An Empirical Study on the Synergistic Development of Higher Education Scale and Economic Growth in China

Mingbo Ji\(^1\), Jia Luo\(^2\),*, and Xiao Wang\(^3\)

\(^1\)School of Economics, Sichuan University, Chengdu 610065, People’s Republic of China
\(^2\)College of Biomedical Engineering, Sichuan University, Chengdu 610065, People’s Republic of China
\(^3\)JP Morgan Chase & Co, Plano, Texas, 75024, USA

Abstract. Examining the equalization of higher education and how it affects the economic growth of each region in China is crucial from both a theoretical and practical standpoint as it pertains to public services since higher education has a significant impact on a nation’s or region’s competitiveness. In this context, this research uses data from 1997 to 2020 to examine the economic impact of higher education on each province using the education composite index. On the other hand, the generalized least squares method was used to analyze the effects of GDP per capita, high school graduation rates, and educational policies on economic development from 1988-2018. The empirical findings indicate that higher education throughout the sample period contributed 15.73% to economic growth and 0.18% to the general level of education. Additionally, there is a strong association between the number of recent high school graduates, GDP per capita, and national policy and enrollment size. Keywords: Education scale, Economic and social effects, Education efficiency.

1 Introduction

Higher education provides a strong driving force for economic development. On the one hand, higher education provides scientific and technological innovation and a highly qualified employment population, which promotes economic development. At the same time, economic development brings a significant increase in education funding, which leads to further quality improvement in higher education development. In the case of China, the reform and opening up and the restoration of higher education were launched simultaneously in 1978, and the two promoted each other, making China rapidly become a significant economic and educational power. The rapid expansion of higher education has gained popularity. The gross enrolment rate of higher education, which is a crucial indication for the national and provincial planning of education, climbed progressively from 12.5% in 2000 to 57.8% in 2021. The Tenth Five-Year Plan for National Economic and Social Development of the People’s Republic of China, which was published in March 2001, is the document that systematically promotes the expansion of higher education at the national level following the declaration of the strategy in 1999. After that, various documents including the National Education Development Eleventh Five-Year Plan Outline, National Medium and Long-term Education Reform

*e-mail: jiiajia@163.com

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).
and Development Plan Outline (2010-2020), National Education Development Twelfth Five-Year Plan Outline, National Education Development Thirteenth Five-Year Plan Outline, and National Education Development Fourteenth Five-Year Plan Outline were released one after another to keep promoting the expansion level and gross enroll. However, it is also essential to see that, especially in recent years, China’s economy has entered a new period and a new normal, and economic development has been plunged into uncertainty. In such a context, China has to pay more attention to strengthening higher education development and promoting the quality of human capital and science and technology progress [1] (Du, 2015). In some countries that are attempting to shift their traditional economy to a more knowledge-intensive footing, the experience in transforming the higher education system is highly relevant to their development [2] (Azman et al., 2014). However, how has the development of higher education in each of China’s provinces impacted regional economic growth in recent years? How significant are the disparities between provinces? These questions have yet to be studied but have important implications for China’s economic development. This paper contributes to the existing literature in the following two aspects: we introduce the method based on the comprehensive index of education to consider the population distribution at different educational levels, and then we measure the contribution of higher education to economic growth in China for the period 1997-2020. Then we use generalized least squares to investigate the effects of economic development, the size of high school graduations, and national policies on the size of higher education, making this paper a thorough investigation of the relationship between higher education and economic development from two angles.

The remainder of the essay is structured as follows. In Section 2, the pertinent literature is reviewed. The research methods and data are described in Section 3. The findings and discussion are presented in Section 4, and the conclusions and suggested policy changes are presented in Section 5.

