Analysis to the Reform Process Effectiveness of Chinese High-speed Railway Industry Based on the Total Factor Productivity

JIN ZENG, XIANG CHAO and CHUN-JIAO DONG

ABSTRACT

This paper selects the Total Factor Productivity (TFP) as the comprehensive index reflecting the productivity change in the railway industry. Using the Solow residual method with the characteristics of the China railway, we construct the estimated econometric model of productivity to study the TFP of the railway passenger transportation industry over the past decade and the High-speed railway (HSR) in the next period of time. By analyzing the trend and cause of the TFP change briefly, some policy recommendations are proposed for the HSR’s sustainable development. The results show that comparing with the general railway, the technological advantages of the HSR is prominent.

INTRODUCTION

Since 2008 the first Chinese HSR passenger dedicated line, Beijing-Tianjin intercity HSR had been officially opened. From July 2011, the Beijing-Shanghai HSR was put into operation, China has launched a number of dedicated passenger lines into operation, and this indicates that the golden period of the HSR development is coming! The rapid development and construction will inevitably be accompanied by huge investment! Many experts are opposed by large-scale borrowing to finish the process of HSR, and the development will be facing a very dangerous debt crisis [1]. Then, what kind of impact will be given to Chinese railway industry by the development of HSR? Technological progress to promote production efficiency, or the debt crisis led to production inefficient caused by bad investments? In this paper, based on the HSR development existing controversy problem, the TFP calculation is the research aim for assessing the effectiveness.

Jin Zeng, Xiang Chao, School of Transportation, Beijing Jiaotong University, Beijing, 100044, China
Chunjiao Dong, Center for Transportation Research, the University of Tennessee, 600 Henley Street, Tennessee, 37996, USA
In the early time, researchers had studied the efficiency of railway in the framework of the production theory. Caves et al. (1980) [2] have adopted input and output function to measure the American railway productivity from 1951 to 1974 based on the new classical theory, but the selection of different production function may lead to different research results by using this method. Nash (1985) [3] and Thompson et al. (1991) [4] have adopted the theory of partial factor productivity to measure the efficiency of railway production. Nevertheless, the research method of the partial factor productivity needs the explicit input and the output price. An increase of the production efficiency of an element is likely to be at the expense of the production efficiency of other elements. This is a deficiency of the partial factor productivity method. Bookbinder et al. (1993) [5] have adopted DEA method to analyze the efficiency difference between two Canadian railway lines and five American railway lines. Yu (2008) [6] created have adopted traditional DEA and network DEA methods by using data on 40 global railway companies for 2002 to measure the efficiency and effectiveness. Nashand et al. (2010) [7] have applied two-stage DEA analysis to 43 railway organizations and they found that the transaction factors are more determinative in achieving technical efficiency than the corporate factors. However, the DEA method is not applicable to the time series data of a single industry.

In HSR aspect, Couto et al. (2008) [8] have analyzed the effect on productivity generated by the utilization of HSR technology, which shows the most relevant contribution to the improvement of service quality. Couto (2011) [9] has applied the derived theoretical expressions of embodied technological progress to isolate the effects of HSR technology on productivity growth by using data that relate to European rail systems during the period from 1972 to 1999.

But there are relative few literatures found on the production efficiency calculation for HSR, it is necessary to study whether the HSR production efficiency is more truly improving the production efficiency than the conventional railway and we should know the size increased.

CHINA’S RAILWAY INDUSTRY ESTIMATES OF TOTAL FACTOR PRODUCTIVITY GROWTH

Because the railway is a traditional natural monopoly industry, TFP growth can reflect the economic development efficiency. We adopt Solow residual method to complete the TFP value computation.

RAILWAY INDUSTRY PRODUCTION FUNCTION ESTIMATES

We assume the production function of China's railway industry as follows:

\[ Y = f(K, L, t) \]  
(1)

Where, \( Y \) is a yield amount, \( K \) is an amount of capital investment, \( L \) is labor input, \( t \) is a time variable, \( f \) is a differentiable function. Suppose technological progress is "neutral", with Hicks neutral technical progress, the production function is that

\[ Y = A(t)K(t)\alpha L(t)^\beta \]  
(2)

