

Research on the contribution rate of higher education to economic growth in the Yangtze River Delta

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Abstract: Based on the C-D growth function and utilizing the Denison factor analysis method, this paper calculates the contribution rate of higher education in the Yangtze River Delta region, consisting of three provinces and one municipality, to economic growth from 2002 to 2021. The results indicate that higher education in the Yangtze River Delta region plays a crucial role in driving economic growth, with contribution rates exceeding 4% consistently. While the educational levels in the three provinces and one municipality have improved, and the educational structure has been optimized, there are variations in the contribution rates of higher education to economic growth, with Shanghai standing out prominently. Therefore, the Yangtze River Delta region should increase the duration of education, enhance the overall level of education, continuously optimize educational institutions, improve the overall educational quality, strengthen regional cooperation and communication, promote knowledge sharing, and foster economic development.

Keywords: Yangtze River Delta; Higher education; Economic growth.

1. Introduction

In the current globalized and market-oriented economic environment, higher education has become one of the critical factors for national and regional economic development. As the economy continues to grow, and higher education becomes more widespread, many countries are increasing their investments in higher education. The Yangtze River Delta region in China is one of the most economically developed areas, where the role of higher education has become increasingly prominent in the region's economic development. However, there are differences in the development of higher education and its contribution to economic growth among provinces and municipalities. This paper aims to use the C-D growth function as a foundation, apply the Denison factor analysis method to compare and analyze the contribution rates of higher education to economic growth in the three provinces and one municipality in the Yangtze River Delta region, and propose relevant policy recommendations based on the available data.

2. Literature Review

2.1. Research on the Relationship between Higher Education and Economic Growth

The relationship between higher education and economic growth has been the subject of extensive research by scholars both domestically and internationally, employing various methodologies. Internationally, the exploration of this relationship traces back to the 1960s when Denison proposed that the level of education among the workforce impacts economic growth. Gemmell (1996) found that higher education had a more significant impact on economic development in developed countries, whereas basic education played a more prominent role in less developed nations [1]. Lussiana T (2013) employed mathematical models and investment return theory to discuss the relationship between higher education and regional economic growth from the perspectives of individuals, households, and governments, offering recommendations on how to align higher education

with regional economic growth [2].

Research on the interrelationship between higher education and economic growth emerged relatively later in China, but it has yielded rich findings. Chen Junsheng and Liu Yirong (2008) compared relevant data in China with that of developed countries and found that, in comparison, higher education in China made a lower contribution to economic growth. The primary reasons for this phenomenon were insufficient investment in higher education and lower levels of educational attainment among the workforce [3]. Xia Yan and Cui Yuping (2016) studied the application of quantitative analysis theory to the relationship between regional economic growth and higher education, discovering that changes in higher education investment and income were consistent with the degree and temporal-spatial coordination of regional economic growth [4]. Fan Xing and Ma Shucai (2017) used human capital theory to construct a model for calculating the contribution of education to economic growth and found regional disparities in the contribution of higher education to economic growth, emphasizing the need for tailored development strategies in higher education [5].

2.2. Research on the Contribution Rate of Higher Education to Economic Growth

Developed countries have long emphasized the accumulation of human capital and conducted early research on the contribution rate of education to economic growth, with notable figures such as Schultz and Denison. As early as 1961, Schultz used the method of education investment return rate to estimate that education's contribution to the Gross National Product of the United States between 1929 and 1957 was 33%. Denison (1962) found that education's contribution to U.S. economic growth was 12% between 1909 and 1929, increasing to 23% between 1929 and 1957, nearly doubling due to an improvement in the education level of the workforce [6]. Kusev Petko (2016) employed the VAR model and various methods to establish a theoretical model of the relationship between economic growth and higher education investment, exploring the dynamic relationship between higher education and economic growth [7]. Goos Mieke

(2018) utilized an optimized S-shaped principal component analysis to comprehensively evaluate economic growth and higher education systems, comparing regional differences and assessing the degree of coordination in different regions, elucidating the reasons for and issues of the uneven development of higher education and regional economic growth [8].