2 Relevant Literature Review

In the OECD countries, the evidence suggest that education spurs growth and in turn growth improves human capital formation in high-income OECD economies [3](Bayraktar-Saglam, B., 2016), particularly within North European countries [4](Sterlacchini, 2008). The same conclusion is provided based on 284 European areas (NUTS 2) during an 18-year period (from 2000 to 2017) [5](Agasisti, T. and A. Bertoletti, 2022). In Russia, the relationship between regional higher education system effectiveness and regional economic growth rates between 2012 and 2015 shows significant results [6] (Agasisti, T., et al., 2021). This study approach is supported by studies on higher education and industrial growth in China [7](Bai et al, 2020). From the perspective of the spatial differences in China’s educational development, exploring the impact of education on economic development is of great importance for alleviating the principal contradiction between China’s inter provincial education and economic development [8](Zhang, Y. and J.G. Liu, 2022). The regional analysis reveals that higher education impacts become twice as strong when the enrollment rates are greater than a certain level (a kink point)[9] (Maneejuk, P. and W. Yamaka, 2021). And this effect is more intense in less wealthy regions, we may conclude that higher education plays a positive role in regional economic and social cohesion [10](Dominguez, J.,2021). The progress of general social salaries and benefits can also be facilitated by the growth of higher education [11–13](Bohm et al, 2015; Lee and Kim, 2009; Parro and Reyes, 2017). Higher education’s expansion is seen to be a major factor in promoting green growth [14] (Li et al., 2022), and it affects the region’s competitiveness through the university’s entrepreneurial activities [15](Guerrero et al, 2016). Universities have a wide range of effects on the development of the cities, economic growth, and socio-cultural structures of the communities [16](Cetin, M.,
et al., 2021). Though the expansion of higher education requires threshold development of the state and the middle class, it is primarily powered not by economic growth but by the ambitions of families to advance or maintain social position [17](Marginson, S., 2016). As the demand for workers with greater education rises, inequality will first rise. The greater returns to education do, however, stimulate agents to invest in higher education, resulting in a subsequent deepening of human capital that lessens inequality at later stages of development [13](Parro, F. and L. Reyes, 2017). The effectiveness of universities and the number of graduates may be compared as qualitative and quantitative indicators of human capital growth, respectively [18](Barra C. and Zotti R., 2017). Using a Nonlinear Autoregressive Distributed Lag (NARDL) model, people find that an increase in higher education utilization (the unemployed labor force with higher education) suppresses economic growth, while a decline in the higher education utilization (the unemployed labor force with higher education) promotes economic growth [19](Qi, D., et al., 2022).

A empirical analysis shows that the public investment in higher education carried out in Mexico between 2004 and 2015 has not satisfactorily boosted the levels of productivity in order to achieve greater economic growth and social welfare. Nevertheless, higher rates of coverage and schooling have indeed had a positive impact on the rise of per capita income [20](Lagarde, A. M., et al., 2021). However, when the market structure adjusts fully in the long run, the education subsidy expands the number of firms but reduces economic growth. These unfavorable predictions of an education subsidy on economic growth are partly consistent with the empirical findings that mass higher education does not necessarily lead to higher economic growth [21](Morimoto, T. & K. Tabata, 2020).

However, in terms of the relationship between higher education and economic growth, there are more macro studies in the existing literature on the subject and fewer studies focusing on the impact of higher education on regional economic development. In addition, in terms of measured indices of higher educational activities, existing literature tends to focus on the total higher education or higher education scale while often ignoring the quality of higher education. In fact, taking the quality-oriented and intensive development path has become the desired direction of China’s higher education reform.

### 3 Methods and Data

#### 3.1 Comprehensive Index of Education

Following the method proposed by the United Nations Development Programme (UNDP), we construct the comprehensive index of education to measure the educational level of the population aged 6 years or older in China. The population’s labor predigested rates, which show how different levels of education affect labor quality and are often utilized in education economics research [22](Yang and Liu, 2014), must be known before the calculations can be made. Assume that \( r_p \), \( r_{jh} \), \( r_{sh} \) and \( r_c \) represent the labor predigested rates of the population at each level of education: primary school, junior high, senior high, and college. As the number of years of primary school education per capita is regarded as the origin of the calculation, the labor predigested rate of primary school education is set as 1, namely \( r_p = 1 \). Meanwhile, the labor predigested rates of the Chinese population with junior high school, senior high school, and college education can be set as \( r_{jh} = 1.2 \), \( r_{sh} = 1.4 \) and \( r_c = 2 \), respectively, based on the incomes of laborers with different educational levels and pertinent research on the relationship between China’s higher education and economic growth (such as Zhang et al. (2006)[23], Yang and Liu (2014)). According to a study on higher education research in central China (Zhu Tiantian eta al, 2017 [24]), the average growth rate of educational
comprehensive indices of the population aged 6 years or older in province during the period from 1997 to 2020 \((R_i)\) can be written as Eq. (1):

\[
R_i = \sqrt[24]{A_{2020,i} / A_{1997,i}} - 1. \tag{1}
\]

