship between the national fertility rate and the economy with the implementation of the policy, the national fertility rate and economic indicators are divided into three parts, due to the limitations of data, these three zones are roughly divided according to the policy implementation year. 1952-1977 corresponds to the first two stages, 1978-2001 corresponds to the third stage and 2002-2020 corresponds to the fourth stage. The equation (3) is estimated by OSL linear regression, which expresses the birth rate in thousands, which is the $fertility_i$ in the equation, is associated with per capita GDP, per capita GDP from 2002 to 2020 and a random error term. In the equation $(2002-2020)_i$, it refers to 1 if the year is between 2002 and 2020, otherwise it is 0.

$$fertility_i = \beta_0 + \beta_1 * GDP \text{ per capita}_i + \beta_2 * GDP \text{ per capita}_i * (2002 - 2020)_i + \theta_i \quad (3)$$

In addition, according to the three different growth trends of fertility rate relative to GDP per capita in the scatter diagram, it is divided into three sections for analysis respectively. Based on the measurement of per capita GDP, the classification is divided into three stages: less than 1000, more than 1000 but less than 10000, and more than 10000. The Segmented equations (4)(5)(6) are estimated by OSL linear regression.

$$\text{fertility}_{i1} = \lambda_0 + \lambda_1 * \text{GDPpercapita}_{i>10} + \rho_i \quad (4)$$

$$\text{fertility}_{i2} = \lambda_0 + \lambda_1 * \text{GDPpercapita}_{1< i < 10} + \rho_i \quad (5)$$

$$\text{fertility}_{i3} = \lambda_0 + \lambda_1 * \text{GDPpercapita}_{i<1} + \rho_i \quad (6)$$

3.3 Provincial Relationship between Fertility and Economics Variable Cross Space

Firstly, due to China's vast territory, in order to more clearly explain the regional differences, this paper first classifies 31 provinces in Chinese mainland according to their geographical location and divides them into three categories: Eastern, central and western. Secondly, OSL linear regression is used to estimate the equations (7) (8) (9) showing the correlation between regional fertility fertility_j and regional GDP per capita GDPpercapita_j in the three regions.

$$\text{fertility}_{j1} = \varphi_0 + \varphi_1 * \text{GDPpercapita}_{Ej} + \omega_j \quad (7)$$

$$\text{fertility}_{j2} = \varphi_0 + \varphi_1 * \text{GDPpercapita}_{Mj} + \omega_j \quad (8)$$

$$\text{fertility}_{j3} = \varphi_0 + \varphi_1 * \text{GDPpercapita}_{Wj} + \omega_j \quad (9)$$

4. Data

4.1 National Fertility and Economics Variable

Table 2. National fertility and economics variable

variables	N	Mean	Stdev	median	min	max	range
Fertility (‰)	71	22.11	9.35	19.9	8.52	43.6	35.08
GDP (100million)	69	152579.18	269279.52	10376.2	679.1	1015986.2	1015307.1
GDP PER CAPITA	69	11299.30	19331.89	973.0	119.0	72000.0	1881.0

The data includes national fertility for 71 years from 1950-2020 and national economics for 69 years from 1952-2020 (Source: China National Bureau of Statistics). The fertility rate in this data refers to the annual fertility rate. Its calculation formula is: birth rate = annual birth population / annual average population * 1000 ‰. In the formula: birth number defined as live births, that is, when the fetus leaves the mother (regardless of the number of pregnancy months), it has breathed or other life phenomena. The annual average population refers to the average population at the beginning and end of the year which can also be replaced by the population in the middle of the year.