As China enters a new historical development period, education, particularly higher education, as a strategic focus of economic and social development, has attracted scholars' attention regarding its contribution to economic growth. Domestic scholars researching the contribution of higher education to economic growth have predominantly employed Western research methods. Cui Yuping (2001) estimated China's contribution rate of higher education to economic growth early on, using the Denison factor analysis method, calculating a contribution rate of 0.48% between 1982 and 1990 [9]. Yang Tianping and Liu Zhaoxin (2014) employed quantitative methods and calculated that between 2001 and 2011, higher education contributed 3.62% to China's economic growth [10]. Cai Wenbo and Wang Bangquan (2014) calculated the contribution rate of higher education to economic growth in twelve provinces, autonomous regions, and municipalities in the western region between 1998 and 2011, finding variations among regions [11]. He Yinjuan (2022) used the Denison economic growth factor model to quantitatively calculate the contribution rate of higher education to economic growth in six central provinces between 2004 and 2019, revealing significant disparities in contribution rates [12]. Wu Lin (2016) calculated a contribution rate of only 0.73% for higher education to economic growth in the Yangtze River Delta region between 2001 and 2013, excluding Anhui province from the analysis [13]. In addition, many scholars have conducted research on the contribution rate of higher education to economic growth in specific provinces and cities.

2.3. Literature Review Summary

In summary, previous scholars' research has consistently demonstrated the positive impact of higher education on economic growth, and specific contribution values have been calculated. Although scholars have used various methods, the Denison factor analysis method has garnered significant recognition in calculating the contribution rate of education to economic growth. While domestic research on this topic began later than international research, it has shown promising progress. With the expansion of university enrollment, China has seen a surge in research outcomes. However, there are also limitations. First, some scholars defined higher education as undergraduate and above, excluding colleges, which may introduce significant errors in the calculation results. Second, the time spans of most studies are relatively short, typically within a decade. Third, in terms of regional studies, research on the Yangtze River Delta region has been relatively scarce. Therefore, this paper aims to address these limitations by building upon previous research, using the C-D growth function as a basis and employing the Denison factor analysis method to calculate and compare the contribution rates of higher education to economic growth in the Yangtze River Delta region since the expansion of university enrollment, and it provides policy recommendations.

3. Model Selection and Data Sources

3.1. Model Selection

The Cobb-Douglas production function is a commonly used economic model for measuring the impact of input factors, such as labor and capital, on output. The model is represented as follows:

$$Y = AK^\alpha L^\beta \quad (1)$$

The Cobb-Douglas production function is widely used in economics to study the contributions of different factors to output and the impact of technological progress on economic growth, among other issues. Denison extended this model to four different scales for measuring labor. This article utilizes the years of education of the labor force and, through derivation, calculates the final formula to determine the contribution rate of higher education to annual economic growth.

$$C_e = \beta e/y \quad (2)$$

$$C_h = e_h \beta e/y \quad (3)$$

$$C_e = \beta R_e/y \quad (4)$$

$$C_h = E_h \times C_e = E_h \beta R_e/y \quad (5)$$

C_e represents the contribution rate of education to economic growth, where β is the labor elasticity coefficient, e is the annual growth rate of educational investment, and y is the annual growth rate of the national economy.

In practical calculations, this paper simplifies labor by using the years of education per worker, which is a common scale in academic research. Consequently, it calculates the composite education index (R_e) to replace the annual growth rate of educational investment (e). The composite education index reflects the average educational attainment per worker in a given year and region and is theoretically equivalent to the annual growth rate of educational investment, reflecting the actual impact of educational investment.

E_h represents the share of higher education in the annual growth rate of the composite education index. Based on this, the paper uses this model as the fundamental framework for researching the contribution rate of higher education to economic growth in the Yangtze River Delta region. The value of β , set at 0.73, is determined based on the research of Chinese scholars [14].