Then, the number of schooling years at various educational levels of population in province \(i\) in year \(t\) is shown in Eqs. (2) to (5).

\[
T_{t,i,p} = \left( A_{t,i,p} + A_{t,i,jh} + A_{t,i,sh} + A_{t,i,c} \right) * 6. \tag{2}
\]

\[
T_{t,i,jh} = \left( A_{t,i,jh} + A_{t,i,sh} + A_{t,i,c} \right) * 3. \tag{3}
\]

\[
T_{t,i,sh} = \left( A_{t,i,sh} + A_{t,i,c} \right) * 3. \tag{4}
\]

\[
T_{t,i,c} = A_{t,i,c} * 4. \tag{5}
\]

where \(T_{t,i,p}, T_{t,i,jh}, T_{t,i,sh}, T_{t,i,c}\) represent the years of education per capita in primary education, junior high education, senior high education and university, and \(A_{t,i,p}, A_{t,i,jh}, A_{t,i,sh}, A_{t,i,c}\) represent the proportion of the population with primary education, junior high education, senior high education and university education in province \(i\). The comprehensive index of education of the population aged 6 years or older in province \(i\) in year \(t\) can be specified as Eq. (6).

\[
I_{t,i} = T_{t,i,p} * r_{p} + T_{t,i,jh} * r_{jh} + T_{t,i,sh} * r_{sh} + T_{t,i,c} * r_{c}. \tag{6}
\]

The average growth rate of the educational comprehensive indices of the population aged 6 years or older in province \(i\) from 1997 to 2020 \((R'_i)\) after removing higher education is presented in Eq. (7).

\[
R'_i = \sqrt[24]{I_{2020,i} / I_{1997,i}/A_{c}^{2020,i} / A_{c}^{1997,i}} - 1. \tag{7}
\]

Therefore, the contribution rate of higher education in province \(i\) to the comprehensive index of education is displayed in Eq. (8). the proportion of higher education’s contribution to the average annual growth rate of the comprehensive index of education in province \(i\) is given by Eq. (9).

\[
C_i = R_i - R'_i. \tag{8}
\]

\[
En_i = \left( \frac{R_i - R'_i}{R_i} \right) \times 100\%. \tag{9}
\]

### 3.2 Estimating the Total Economic Growth Contribution of Higher Education

Assume that the average annual growth rate of GDP in province \(i\) from 1997 to 2020 is \(Y_i\), and based on numerous studies for the situation in China [25–27](Cui, 2001; Hu and Liu, 2004; Yao and Chen, 2012), we set the value of \(\beta\) to 0.73 here. Then, the contribution rate of education on the whole to economic growth in province \(i\) can be calculated using Eq. (10) while that of higher education in province \(i\) is shown in Eq. (11).

\[
G_i = \frac{\beta \times R_i}{Y_i}. \tag{10}
\]

\[
Cn_i = G_i \times En_i. \tag{11}
\]
3.3 Estimating the Impact of Economic Growth on the Size of Higher Education

The dependent variable is $Y$: the number of higher education enrollment; the independent variables are three, namely, $x_1$: the level of economic development; $x_2$: the number of fresh high school graduates; $D$: policy factors. A multiple linear regression model is created under the assumption that the independent and dependent variables are linearly related:

$$Y_i = \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 D + \mu_i.$$  (12)

Where $\beta_1 (i = 1, 2)$ denotes the coefficients of the explanatory variables and $\mu_i$ is the random error term.