4.2 Timing Planned Fertility Policy

The timing planned fertility policy can be roughly divided into four stages according to time. From 1949 to 1953, Chinese policy encouraged people to give birth to children, therefore, China's fertility rate remained very high during this period. Between 1954 and 1977, the state began to control the fertility rate. Practice has proved that the policy has played a positive role in controlling the birth rate of Chinese population, and the rapid economic rise was accompanied by a rapid decline in fertility. From 1978 to 2001, it was the stage of strictly implementing the family planning policy. The family

planning policy experienced strict family planning and gradually relaxed in the later stage. Therefore, the fertility rate decreased slowly while the decline rate was also decreasing. Compared with the previous period, the decline rate of fertility is slower. The momentum of excessive population growth and the pressure on resources and environment has been effectively controlled and alleviated, and promoted rapid economic development and social progress, the economy grew rapidly. Since 2002, the government began to gradually relax the control of the family planning policy. At this stage, fertility was encouraged again, the decline rate of fertility slowed down further until it was almost flat, and the economy rose steadily.

4.3 The Provincial Data for Fertility and Economics Variable

We summarize the fertility rate and per capita GDP of 31 provincial administrative regions in Chinese mainland in the past 20 years and apply them to the analysis. Due to the length, the table is placed in the appendix A.

Due to the need to analyze the impact of geographical location, taking China's economic geography division standard as a reference, 34 provinces in China are divided into three parts: the East, the middle and the West. Since the fertility rate needs to be analyzed here, it is slightly different from the original standard. Eastern China includes nine regions: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong and Guangdong. Central China includes Shanxi, Inner Mongolia, Heilongjiang, Jilin, Anhui, Jiangxi, Henan, Hubei, Hunan, Guangxi and Hainan. Western China includes Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. (Source: China National Bureau of Statistics).

5. Estimates

5.1 The Empirical Results for the National Level Over Time

Table 3. The effect of national GDP per capita on the national fertility

Variable	National economics
	(1)
National economy	-0.2796 *** (0.0463)
N	69
R^2	0.3428

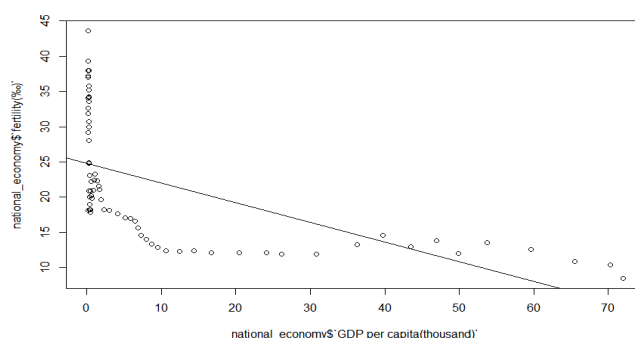


Figure 5. The line regression of fertility

According to the second column in the second row of Table 3, the factor of the linear regression is -0.28. Therefore, from 1950 to 2020, the linear regression equation between fertility and per capita GDP is $\text{fertility} = -0.28 * \text{GDP per capita} + 24.82$. From this, it is concluded that there is a negative correlation between national fertility and per capita GDP, and the fertility decreases at the rate of 0.28

for every 1000 increase in per capita GDP. From Figure 5, we can see the scatter diagram and linear regression curve between national fertility rate and economic status.

Table 4. The exponential effect of national GDP per capita on the national fertility

Variable	Naeco
	(2)
β_0	22.31205 *** (0.58909)
β_1	-0.19994 *** (0.01628)
N	69

However, it can be seen from Figure 5 that the linear regression equation is not coupled with the relationship between fertility and per capita GDP. Therefore, this paper uses exponential regression to estimate the exponential regression equation between fertility and per capita GDP again. The coefficient $\beta_0 = 22.31$ is obtained in the second column of the second row of Table 4, and the coefficient $\beta_1 = -0.2$ is obtained in the second column of the third row. Then the exponential regression equation between national fertility and per capita GDP is fertility = $22.31 * (\text{GDP per capita})^{(-0.2)}$. From this, it can be concluded that there is a negative correlation between fertility and per capita GDP, and the decline rate of fertility decreases with the increase of per capita GDP. The exponential regression curve between fertility and per capita GDP can be seen in Figure 6.

