Study on Regional Differentiation of Quantitative and Qualitative Dividends of Population under Economic Growth Objectives Based on Panel Models and Nonparametric Kernel Estimation

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Abstract. In this paper, on the basis of combing through the relevant studies and theories in the field of China's demographic dividend, provincial panel data of 31 provinces, autonomous regions, and municipalities directly under the central government (excluding Hong Kong, Macao, and Taiwan) in China for the period of 2010-2020 are selected. Firstly, China's demographic dividend and the current situation of economic development are analyzed, and then panel regression models and non-parametric kernel regression models are constructed to explore the relationship between the demographic dividend's impact on economic growth in terms of both population size and population quality, while long-term equilibrium and short-term volatility are taken into account to realize the analysis of large-scale panel data. The empirical results show that China's population quantity dividend is disappearing, while the population quality dividend is increasing. The population quality dividend has a significant positive impact on economic growth, while the population quantity dividend has a convergence in relatively less economically developed regions. However, both the population quantity dividend and the population quality dividend have significant differences among different provinces. Based on the above theoretical analysis and empirical research, this paper puts forward some suggestions, including optimizing the population structure, improving the population quality, and rationally allocating regional resources. It is hoped that the relevant government departments can seize the current opportunities and advantages, strive to realize the transformation of population size and the improvement of population quality, and actively develop the demographic dividend.

Keywords: demographic dividend, economic development, panel regression model, nonparametric kernel regression.

1. Introduction

The population issue is an important factor affecting China's modernization process and a strategic issue related to the great rejuvenation of the Chinese nation. The report of the twentieth CPC National Congress clearly stated that Chinese-style modernization is a modernization with a huge population, and called for research into the issue of supporting Chinese-style modernization with high-quality population development.

China is the most populous country in the world, and population plays an important role in economic development. Since the founding of New China, China's economy has made a historic leap from poverty and backwardness to the world's second-largest economy, which is closely related to changes in the growth and structure of its population. After the reform and opening up, China implemented the family planning policy, effectively controlling the population growth rate, and at the same time, with the improvement of people's living standard and medical service level, the birth rate and death rate have dropped significantly, forming a population structure of "young and old, small and adult". This structure has led to a significant reduction in the social dependency ratio, providing a demographic dividend for economic development and social progress.

However, this demographic dividend is not permanent, and as the demographic transition deepens, China faces serious challenges such as low fertility, aging, and a declining labor force. According to the international community's standard for the division of an aging society , China has officially entered an aging society in 2000; after the full liberalization of the two-child policy in 2016, the birth population did not reach the expected level; at the end of 2022, China experienced negative population growth for the first time in nearly 61 years. These phenomena show that China's demographic dividend is gradually disappearing, and may even be transformed into a demographic liability, which adversely affects economic growth. Therefore, how to cope with the decline and transformation of the demographic dividend and how to promote the transformation and upgrading of the mode of economic growth are major issues that need to be urgently addressed in China at present.

2. literature review

Many scholars have studied the impact of demographic change, especially population aging, on economic growth. Sun Aijun and Liu Shenglong (2014) found through sample analysis that economically developed regions have a greater contribution to the contribution of demographic change to economic growth, but there is still a positive and significant impact at the national level. Che Shiyi, Chen Wei and Guo Lin (2011) point out that although China is still enjoying a demographic dividend, many regions face the challenges of aging and low fertility. A study by Liu, Kaihao and Liu, Yulin (2014) found that demographic change is an important factor affecting economic growth globally and is difficult to be replaced.

China is a country with a large population and an early release of the demographic dividend, but Barsukov, Zhang Guangxiang, and Shicheng (2021) point out that China is now facing a transition of population aging, a systemic transition that will have far-reaching impacts on, among other things, the labor force and the consumer market.Jones (2020) also argues that a declining population will result in a contraction of the labor market, which will impede economic development.