We can conclude that:

\[ a = y - \alpha k - \beta l \]  
(3)
In which, \( y = 1/Y \times dY/dt \), \( a = 1/A \times dA/dt \), \( k = 1/K \times dK/dt \), \( l = 1/L \times dL/dt \),

Resulting in the Solow growth equation. We normalize \( \alpha, \beta \),

\[
\alpha^* = \alpha/(\alpha + \beta), \quad \beta^* = \beta/(\alpha + \beta), \quad \alpha^* + \beta^* = 1,
\]

thus we get that

\[
a = y - \alpha^*k - \beta^*l
\]

This is the growth rate equation where \( y \) is the yield growth rate, \( k \) is capital investment growth rate, \( l \) is labor investment growth rate, \( \alpha^* \) is the output elasticity of capital investment, \( \beta^* \) denotes output of the flexibility of labor investment.

**RAILWAY INDUSTRY AND HIGH-SPEED RAIL GROWTH RATE OF TOTAL FACTOR PRODUCTIVITY**

1) Railway industry TFP calculation

This article is originally planned for ten years’ estimation of TFP of the rail passenger transport industry from 1999 to 2008. Because before the China HSR started operation in 2008, but it is not easy to divide huge data about freight and passenger transportation. So, we adopt the entire rail industry estimation of TFP growth to calculate the results that are shown in Table 1.

<table>
<thead>
<tr>
<th>Years</th>
<th>Labour growth (%)</th>
<th>Fixed assets Growth (%)</th>
<th>Yield growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2000</td>
<td>1.0259</td>
<td>-0.7670</td>
<td>9.4232</td>
</tr>
<tr>
<td>2001-2002</td>
<td>-1.7330</td>
<td>11.1455</td>
<td>15.0166</td>
</tr>
<tr>
<td>2002-2003</td>
<td>-1.7060</td>
<td>8.4503</td>
<td>3.1897</td>
</tr>
<tr>
<td>2003-2004</td>
<td>-1.6780</td>
<td>5.2356</td>
<td>9.6098</td>
</tr>
<tr>
<td>2004-2005</td>
<td>-1.9420</td>
<td>4.3702</td>
<td>17.4050</td>
</tr>
<tr>
<td>2005-2006</td>
<td>-0.7800</td>
<td>13.7370</td>
<td>15.3711</td>
</tr>
<tr>
<td>2006-2007</td>
<td>5.3237</td>
<td>3.7809</td>
<td>5.1055</td>
</tr>
<tr>
<td>2007-2008</td>
<td>-0.4600</td>
<td>-3.1280</td>
<td>32.1023</td>
</tr>
<tr>
<td>Mean</td>
<td>-0.7040</td>
<td>6.8924</td>
<td>13.3205</td>
</tr>
</tbody>
</table>

Using SPSS Linear regression analysis, we can obtain the results as follows:

\[
\ln Y = -19.807 + 1.758 \ln K + 2.343 \ln L
\]

(5)

Regularizing the obtained results,

\[
\alpha^* = \alpha/(\alpha + \beta), \quad \beta^* = \beta/(\alpha + \beta), \quad \alpha^* + \beta^* = 1,
\]

we can get \( \alpha^* = 0.4287, \quad \beta^* = 0.5713 \). Using the formula \( a = y - \alpha^*k - \beta^*l \), the TFP growth rate results are shown in Figure 2.
From 1999 to 2008, the average annual TFP growth of China's railway industry is about 10.58% and TFP growth in this decade was "W"-type change. But it maintained a growth trend emerged in 2003 and the lowest rate is 0.12%. From 2001 to 2002 and 2004 to 2005 and 2007 to 2008 these three significant growth period, it peaked in 2008 about 31% and most fluctuation level of the data are in the average value 10.58%.

2) Total factor productivity computation of HSR

Because the first China HSR started operation in 2008 is from Beijing station to Tianjin station, we choose 2009 as the start point and Beijing-Tianjin inter-city railway to calculate TFP of HSR industry.