3.4 Data Specification

The number of students who took the college admission exam increased dramatically once it was reinstated in 1977, while the higher education institutions were not designed to accommodate increasing student enrollment. The degree of national economic growth has not yet increased during this time period, which has led to a modest scale of college enrolment that does not fairly represent the relationship of higher education. Consequently, the data beginning node for this study was chosen in 1988, a year with greater enrollment stability. For this article, enrollment figures($Y$) from 1988 to 2018 are chosen.

In addition, the national education policy is set as a dummy variable($D$), the policy of expanding college entrance examination is being promulgated in 1999, the variable is $D_1$ before 1999, its value is set to 0, and the variable is $D_2$ after the expansion, its value is set to 1. The GDP per capita statistic is used to replace the economic growth($x_1$) variable. The number of high school graduates in a given year will have an impact on higher education enrolment as well, setting the number of high school graduates at ($x_2$). All the data are from the China Statistical Yearbook over the years.

3.5 Descriptive Analysis

The descriptive statistical analysis of the data is presented in this part. The average enrollment size is 207.19k, with maximum and minimum values of 422.16k and 30.05k, respectively. The GDP per capita increased from a minimum of 1378 RMB to a maximum of 64644 RMB, with 20010 RMB serving as the mean. See table 1 for details.

Table 1. Descriptive analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y$</td>
<td>31</td>
<td>207.1876</td>
<td>145.4814</td>
<td>30.0496</td>
<td>422.159</td>
</tr>
<tr>
<td>$x_1$</td>
<td>31</td>
<td>2.0126</td>
<td>1.9494</td>
<td>0.1378</td>
<td>6.4644</td>
</tr>
<tr>
<td>$x_2$</td>
<td>31</td>
<td>508.3335</td>
<td>264.6374</td>
<td>201.6441</td>
<td>836.0593</td>
</tr>
</tbody>
</table>

4 Results and Discussion

4.1 The Contribution Rates of Higher Education to the Comprehensive Indices of Education

After removing higher education from the Eq. (1) to (11), we calculate the average growth rate of the comprehensive indices of education from 1997 to 2020; next, we calculate the
Out of the four areas, the East contributes the most to the Education Composite Index (0.24%), while the Northeast contributes the least (0.12%). This is mostly due to the fact that the eastern area has 1028 higher education institutions, compared to the northeastern region’s 258 institutions. The Eastern area also has the largest total contribution of higher education to economic growth (25.33%), while the Central region has the lowest contribution (9.18%). In comparison to other regions, the eastern region not only has a large number of colleges and universities, but also significantly more prestigious colleges and universities (such as 985 and 211 projects). In the center area, Anhui Province, for instance, has 120 institutions by 2020 (1 from the 985 program and 3 from the 211 program), Henan Province has 151 institutions, but none of them provide 985 programs, and there is just one 211 program. Higher education does not significantly contribute to economic growth because there aren’t many prestigious colleges in the area.
4.2 The Impact of Economic Growth on the Size of Higher Education Institutions

It is possible to find $x_i$, $y_i$, i.e. GDP per capita and the number of recent high school graduates over time, with no turning point in GDP per capita, as shown in the following figure 1 to figure 3.

The first step was to run multiple regressions, and the preliminary findings revealed that all coefficients were relatively significant, demonstrating that the assumed independent variables were indeed the primary influences on the scale of college and university enrollment and that the model fit the data fairly well. When the random error term in the model was tested for heteroskedasticity using three lags, it was discovered to be heteroskedastic. This was fixed by setting $\sigma_1 = 1 / (x_1 + x_2)$ and regressing the model using the weighted least squares approach.

Then, the model is changed using the generalized difference approach to generate $x_3 = (x_2 - 262.91) \times D_2$ in order to eliminate the autocorrelation that is present in the random perturbation term. The results are shown in the following table 4.