In the past few decades, scholars studying population-economy interactions have explored the concept, scope, path and effects of the "demographic dividend". Cai Fang and Wang Dewen (1999) first proposed the concept of "demographic dividend", arguing that under appropriate conditions, demographic dividend can increase labor supply, release potential, and promote economic growth. Wang Jinying and Yang Lei (2010) used empirical methods to analyze the timing of China's demographic transition and the contribution of the demographic dividend to China's economic growth, and found that the demographic dividend has a huge role in promoting economic growth, but its effect is gradually declining, and it is necessary to further promote the industrial upgrading and enhance the development of the intellectual field in order to improve labor productivity and maintain economic prosperity.

Human capital, as a direct element of population quality dividend, plays an important role in economic growth. As early as 1960, T. W. Schultz put forward the concept of human capital investment, arguing that education and skills training are a kind of investment in human capital, which is crucial for both social and economic development.

In recent years, many studies at home and abroad have also supported this view. For example, Yang Jianfang, Gong Liutang and Zhang Qinghua (2006) constructed a neoclassical growth model incorporating investment in education and health, verifying the importance of investment in education and health in realizing economic growth and social progress. Yang Chenggang and Yan Dongdong (2017) analyzed the impact of the quality and quantity of human capital on cultivating high-quality workers and promoting technological progress in terms of the changing trend of the demographic dividend effect. The results of the study are consistent with the conclusions of Yang Jianfang et al. (2006) that investment in education and health is crucial to the formation of human capital and the impact of economic growth.

3. Methodology

3.1 Overall Research Design

This study will use a variety of research methods, including literature analysis, historical analysis, statistical modeling, the combination of normative and empirical analysis, and comparative analysis, in order to comprehensively and deeply investigate the impact of China's demographic dividend on economic development.

First, through the literature analysis method, relevant domestic and foreign literature is collected using online databases, such as China Knowledge Network, in order to learn the relevant theories and the latest research dynamics on the impact of demographic dividend on the economy. In addition, the research is supplemented by consulting Internet resources to ensure comprehensiveness and timeliness.

Second, the historical analysis method is used to analyze the trend of China's demographic structure change as well as the reasons for the demographic dividend and the future trend of change by applying historical population data. By exploring the laws of population historical evolution and the intervention of national family planning policies, the demographic transition in China is understood in depth.

Next, a statistical modeling approach is used to first collect the necessary data using data sources such as statistical yearbooks and conduct descriptive analysis. Subsequently, considering the role of long-run equilibrium and short-run fluctuations, the impact of China's demographic dividend changes on economic growth is comparatively analyzed from two perspectives: parametric linear regression and nonparametric kernel regression. This approach will provide a basis for quantitative analysis and reveal the correlation between demographic dividend and economic development.

Meanwhile, this study will comprehensively utilize the normative analysis method and empirical analysis method. The normative analysis method is used for theoretical analysis to explore the impact of China's demographic dividend on economic development; the empirical analysis method verifies the relationship between the demographic dividend and economic development by incorporating the demographic dividend's metrics into statistical models. Through the combination of these two methods, the scientificity and expandability of the study are enhanced.

Finally, the comparative analysis method is used, including vertical comparison and horizontal comparison. Through vertical comparison, researchers will analyze the changes of demographic dividend in different periods in the same region; while horizontal comparison will focus on the differences of demographic dividend between different regions at the same point in time. This study will analyze in detail the demographic dividend and the status of economic development of each province in China, and divide China into different echelons of regions in order to study the impact of the demographic dividend on economic development in different regions and to propose targeted policy recommendations.

To sum up, this study will adopt a variety of research methods to comprehensively and deeply study the impact of China's demographic dividend on economic development by comprehensively analyzing domestic and foreign literature, historical data, statistical modeling, normative and empirical analysis, and comparative analysis.