3.2. Data Sources

The data for this paper is derived from the statistical yearbooks of the three provinces and one municipality in the Yangtze River Delta region for the years 2003 and 2022, as well as the China Labor Statistical Yearbook for the same years. The main data selected includes the educational attainment of the workforce in the three provinces and one municipality of the Yangtze River Delta region in 2002 and 2021, as well as the GDP with price factors removed.

4. Empirical Analysis

4.1. Calculation Method for the Contribution Rate of Higher Education to Economic Growth

4.1.1. Growth Rate of Composite Education Index (R_e)

The first step is to calculate the average years of education for employees in the three provinces and one municipality in the Yangtze River Delta region. The statistical results for the educational attainment of employees in the Yangtze River Delta region for the years 2002 and 2021 are presented in

Table 1.

Table 1. Distribution of Education Level of Employees in the Yangtze River Delta Region

	Never attended school	Primary school	Junior high school	Senior high school	College and above
2002					
Jiangsu	9.5	26.4	45.3	14.3	4.5
Zhejiang	7.7	31.1	39.6	13.7	7.9
Anhui	13.5	32.1	44.4	7.0	3.0
Shanghai	2.7	12.6	39.2	29.3	16.2
2021					
Jiangsu	1.8	11.9	38.2	20.3	27.8
Zhejiang	2.0	15.1	37.9	17.8	27.2
Anhui	5.3	18.9	41.8	14.3	19.7
Shanghai	0.5	4.6	25.5	17.4	52.0

From the statistical results, it can be observed that there has been a significant improvement in the educational attainment of employees in the Yangtze River Delta region. Assuming a primary school education duration of 6 years, and 3 years for junior high school and senior high school, and 4 years for college and above, the average years of education for employees in the three provinces and one municipality in the Yangtze River Delta region can be calculated. The results are shown in Table 2.

Table 2. Per capita education years of employees in the Yangtze River Delta (years)

	Primary school	Junior high school	Senior high school	College and above
2002				
Jiangsu	5.430	1.923	0.564	0.180
Zhejiang	5.538	1.836	0.648	0.316
Anhui	5.190	1.632	0.300	0.120
Shanghai	5.838	2.541	1.365	0.648
2021				
Jiangsu	5.892	2.589	1.443	1.112
Zhejiang	5.880	2.487	1.350	1.088
Anhui	5.680	2.270	1.020	0.790
Shanghai	5.970	2.847	2.082	2.080

The next step is to calculate the Composite Education Index for employees in the Yangtze River Delta region, which is the sum of the product of education levels and labor simplification rates. Employees have different labor productivity levels due to variations in their educational backgrounds, and Denison considered that 60% of the wage difference is due to the impact of differences in education levels on labor productivity. Based on reference to Denison's labor simplification rates and considering China's specific conditions, domestic scholars have determined that the labor simplification rates for primary school, junior high school, high school, and higher education in China are 1, 1.2, 1.4, and 2, respectively [15]. This paper also adopts these rates to calculate the Composite Education Index. The third step involves calculating the growth rate of the Composite Education Index (R_e). The results are shown in Table 3.

Table 3. Composite Education Index and Growth Rate

	Jiangsu	Zhejiang	Anhui	Shanghai
2002	8.8872	9.2804	7.8084	12.0924
2021	13.2430	12.9304	11.4103	16.4612
R_e	2.12%	1.76%	2.02%	1.64%

4.1.2. The Share of Higher Education in the Growth Rate of the Composite Education Index (E_h)

The first step is to calculate the annual average growth rate of per capita higher education years (R_h). This calculation aims to understand the per capita higher education situation in the three provinces and one municipality in the Yangtze River Delta region for subsequent comparative analysis. Taking Jiangsu Province as an example, according to Table 2, the annual growth rate of per capita higher education years is calculated as follows: $R_h = [(1.112 / 0.180)^{(1/19)} - 1] \times 100\% = 10.06\%$. Similarly, for Jiangsu Province, Zhejiang Province, Anhui Province, and Shanghai Municipality, the annual growth rates of per capita higher education years are 10.06%, 6.72%, 10.40%, and 6.33%, respectively. The second step is to calculate the share of higher education (E_h) in the growth rate of the Composite Education Index. First, exclude the higher education component from the growth rate of the Composite Education Index, and then calculate the share of higher education in the growth rate. The results are shown in Table 4.