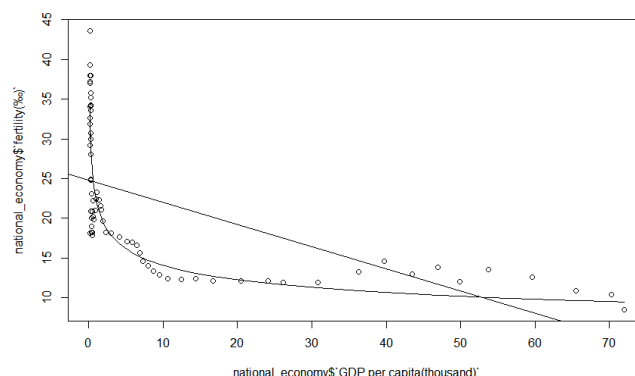


Figure 6. The exponential regression of fertility

5.2 The Empirical Results for the National Level Over Time with Timing Fertility Policy

Table 5. The effect of timing national GDP per capita on the national fertility

Variable	National economics
	(3)
B2002	-2.1178 *** (0.3441)
A2002	2.0935 *** (0.35)
N	69
R^2	0.6117

According to the estimated values obtained in the second column of the second rows of Table 5, we can see that before 2002, the linear regression estimate between fertility and per capita GDP was -2.12, which was significant and negative. From 2002 to 2020, the estimated value is $-2.12 + 2.09$, that is -0.03, less than 0.1. This connection is not obvious. It can be said that there is almost no connection between fertility and per capita GDP from 2002 to 2020. Before 2002, the fertility rate

declined with the growth of the economic situation, while in 2002 and after, the decline rate decreased significantly, and even during this period, there was little relationship between the two. Moreover, in this table, it is worth noting that t value is much greater than 2, which shows that at the national level, the relationship between fertility and per capita GDP obtained by linear regression is reliable and precise.

Table 6. The effect of partial national GDP per capita on the national fertility

Variable	Gpc<1000	1000<Gpc<10000	Gpc>10000
	(3)	(4)	(5)
Gpc	-23.183 *** (5.361)	-1.0656*** (0.08736)	-0.02458 (0.01543)
N	35	16	18
R^2	0.3423	0.9078	0.08291

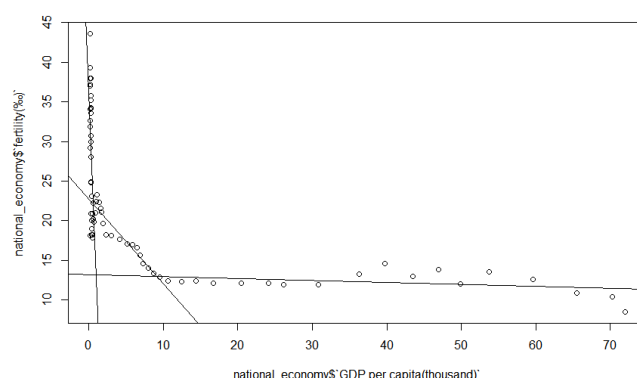


Figure 7. The different timing linear regression of fertility

The per capita GDP is divided into three parts: less than 1000, more than 1000 but less than 10000, and more than 10000. From the second column in the second row of Table 6, when the per capita GDP is less than 1000, the coefficient is -23.18, that is, when the per capita GDP is less than 1000, the linear regression equation between fertility and per capita GDP is fertility = 35.89-23.18 * GDP per capital, which shows that there is a negative correlation between the two, and when the per capita GDP increases, the fertility rate decreases at the rate of 23.18. When we couple the range of per capita GDP with time, we will find that the fertility rate decreased the fastest from 1952 to 1986, as high as 23.18. Considering the time period of the promulgation of the national fertility policy, we can see the effect of fertility policy in different periods on the relationship between fertility and economic status. we can almost ignore the policy of encouraging fertility from 1950 to 1953, because this period is too short to see the role of fertility policy in fertility and economic conditions. When we focus on 1954 to 1986, this stage just covers all the stages of advocating family planning and half the stage of strictly implementing family planning. In this half stage, almost all policies strictly implementing family planning have been fully promulgated. During this period, due to the vigorous promotion of family planning, the adherence to the policy of "late, rare and less" and the strict implementation of the one-child policy for a long time, the fertility rate decreased significantly with economic growth.