3.2 Data source and description

The original data come from China Statistical Yearbook and statistical yearbooks of provinces (autonomous regions and municipalities), and some data are missing or unpublished, which are obtained by interpolation method or historical data calculation in this paper. After finishing, the final panel data structure is shown in the following Table 1, which contains 31 individuals, 11 years of observation data, and 3 variables, and is a balanced panel dataset.

Table 1. Descriptive statistics of the sample data

Name	Minimum	Median	Mean	Standard Deviation
Pgdp	12882	43956	51266	27077.9
LnPgdp	9.464	10.691	10.730	0.4692
Td	19.27%	37.15%	36.95%	0.0671
Edu	5.69%	20.40%	22.85%	0.1168

3.2.1 Dependent Variables

Through the histogram of GDP per capita (Figure.1) It can be seen that the data shows a right-skewed distribution, so we logged the data to arrive at a new distribution that can be approximated as a normal distribution.

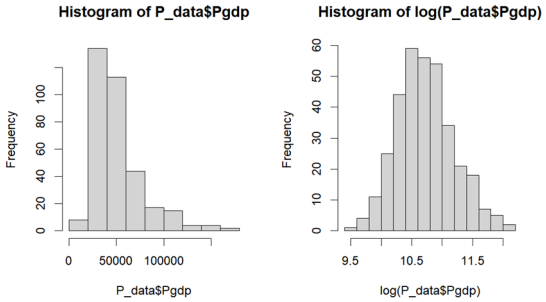

Figure 1. Distribution of GDP per capita with logarithmic treatment

3.2.2 Independent variables

Plotting a scatter plot in Figure.2 to observe the relationship between GDP per capita and each numerical variable, it is found that there is a clear positive correlation between the ratio of high school education and above to the population aged 6 and above and GDP per capita, while there may be some negative correlation between the total dependency ratio and GDP per capita.

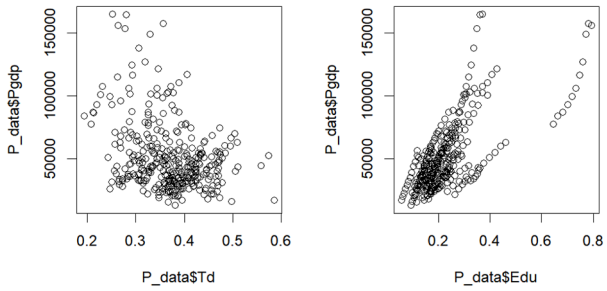

Figure 2. Scatterplot of GDP per capita versus total dependency ratio and proportion of population aged 6 and over with a high school education and above

3.2.3 Control variables

Plotting a box-and-line graph (Figure.3) to observe the trend of each variable over time, it is found that GDP per capita and the percentage of population aged 6 and above with a high school education and above show an increasing trend over time, while the trend of the total dependency ratio over time could not be detected intuitively.