Table 4. The Share of Higher Education in the Growth Rate of the Education Composite Index

	Jiangsu	Zhejiang	Anhui	Shanghai
E_h	35.85%	34.66%	31.19%	57.93%

4.1.3. The GDP annual average growth rate (y)

GDP is a fundamental indicator used to measure the economic development of a country or region. In this study, the average annual GDP growth rate from 2002 to 2021 is used to represent the economic growth situation of the three provinces and one municipality in the Yangtze River Delta region. Jiangsu, Zhejiang, Anhui, and Shanghai accounted for 10.33%, 12.35%, 9.56%, and 8.78% respectively.

4.1.4. Contribution of Higher Education to Economic Growth (C_h)

Based on the formula $C_h = E_h \times C_e = E_h \beta R_e / y$, first calculate the contribution rate of education to economic growth (C_e). This can be computed using the data from Table 4 for the growth rate of the Composite Education Index (R_e) and the annual average GDP growth rate (y). Then, calculate the contribution of higher education to economic growth (C_h) using the data from Table 4 for the share of higher education in the growth rate of the Composite Education Index (E_h). The results are shown in Table 5.

Table 5. Contribution rate of education and higher education to economic growth

	Jiangsu	Zhejiang	Anhui	Shanghai
C_e	12.53%	13.64%	14.27%	13.44%
C_h	4.49%	4.66%	4.45%	7.90%

4.2. Data Analysis

Firstly, it is worth noting the values of educational attainment of employees involved in the calculation of the growth rate of the Composite Education Index (R_e). From the data mentioned above, it is evident that the level of higher education in the Yangtze River Delta region has significantly improved over the past 20 years. Among all provinces and regions, the proportion of employees with a degree at or above the college level (referred to as higher education) has notably increased, indicating that more people are receiving higher education. Compared to 2002, the data for 2021 shows a decrease in the proportion of employees who have not received any formal education, while the proportion of employees with a high school and higher education has increased. This suggests an overall improvement in educational attainment in the Yangtze River Delta region, with more individuals attaining higher levels of education. The situation varies across regions, with Shanghai leading in educational attainment, ranking first in the Yangtze River Delta region, with a significant increase in the proportion of employees with higher education, reaching 52.0%. Jiangsu and Zhejiang provinces have relatively high proportions of employees with higher education, while Anhui province has a relatively lower proportion, at 19.7%. However, the growth rate of employees with higher education over the past 20 years is the highest, exceeding 550%, making it the highest in the Yangtze River Delta region. In terms of the growth rate of the Composite Education Index (R_e), as per the results in Table 1, the Yangtze River Delta region's three provinces and one city have similar annual average growth rates, all exhibiting a stable growth trend. This indicates that continuous attention and investment in education in the Yangtze River Delta region have been conducive to improving education levels and driving economic and social development. Jiangsu province has the highest growth rate at 2.12%, while Shanghai has the lowest at 1.64%. The annual average growth rate is a relative value. Combining the data from Table 3 on the Composite Education Index for the Yangtze River Delta region, Jiangsu province has a relatively higher initial value for the Composite Education Index but ranks first in terms of growth rate, indicating that Jiangsu province has experienced relatively stable educational development with sustained growth. Although Shanghai has the lowest growth rate, it has the highest initial and current values for the Composite Education Index. Despite the lower growth rate, its education level remains relatively high. It is worth noting that Anhui province, despite having the lowest initial and current values for the Composite Education Index, has the second-highest growth rate in the Yangtze River Delta region. This indicates that, despite a relatively less advanced education level, Anhui province has been making continuous efforts to invest in and develop its education system, resulting in rapid growth. This is further reflected in Anhui's annual average growth rate of 10.40% in per capita years of higher education, the highest in the Yangtze River Delta region. Additionally, it can be observed that the average growth rate of per capita years of higher education is relatively high, indicating that these regions have made some achievements in increasing the