From the third column in the second row of table 6, when the per capita GDP is greater than 1000 but less than 10000, the coefficient of the linear regression equation between fertility and per capita GDP is -1.07, that is, when the per capita GDP is greater than 1000 but less than 10000, the linear regression equation between fertility and per capita GDP is that fertility = 22.68-1.07 * GDP per capital. This shows that there is a negative correlation between the two, and when the per capita GDP increases, the fertility rate decreases at the rate of 1.07. When the per capita GDP increased from 1987 to 2002, the fertility rate decreased, and the decline rate did not stop at this stage. When the time

advanced to 1987 to 2002, we can see that although the family planning policy was still strictly implemented during this period. However, since 1984, the policy has allowed the relaxation of the one-child policy under certain conditions. At the same time, when considering the implementation of the policy, we also need to consider the delay and practicality of the implementation of the policy. After the harsh family planning policy from 1954 to 1986, the decline rate of the fertility rate between 1987 and 2002 was much lower than that before. Therefore, during this period, the fertility rate decreased gently with economic growth.

Similar to the previous two groups, when the per capita GDP is greater than 10000, the coefficient of the linear regression equation between fertility and per capita GDP is -0.02, that is, when the per capita GDP is greater than 10000, the linear regression equation between fertility and per capita GDP is fertility = 13.17-0.02 * GDP per capital, This shows that there is a negative correlation between the two, and when the per capita GDP increases, the fertility rate decreases at the rate of 0.02. From 2003 to 2020, the fertility rate decreased again and reached the lowest point, which is only 0.02. After 2003, China has successively adopted the "separate two children" policy and the "comprehensive two children" policy. Even by 2020, the state will liberalize the "three child policy", and the decline rate of fertility will be much lower again. During this period, with the growth of economic conditions, the decline of fertility can be said to be very slow and close to stagn.

Figure 7 shows the scatter plot of national fertility rate and per capita GDP and the linear regression curve of three different stages. Seeing from the figure that between 1954 and 1986, that is, the line on the left in the figure is the linear regression curve of this period, and its decline rate is very large, close to the vertical. Between 1987 and 2002, that is, the straight line in the middle of the figure is the linear regression curve between fertility and per capita GDP. We can see that the decline rate is much slower than the straight line on the left, but it still shows a downward trend. From 2003 to 2020, it is the rightmost straight line in the figure. This regression curve is close to the horizontal, and its decline rate is very low.

5.3 The Empirical Results for Provincial Level Cross Space

Table 7. The effect of regional GDP per capita on the regional fertility

Variable	Eastern	Central	Western
	(7)	(8)	(9)
Gpc	-0.06892 (0.03619)	-0.1576 (0.1980)	-0.2353 (0.1395)
N	10	11	10
R^2	0.2259	-0.03801	0.1701

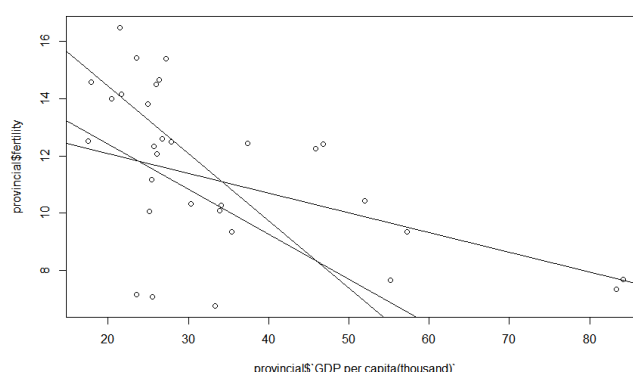


Figure 8. The different regional linear regression of fertility

Chinese mainland's 31 provinces are divided into three sub regions: the East, the middle and the West. From the second column in the second row of Table 7, when the region is Eastern, the coefficient of the linear regression equation between fertility and per capita GDP is -0.07, that is,