This econometric analysis shows that gross national product (GDP) per capita does have an impact on the undergraduate enrollment scale of colleges and universities; economic development can lead to a rise in educational demand, and conversely, favorable economic development means an increase in educational investment funds, providing solid economic
support for the expansion of undergraduate enrollment scale. Secondly, the number of fresh high school graduates is another fundamental factor of the undergraduate enrollment scale, and the scale of graduates is the primary source of undergraduate students. Thirdly, national policymaking for higher education is also an important influencing factor for higher education institutions’ undergraduate enrollment scale. From the above analysis icons, we can see a data turning point in 1999, from the previous smooth and stable state to a significant increase.

We use the technique of substituting explanatory variables to evaluate the reliability of the fundamental regression results. GDP per capita is used as the new explanatory variable in place of disposable income per capita. Table 5 displays the regression’s findings. As the per capita disposable income variable $x_1'$ is significantly positive or negative and is not statistically different from the per capita GDP and the direction, the regression findings demonstrate the robustness of the regression results.

Table 5. Results of robustness tests

<table>
<thead>
<tr>
<th></th>
<th>$x_1'$</th>
<th>$x_2$</th>
<th>$x_3$</th>
<th>_cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>0.3674***</td>
<td>-0.1537***</td>
<td>0.1685***</td>
<td>2.2846***</td>
</tr>
<tr>
<td></td>
<td>(0.0303)</td>
<td>(0.2315)</td>
<td>(0.0900)</td>
<td>(0.8759)</td>
</tr>
</tbody>
</table>
to the comprehensive education index. Primary education’s contribution to the composite education index varies little between the east and the center, with the west having the biggest contribution and the northeast having the lowest, likely due to the region’s historically low fertility rate and demographic base. It improves our knowledge of how higher education is progressing in China. Even though China’s educational system has been working toward a balanced development over the past ten years, parity in higher education still needs to be improved.

Second, opinions on how higher education affects economic growth are divided. Higher education contributes most to economic development in the eastern regions, which have the highest levels, and the western regions, which have relatively low levels, reaching 25.33% and 18.73%, respectively, while in the central and northeast regions, the contribution rate is below 10%. According to the current state of China’s economy and higher education, universities in the eastern regions, where the economy is stronger, rely more on higher education to support their capacity for conducting scientific research. In contrast, universities in the western regions primarily use it to train highly skilled workers. Higher education has less impact in the central and northeastern regions, where economic development is at a crossroads.

Third, the econometric analysis shows that gross national product (GDP) per capita does have an impact on the undergraduate enrollment scale of colleges and universities; economic development can lead to a rise in educational demand, and conversely, favorable economic development means an increase in educational investment funds, providing solid economic support for the expansion of undergraduate enrollment scale. Secondly, the number of fresh high school graduates is another fundamental factor of the undergraduate enrollment scale, and the scale of graduates is the primary source of undergraduate students. Thirdly, national policymaking for higher education is also an important influencing factor for higher education institutions’ undergraduate enrollment scale. From the above analysis icons, we can see a data turning point in 1999, from the previous smooth and stable state to a significant increase.

The enrollment size of higher education institutions is consistent with the previous theoretical statement that there is a strong correlation between enrollment size and the number of recent high school graduates, GDP per capita, and national policies. This model illustrates that the change of enrollment scale is subject to both objective and subjective factors, and its specific scale should be formulated regarding both the internal scale of education, such as the number of fresh high school graduates and the external factors of education, such as the level of economic development. Of course, this model should also be introduced from the annual birth population, and the number of colleges and universities should be introduced to the analysis; in addition, in the test of heteroskedasticity, we use the ARCH test, the test requires a large sample, our sample size is smaller slightly inappropriate.

6 Disclaimer

Any conclusion in this article made by Xiao is his personal opinion and is not the opinion or policy of the financial institutions (Firms) he is (has been) working for. Xiao strictly follows the data protection policy of the Firms and treat information of employers, employees, customers, stakeholders and other interested parties with the utmost care and confidentiality. Any conclusions made by Xiao and any supporting evidences (data, methodology, mathematical proofs, simulation and testing code, etc.) provided in this article are the intellectual properties derived from Xiao’s academical training and experiences, and are irrelevant to the Firms.
References

[8] Y. Zhang, J. Liu, Sustainability 14, 16289 (2022)