prevalence of higher education and raising people's educational levels. However, the growth rate of the Composite Education Index is relatively low, which may suggest that improvements in other education levels are relatively slow or that other factors are influencing the Composite Education Index.

Secondly, in the calculation of the contribution rate of higher education to economic growth (C_h), the shares of higher education in the growth rate of the Composite Education Index (E_h) and the contribution rate of education to economic growth (C_e) are also worth noting. E_h , the proportion of higher education in the annual growth rate of the Composite Education Index, reflects the weight of higher education in overall educational development. According to the calculated results, the proportions of higher education in the annual growth rates of the Composite Education Index for Jiangsu, Zhejiang, Anhui, and Shanghai are 35.85%, 34.66%, 31.19%, and 57.93%, respectively. It can be seen that Shanghai has the highest proportion of higher education in the annual growth rate of the Composite Education Index, indicating that Shanghai places more emphasis on and invests more in the development of higher education. While the proportions of higher education in the annual growth rates of the Composite Education Index for Jiangsu, Zhejiang, and Anhui are relatively lower, they are all above 30%, suggesting that the development of higher education is also receiving a certain degree of attention in these regions. C_e , the contribution rate of education to economic growth, reflects the extent to which education impacts economic growth in a region or country. The calculated results show that the contributions of education to economic growth (C_e) for Jiangsu, Zhejiang, Anhui, and Shanghai are 12.53%, 13.64%, 14.27%, and 13.44%, respectively. This indicates that education has a positive impact on the economic growth of these regions. Anhui province has the highest contribution rate of education to economic growth, suggesting significant progress in education development compared to other regions in the upper Yangtze River Delta. In terms of the final results, the contribution rates of higher education to economic growth (C_h) for Jiangsu, Zhejiang, Anhui, and Shanghai are 4.49%, 4.66%, 4.45%, and 7.90%, respectively. This indicates that higher education has played a positive role in the economic growth of these regions. Particularly in Shanghai, the contribution rate of higher education to economic growth is the highest, reaching 7.90%, indicating that higher education plays a significant role in driving economic development in Shanghai. The contribution rates of higher education to economic growth in Jiangsu, Zhejiang, and Anhui are also significant, all exceeding 4%.

5. Research Conclusions

5.1. Increasing Average Years of Education

The educational level in the Yangtze River Delta region has significantly improved over the past 20 years, especially in terms of the prevalence of higher education and the increase in average years of education per person. This has played a positive role in cultivating high-quality talents to meet the needs of economic development. The data shows a significant increase in the proportion of the population with higher education across provinces and cities. Particularly, Anhui province stands out, with the proportion of individuals with higher education increasing fivefold between 2002 and 2021.

5.2. Optimizing Educational Attainment

The educational structure in the Yangtze River Delta region has also undergone positive changes, with the proportion of higher education gradually increasing. Higher education has a higher contribution rate to economic growth and has produced more skilled and innovative talents, driving industrial upgrading and technological innovation. Over time, changes in educational structures have been observed across regions. In 2002, the proportion of the population with a middle school education was higher, while by 2021, there was an increase in the proportion of individuals with higher education. This indicates that the Yangtze River Delta region has optimized and adjusted its educational structure, placing greater emphasis on raising the level of higher education to meet the needs of economic development.