when the region is Eastern, the linear regression equation between fertility and per capita GDP is $\text{fertility} = 13.45 - 0.07 * \text{GDP per capital}$, which shows that there is a negative correlation between the two. And when the per capita GDP increases, the fertility rate decreases at the rate of 0.07. From the third column in the second row of Table 7, when the region is the Central, the coefficient is -0.16, that is, when the region is belongs to the Middle, the linear regression equation between fertility and per capita GDP is $\text{fertility} = 15.56 - 0.16 * \text{GDP per capital}$. This shows that there is a negative correlation between the two, and when the per capita GDP increases, the fertility rate decreases at the rate of 0.16. Similar to the previous two groups, when the region is Western, the coefficient of the linear regression equation between fertility and per capita GDP is -0.24, that is, when the region is belongs to the Western, the linear regression equation between fertility and per capita GDP is $\text{fertility} = 19.15 - 0.24 * \text{GDP per capital}$. This shows that there is a negative correlation between the two, and when the per capita GDP increases, the fertility rate decreases at the rate of 0.24. Figure 4 shows the scatter plot of national fertility rate and per capita GDP and the linear regression curve of three different stages.

It is worth noting that based on the Table 7, we can see that the linear regression estimates for the East, middle and West in the table are imprecise, which can be explained. Since the estimated value between the country's fertility rate and per capita GDP in section 5.3 is significant, that is, the time relationship in section 5.3 is reliable. At the same time, we can see that the estimated value between the country's fertility rate and per capita GDP from 2002 to 2020 is -0.02, basically the two can be regarded as having no relationship. The data we used in part 5.4 is from 2000 to 2019, and the time of these two parts is basically the same. Therefore, since the relationship between fertility and per capita GDP of the whole country is very small during this period, it is not difficult to find that the linear regression estimation between fertility and per capita GDP in the three regions is not precise.

Comparing three regions, firstly, the intercept of the linear regression model of the three regions is analyzed. Because $13.45 < 14.56 < 19.15$, the intercept of the eastern region is the smallest, followed by the central region, and the intercept of the western region is the largest, which can get the conclusion that the fertility rate of the eastern region is the lowest, the central region is the second, and the fertility rate of the western region is the first of the three regions. Secondly, the three coefficients in the linear regression equation are analyzed. The -0.07 in the eastern region is the largest, so the change of fertility in the eastern region is the most gentle, and the decline rate of fertility is the smallest under the condition of per capita GDP growth. The western region has a minimum coefficient of -0.24, which means that the fertility rate in the western region is the most sensitive to the change of per capita GDP. With the change of economic conditions, the fertility rate also changes the most violently. The coefficient of the central region is -0.16, which is between the eastern region and the western region. The fertility rate in the central region decreases at a medium level for the change of economic status. It can be concluded that the fertility rate in the eastern region is the most insensitive to the change of economic situation, while the western region is the most sensitive. In other words, when the economic situation increases, the fertility rate in the western region decreases mostly.

6. Conclusion and Policy Implications

Firstly, generally speaking, with the increase of economic conditions, the national fertility rate shows a downward trend over time, and the decline rate of fertility also shows a downward trend from 1952 to 2020. If we take 2002 as the node and compare the relationship between fertility and per capita GDP before and after 2002, the relationship between fertility and per capita GDP before 2002 is significant, and the national fertility decreases with the increase of per capita GDP. Correspondingly, after 2002, the relationship between fertility and per capita GDP is almost negligible. Starting from the quantitative value of per capita GDP which divided into three intervals it can be seen that these three intervals have a consistent downward trend of fertility with the increase of per capita GDP. The interval less than 1000 has the fastest and most significant decline rate, in terms of corresponding time, from 1952 to 1977, the fertility rate decreased rapidly and significantly

with the growth of per capita GDP. For the interval greater than 10000 but less than 10000, the decline rate slows down compared with the previous interval, but it is also significant and negative, from 1978 to 2002, fertility decreased gently with the improvement of economic conditions.. For the interval greater than 10000, the decline rate is smaller or even negligible compared with the first two intervals. Although the relationship between fertility and per capita GDP in this interval shows a downward trend, it is not significant, which can even be regarded as irrelevant. So from 2003 to now, the fertility rate has hardly changed with the change of economic conditions.