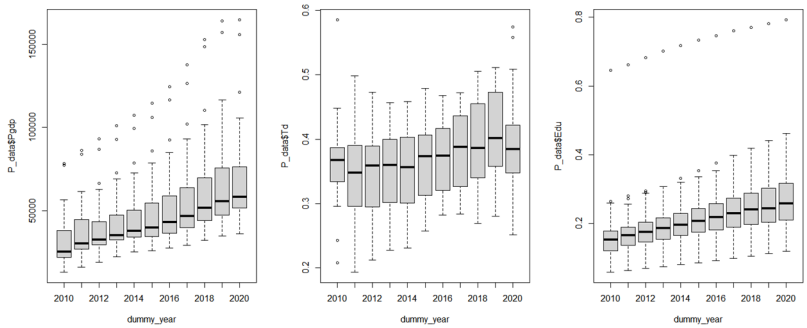

Figure 3. Distribution of variables by year

Plotting a box-and-line diagram (Figure.3) to observe the distribution of each variable in each province and sorting the variables by their means, we find that the per capita GDP of Beijing and Shanghai is significantly higher than that of other provinces, while Gansu and Guizhou lag behind; the total dependency ratio of Guangxi and Guizhou is higher, while the total dependency ratio of Beijing and Shanghai is lower; and the ratio of senior high school education and above to the population of 6 years old and above is higher in Shanghai and Hunan, while the Tibet and Guizhou The proportion is relatively low in Tibet and Guizhou. Overall, the more economically developed regions have lower total dependency ratios and higher ratios of senior secondary education and above to the population aged 6 and above. That is to say, there is a certain negative correlation between GDP per capita and the total dependency ratio, and a certain positive correlation with the proportion of people aged 6 and over with a high school education and above.

3.2.4 Regional division

On the basis of having an understanding of the situation in each province, we divided provincial units with similar levels of economic development into one category to prepare for the next empirical analysis. We divide the echelons based on the average GDP per capita of each province, and the division results are as follows:

First echelon (GDP per capita: 25,000-30,000): Beijing, Shanghai.

Echelon 2 (GDP per capita: 20,000-25,000): Fujian, Jiangsu.

Third tier (GDP per capita: 15,000-20,000): Tianjin, Chongqing, Guangdong, Hubei, Zhejiang.

Fourth tier (GDP per capita: 12,500-15,000): Shaanxi, Anhui, Inner Mongolia.

Fifth tier (GDP per capita: 10,000-12500): Tibet, Yunnan, Guizhou, Sichuan, Shandong, Jiangxi, Hunan.

Sixth tier (GDP per capita: 5000-10000): Guangxi, Xinjiang, Ningxia, Qinghai, Gansu, Heilongjiang, Hainan, Jilin, Liaoning, Shanxi, Hebei, Henan.

4. Result

4.1 Panel Regression Results

We estimate the model using the ordinary least squares method and the estimation results are as follows in Table 2:

Table 2. Model regression results

lny	Coef.	St. Err.	t-value	p-value	[95%Conf	Interval]	Sig
Td	-.275	.199	1.38	.0966	-.114	.664	*
Edu	3.488	.19	28.92	0	5.116	5.86	***
Constant	9.49	.075	126.88	0	9.343	9.636	***
Mean dependent var		10.775	SD dependent var			0.446	
Overall r-squared		0.612	Number of obs			310	
Chi-square		848.187	Prob > chi2			0.000	
R-squared within		0.787	R-squared between			0.584	

*** p<.01, ** p<.05, * p<.1

The model has a goodness of fit R^2 of 0.787, and there is no heteroskedasticity and all the variables are also significant. The final panel regression model is obtained: The model has a goodness of fit R^2 of 0.787 and there is no heteroskedasticity and all the variables are also significant. The final panel regression model is obtained:

$$\widetilde{\ln y}_i = 9.49 - 0.275\mathrm{Td}_i + 3.488\mathrm{Edu}_i + u_i \ , \qquad i = 1,2,\dots,31 \tag{1}$$

At the same time, this paper also does a regression analysis of the impact of the demographic dividend on economic development in each province to compare the differences between different provinces.

4.1.1 Population size

From the regression model in Table 3 and Table 4, it can be seen that for the 31 provinces, the indicator representing the number of labor force and the pressure of dependency on the labor force (total dependency ratio) is estimated by the least squares method to be -0.257, a level that represents the negative contribution of the total dependency ratio to the economic growth at the national average, which is in line with the conclusions that we have obtained in the theoretical part of the study.