5.3. Excellent Contribution of Higher Education to Economic Growth with Regional Disparities

The contribution rates of higher education to economic growth in the Yangtze River Delta region all exceed 4%, indicating a relatively high contribution compared to other regions. However, there are differences in the contribution rates of higher education to economic growth among different provinces and cities within the Yangtze River Delta region, with Shanghai standing out. Addressing how to narrow the gap in the contribution rates of higher education to economic growth between different provinces and cities within the region and promoting cooperation and exchange among them is a key focus for future development.

6. Recommendations

6.1. Increase the Duration of Education to Raise Overall Educational Levels

Provide universal and quality basic education to ensure that every child receives a high-quality primary education. The government should increase investment in basic education, improve school resources and teacher qualifications, and enhance school facilities and educational environments to ensure that every child has access to a good basic education.

Extend the years of compulsory education to gradually lengthen the period during which students receive basic education. The government can establish relevant policies and regulations and further extend the duration of compulsory education to ensure that more students have access to a longer period of education.

Provide diverse educational pathways and opportunities: Offer various educational pathways and opportunities for students who wish to continue their education. Develop vocational education and skills training, provide continuing education and distance learning opportunities to meet the learning needs and interests of different populations. Strengthen family and community educational support by supporting and guiding families and communities to play important roles in education. Provide relevant resources and training to help parents and community members enhance their education awareness and abilities, collectively promoting an increase in the average years of education for children.

6.2. Continuously Optimize Educational Institutions to Improve Overall Educational Quality

Offer multiple education choices and encourage students to choose educational paths that suit their interests and abilities. In addition to traditional academic education, provide vocational education, skills training, and lifelong learning opportunities. Diverse education options can meet the needs of different populations and provide broader development opportunities.

Emphasize practical and applied skills development: Optimize educational structures by focusing on practical and applied skills development for students. Encourage students to participate in practical projects, internships, and hands-on teaching activities that integrate theoretical knowledge with practical application. Strengthen cooperation with enterprises, industries, and communities to provide practical opportunities and training for problem-solving. Promote lifelong learning: Learning should not be limited to specific age groups or stages. Encourage and support adults in continuing their education, offering flexible learning methods and opportunities such as online learning, distance education, and extracurricular courses. Establish a comprehensive lifelong learning system to allow individuals to continually enhance their knowledge and skills to adapt to rapid societal and technological changes.

Regularly evaluate and adjust educational policies: The optimization of educational structures requires continuous assessment and adjustments. Governments and educational institutions should periodically assess the adaptability and effectiveness of educational structures and make policy adjustments and reforms based on evaluation results. Extensive communication and cooperation with stakeholders should ensure the effective implementation and monitoring of policies.

6.3. Strengthen Regional Cooperation and Exchange to Promote Knowledge Sharing and Economic Development

Share educational resources: Provinces and cities can share educational resources, such as jointly conducting educational projects and sharing educational facilities and teaching staff. Sharing educational resources can enhance the quality of education and provide students with more extensive learning opportunities.

Address regional issues collectively: The Yangtze River Delta region faces many common issues, such as environmental protection, traffic congestion, and population mobility. Provinces and cities can enhance cooperation to jointly research and address these problems. By sharing experiences and resources, they can collaboratively develop solutions and improve the region's capacity for sustainable development.

Host exchange events and conferences: Organize cross-provincial and cross-city exchange events and conferences regularly, providing a platform for experts, scholars, entrepreneurs, and government representatives from various fields to exchange ideas and learn from each other. These activities can facilitate idea exchange, experience sharing, and discussions on collaborative projects.

Promote industry-academia-research collaboration: Encourage collaboration between enterprises, higher education institutions, and research institutions. Establish

mechanisms and platforms for industry-academia-research collaboration, promote technology transfer, innovation cooperation, and the translation and application of scientific achievements. Facilitate talent mobility by encouraging talents to move and exchange within the Yangtze River Delta region. The government can provide convenient talent mobility policies and measures, offering more development opportunities for individuals. Establish talent recruitment and exchange platforms to promote talent mobility and collaboration among provinces and cities.

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