Compare the three changes in time with the national fertility policy. Between 1952 and 1977, the country experienced a stage from short-term support for fertility to long-term encouragement and control of fertility, and the fertility rate decreased significantly. Between 1978 and 2002, the country entered the stage of strictly implementing the family planning policy, and the decline rate of fertility slowed down and the fertility fell steadily. In addition, China's economy has grown significantly since 1978, therefore, from 1978 to 2002, the rate of fertility decline has been controlled, much slower than the previous one. After 2003, the state has gradually liberalized the control of family planning. However, due to the rapid economic development, and the stimulation of income effect on fertility on this basis, between 2003 and 2020, the fertility rate reached an almost stable stage. Although it has a downward trend with the rise of per capita GDP, it has been weak to a negligible extent. It can even be said that there is almost no correlation between economic conditions and fertility during this period.

We also analyzes the relationship between fertility and per capita GDP in Eastern, Central and Western three regions from 2001 to 2019 and the differences in comparison. It is worth noting that at this stage, according to the results of which is precise obtained from the time level, the analysis of the regional fertility rate in this paper is inaccurate. Then, based on this assumption, we can see that the fertility rate increases from east to west. The eastern region has the lowest average fertility rate, while the fertility rate reaches the highest in the western region. The fertility rate of the three regions has maintained a downward trend with the growth of per capita GDP. Under the economic growth, the decline rate of the average fertility rate in the eastern region is the lowest, followed by the central region, and the western region is the highest. This shows that for economic stimulus, the response of the western region is the most rapid and significant, while the eastern region is more gentle, while the central region is in the middle of the two.

This paper focuses on the relationship between fertility and per capita GDP. While per capita GDP changes, income also changes. It can be said that this paper mainly discusses the income effect of economic conditions on fertility. It proves that there is a negative correlation between fertility and income, that is, per capita GDP, at low income, while there is an uncorrelated or positive correlation at high income. Combined with the policy, it also shows that the effective value of children increases with the increase of income, which shows a sign of negative correlation between low income and fertility, which is related to the interaction between the number of children and the quality of children. To some extent, this study reveals the impact of fertility policy on the income effect of fertility in the period of China's development. When the fertility policy is conservative, the income effect is negative, while when the fertility policy is open, the income effect has no effect. Therefore, in order to further promote the recovery of fertility and improve the income effect, the future fertility policy should be further liberalized to achieve the positive impact of income effect. For further research, we should further study the price effect of economic conditions on fertility and explore the changing factors of children's quality. For example, changes in women's education, the impact of women who have attended school on the quality of children, and then affect changes in fertility.

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Appendix A

Table 8. Provincial fertility for 20 years from 2000 to 2019 (a)

	n	mean	sd	median	min	max
Beijing	20	7.67	1.32	8.09	5.10	9.75
Tianjin	20	7.65	0.70	7.66	5.84	8.75
Hebei	20	12.34	0.87	12.83	10.83	13.33
Shanxi	20	11.16	1.05	10.99	9.12	13.06
Neimenggu	20	9.35	0.71	9.39	7.72	10.77
Liaoning	20	6.76	1.04	6.49	5.71	10.70
Jilin	20	7.07	1.21	6.72	5.36	10.31
Heilongjiang	19	7.15	0.79	7.35	5.73	8.48
Shanghai	20	7.33	1.43	7.34	4.85	9.56
Jiangsu	20	9.36	0.23	9.36	9.03	9.76
Zhejiang	20	10.42	0.56	10.30	9.47	11.92
Anhui	20	12.59	0.70	12.72	11.15	14.07
Fujian	20	12.41	1.11	12.10	11.27	15.00
Jiangxi	20	13.81	0.72	13.75	12.59	15.55
Shandong	20	12.45	1.96	11.68	11.11	17.89