Table 3. Comparison of the impact of the total dependency ratio by province

province$_i$	**Td Coef**	**province$_i$**	**Td Coef**	**province$_i$**	**Td Coef**
1Beijing	-.112*	11Anhui	-.062**	21Xinjiang	.213**
2Shanghai	-.181**	12Neimenggu	-.045*	22Ningxia	-.019*
3Fujian	-.244*	13Xizang	-.435*	23Qinghai	.285**
4Jiangsu	-.207	14Yunnan	-.603	24Gansu	.145**
5Tianjin	-.858***	15Guizhou	-.511	25Hainan	.466*
6Chongqing	-.909	16Sichuan	-.462**	26Henan	.258
7Guangdong	-1.056*	17Shandong	-.482*	27Heilongjiang	.359***
8Hubei	-.827**	18Jiangxi	-.614*	28Jilin	.297***
9Zhejiang	-1.29***	19Hunan	-.582	29Liaoning	.306**
10Shanxi	-.039**	20Guangxi	.304***	30Shanxi	.299*
				31Hebei	.416*

*** p<.01, ** p<.05, * p<.1

4.1.2 Population quality

Table 4. Comparison of the Impact of the Percentage of the Population Aged 6 Years and Over with a High School Diploma and Above, by Province

province$_i$	$Edu\ Coef_i$	province$_i$	$Edu\ Coef_i$	province$_i$	$Edu\ Coef_i$
1Beijing	5.214***	11Anhui	3.539*	21Xinjiang	3.053*
2Shanghai	5.519**	12Neimenggu	4.054*	22Ningxia	2.846**
3Fujian	3.123**	13Xizang	5.109	23Qinghai	3.532***
4Jiangsu	2.921*	14Yunnan	4.670*	24Gansu	2.715
5Tianjin	4.091*	15Guizhou	4.273	25Hainan	3.005
6Chongqing	4.214*	16Sichuan	5.025	26Henan	2.726*
7Guangdong	3.202***	17Shandong	5.446*	27Heilongjiang	2.284
8Hubei	3.121**	18Jiangxi	4.310	28Jilin	2.591**
9Zhejiang	4.321**	19Hunan	4.832***	29Liaoning	3.124*
10Shanxi	4.246*	20Guangxi	3.429*	30Shanxi	2.260
				31Hebei	2.248*

*** p<.01, ** p<.05, * p<.1

4.2 Non-parametric kernel regression analysis

4.2.1 Modeling

Modeling non-parametric regression $\overrightarrow{y_i} = m(\overrightarrow{x_i}) + \epsilon_i$, $m(x) = E(Y|X = x)$ is an estimate obtained with a given sample. In this paper, the kernel regression smoothing method will be used, i.e., weighted for averaging according to the kernel function.

$$\widetilde{f(x)} = \frac{1}{h}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right) \tag{2}$$

This article uses the Epanechikov kernel function

$$\mathrm{K(u)} = \frac{3}{4}(1 - \mathrm{u}^2)\mathrm{I}(|\mathrm{u}| \le 1) \tag{3}$$

A weighted calculation is performed; the bandwidth is also selected using the cross-corroboration method and the optimal bandwidth is calculated by the improved AIC.

4.2.2 Model solving

This paper is based on the results of the regional division of China's 31 provinces in the previous chapter, and then from the short-term fluctuations and long-term equilibrium of the two aspects of the establishment of non-participating kernel regression model, the goodness of fit of all the models are better, R^2 are more than 0.83, and get the following regression results in Table 5 and Table 6.

4.2.2.1 Population size

Table 5. Comparison of the degree of impact of the total dependency ratio by echelon

Time	First	Second	Third	Fourth	Fifth	Sixth
2011-2015	-0.147	-0.230	-0.234	-0.837	0.432	0.989
2011-2016	-0.220	-0.221	-0.722	-0.960	0.498	0.903
2011-2017	-0.262	-0.282	-0.708	-0.599	0.504	0.854
2011-2018	-0.599	-0.376	-0.920	-1.128	1.932	0.724
2011-2019	-0.471	-0.239	-0.022	-1.118	-0.378	0.512
2011-2020	-0.158	-0.236	-0.979	-0.493	-0.520	0.321

There are significant differences in the estimates of this parameter across the tertiles, with an overall downward trend in the coefficient of this variable within each tertile; across the tertiles, the impact of the total dependency ratio is consistently negative for tertiles 1 through 4, while the impact of the total dependency ratio shifts from positive to negative for tertiles 5 and 6.