Henan	20	12.07	0.71	11.80	11.02	13.26
Hubei	20	10.10	1.37	10.04	8.26	12.60
Hunan	20	12.50	0.93	12.43	10.39	13.58
Guangdong	20	12.25	1.26	11.82	10.45	15.32
Guangxi	20	14.01	0.44	14.09	13.30	15.14
Hainan	20	14.66	0.51	14.66	12.87	15.67
Chongqing	20	10.28	0.75	10.10	9.17	11.77
Sichuan	20	10.06	0.88	9.89	8.93	12.10
Guizhou	20	14.58	2.10	13.78	12.98	20.59
Yunnan	20	14.17	2.19	13.13	12.53	19.05
Tibet	20	16.49	1.38	15.80	14.60	19.50
Shanxi	20	10.32	0.35	10.24	9.73	11.11
Gansu	20	12.53	0.84	12.48	10.60	14.38
Qinghai	20	15.44	1.64	14.71	13.66	19.25
Ningxia	20	14.51	1.30	14.23	12.62	16.55
Xinjiang	20	15.40	2.17	15.99	8.14	17.57

Table 9. Provincial fertility for 20 years from 2000 to 2019 (b)

	n	mean	sd	median	min	max	range
Beijing	21	84151.05	44704.18	76269.11	24030.79	164927.36	140896.57
Tianjin	21	55157.72	28914.04	52585.07	15901.10	101540.74	85639.64
Hebei	21	25684.94	13912.25	25025.85	6934.67	48528.21	41593.54
Shanxi	21	25420.47	14502.86	24912.98	5684.32	50549.54	44865.22
Neimenggu	21	35369.50	22455.08	33171.12	6488.62	72182.12	65693.50
Liaoning	21	33320.38	16382.44	31762.97	11159.42	58969.24	47809.82
Jilin	21	25532.39	15473.33	23336.37	6530.20	51147.90	44617.70
Heilongjiang	21	23558.61	12110.24	21675.71	7500.66	43009.42	35508.76
Shanghai	21	83291.43	40966.06	77791.58	29908.02	155611.58	125703.56
Jiangsu	21	57278.09	36880.77	52591.05	11674.22	121202.36	109528.14
Zhejiang	21	51954.01	28578.58	50302.74	13172.65	100067.06	86894.41
Anhui	21	26792.09	19386.03	22242.40	5129.33	63379.65	58250.32
Fujian	21	46811.51	31450.47	40624.15	11039.59	105690.66	94651.07
Jiangxi	21	24949.31	17384.43	21029.13	4827.91	56852.18	52024.27
Shandong	21	37369.53	21577.91	35380.16	9199.93	72026.99	62827.05
Henan	21	26103.51	16842.15	24088.25	5325.67	55345.78	50020.10
Hubei	21	33898.71	24444.16	28329.09	6279.49	76647.55	70368.06
Henan	21	27842.89	19398.87	23705.18	5412.22	62886.06	57473.84
Guangdong	21	45901.81	24818.24	44004.02	12497.34	87898.50	75401.16
Guangxi	21	20479.81	13495.01	18551.84	4378.03	44198.48	39820.46
Hainan	21	26355.91	16644.04	23250.86	6676.81	54884.92	48208.11
Chongqing	21	34105.34	24088.55	27955.98	6395.58	78011.86	71616.28
Sichuan	21	25175.90	17764.04	21410.57	4716.29	58083.90	53367.61
Guizhou	21	17945.99	14555.71	12989.36	2742.01	46230.81	43488.80
Yunnan	21	21691.60	15484.78	16808.56	4786.84	51942.17	47155.33
Tibet	21	21526.78	14882.68	17096.67	4565.89	52128.77	47562.88
Shanxi	21	30362.64	21351.33	26359.30	4950.60	66232.99	61282.38
Gansu	21	17487.54	10823.31	15405.08	4186.48	36037.97	31851.49
Qinghai	21	23579.20	15565.38	20323.27	5100.58	50775.34	45674.76
Ningxia	21	26010.88	16653.98	24829.38	5324.91	54451.39	49126.48
Xinjiang	21	27225.89	15981.26	24531.81	7374.80	53375.63	46000.83