4.2.2.2 Population quality

Table 6. Comparison of Impact Levels of Percentage of Population Aged 6 and Over with Higher Secondary Education and Above by Gradient

Time	First	Second	Third	Fourth	Fifth	Sixth
2011-2015	5.266	4.507	3.835	3.093	8.553	0.286
2011-2016	5.592	4.214	3.722	3.583	7.527	0.537
2011-2017	6.116	4.374	3.824	3.802	6.029	0.645
2011-2018	6.658	2.897	4.253	4.443	7.272	0.681
2011-2019	6.901	3.783	3.720	4.512	7.459	1.053
2011-2020	6.525	3.690	4.381	4.379	5.170	3.323

5. Conclusion

5.1 Optimizing population structure

5.1.1 Utilizing the Promotional Role of Relaxed Fertility Policies

After the implementation of China's family planning policy, the fertility rate has dropped significantly, leading to a sharp decline in the number of newborns and even negative population growth. With the improvement of health care and quality of life, the elderly population base is gradually expanding, and the problem of insufficient supply of reserve labor is becoming more and more prominent, which may constrain the sustained growth of the economy. To improve the age structure of the population, the government should implement targeted policies. Although China implemented the "three-child" birth policy in 2021, it has not achieved the expected results. Therefore, the government can increase the willingness to have children through economic and policy incentives. For example, while extending women's maternity leave, the same maternity leave should be given to men in the family, emphasizing the responsibility and role of fathers in childcare.

5.1.2 Improving the old-age security system

In addition to increasing the proportion of young children in the population, the government should also strengthen its focus on the elderly population. It should promote the optimization of the pension insurance system and upgrade and improve the pension security system. Government departments should strategically and comprehensively plan public services for the elderly population, upgrade and

optimize the pension insurance system, and accelerate the pace of reform and strengthen innovation. The construction of the basic old-age insurance system should be promoted uniformly nationwide, and the design of the basic old-age insurance system should be flexibly adjusted according to the actual situation of different regions and families. In addition, the construction of senior citizen activity centers and the establishment of community medical and health service stations provide timely medical assistance and daily health assessment and other services.

5.1.3 Promoting full employment and alleviating labor shortage

An increase in the labor force population is the key to the demographic dividend. In order to alleviate the current problem of the gradual disappearance of the demographic dividend, it is possible to cope with it by increasing the number of employed people. For example, reducing the employment pressure on college students and providing more employment opportunities; flexible delayed retirement policies to encourage the elderly to remain employed; and providing re-employment opportunities and training programs for the elderly. These measures will help alleviate the labor shortage problem and maintain sustained economic growth.

5.2 Improving the quality of the population

The government should further increase its investment in education to promote the full utilization of educated human capital and facilitate economic growth. It should emphasize the cultivation of practical skills and raise the level of high-quality education; rationally allocate educational resources, promote the equalization of educational opportunities, and strengthen investment in basic education in impoverished areas.

5.3 Rational allocation of regional resources

5.3.1 Strengthen inter-provincial human resources interaction and rationally allocate labor resources

Due to China's uneven regional development, the arrival time of the demographic dividend is different. It is necessary to strengthen the flow of labor resources between the east and west, and transfer labor from the west to the east to achieve the optimal allocation of labor resources. Deepen the reform of the household registration system, promote the rural population to enter the cities, promote labor mobility, and introduce corresponding preferential policies to accelerate labor mobility and further expand the benefits of the demographic dividend.

5.3.2 Adjust and optimize socio-economic structure

Provinces should improve the allocation of resources in all aspects, including talents and capital, according to the actual situation, and make a reasonable proportion between different industrial structures. They should focus on solving the problems of unscientific industrial structure and the return of migrant workers to their hometowns, so as to adjust and optimize the socio-economic structure.

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