A. Value added calculation

According to staff, the railway system from August 1, 2008 to end of September 2009, the Beijing-Tianjin HSR operating income was 1.12 billion Yuan. From August 1, 2009 to August 2010, the Beijing-Tianjin rail line transported 25.18 million passengers while the Beijing-Tianjin HSR transported 6.9 million passengers. In 2010, when the volume of Beijing-Tianjin HSR passenger transportation increased by 25.5% in 2009, the attendance was also from 66.4% in 2008 to 75% at growth rate of 25.9%. In 2011, the increase rate of the volume of passengers carried by HSR was 16% compared with 2010. Thus, in this paper, we use the average value 21% as the estimated growth rate in Beijing-Tianjin HSR in the next few years. According to economic development plan of provinces, Beijing's GDP growth target in 2011-2015 is estimated to be 8% and Tianjin’s GDP growth target is 12%. In 2010, the study from Zhao Juan and Lin [10] shows that in 2008 the contribution of the Beijing-Tianjin inter-city railway to the GDP of Beijing-Tianjin region was 6.75% [4]. It is believed that with the increasing efficiency of the Beijing Tianjin HSR operations, the value of the contribution rate will increase year by year Therefore, we calculate the contribution rate of Beijing-Tianjin inter-city railway to the value of GDP in accordance with the growth rate 21% of revenue and the contribution value from HSR is added into the yield value added include the revenue.

B. Labor invest calculation

According to the Beijing Railway Bureau, the number of staff in recent years has not changed much, we select the 0.3% growth rate. Beijing-Tianjin inter-city rail line accounts for 10 % of Beijing railway operating mileage, so we use 10% of the Beijing Railway Bureau staff as the HSR labor input.
C. Capital investment calculation

The Beijing-Tianjin HSR investment in the construction is about 21.5 billion Yuan RMB. It is known that the major expenditures include 700 million Yuan as interest, 600 million Yuan depreciation costs, 500 million Yuan operation and maintenance cost. This is only the first year of operation and maintenance costs using total operating revenue ratio to estimate the future annual period of operation and maintenance costs. The authority of the department confirmed that the recovery period of Beijing-Tianjin HSR investment was 16 years. So we calculate the total investment to share annual fixed assets investment in terms of growth rate 5%. According to the data analysis and calculation, the Beijing-Tianjin HSR 2009-2013 growth rate of the indicators is in the following Table 2:

<table>
<thead>
<tr>
<th>Years</th>
<th>Labor growth (%)</th>
<th>Fixed assets growth (%)</th>
<th>Yield growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-2010</td>
<td>0.2982</td>
<td>5.1112</td>
<td>32.2062</td>
</tr>
<tr>
<td>2010-2011</td>
<td>0.2988</td>
<td>1.4659</td>
<td>30.6967</td>
</tr>
<tr>
<td>2011-2012</td>
<td>0.2984</td>
<td>1.2662</td>
<td>30.7328</td>
</tr>
<tr>
<td>2012-2013</td>
<td>0.2985</td>
<td>4.7074</td>
<td>30.8375</td>
</tr>
<tr>
<td>Mean</td>
<td>0.2985</td>
<td>3.1377</td>
<td>31.1183</td>
</tr>
</tbody>
</table>

Use SPSS linear regression analysis, the specific results are as follows. The results show that the model fit and the significance test are not better than it in the railway industry. The main reason is only five years’ data to estimate. However, the result is still within an acceptable range. The regression results are:

\[
\ln Y = 2.190 + 0.721 \ln K + 0.329 \ln L \quad (7)
\]

Regularizing the results obtained, we can obtain that \( \alpha^* = 0.721, \ \beta^* = 0.329 \). We can get the Beijing-Tianjin HSR TFP growth rate in Figure 3.

We know the TFP growth of Beijing-Tianjin HSR is higher than the level of the railway industry from 2009-2013. The average TFP growth rate of Beijing-Tianjin HSR is 28.58% annually within five years when there is no greater fluctuation and the values maintain around 28%.

![TFP growth in high-speed rail](image.png)

Figure 3. Beijing-Tianjin HSR line chart changes in total factor productivity.
THE RESULTS ANALYSIS AND SUGGESTIONS

1) The results analysis of the production efficiency

It is visible that the railway industry TFP growth rates in 2001, 2004 and 2007 have grown notably. The main reason is that China had carried out the large-scale speeding up three times in three years. In 2001, the network of raising speed basically covered the main areas of the country. The network of raising speed had covered 17 provinces in 2007. In three processes of raising speed, many new technologies and equipment had improved the efficiency of railway transportation so that trains reduced the travel time and structure of transportation products was more reasonable to further improve the quality of service.

China’s railway industry TFP growth rate in 2007-2008 is about 30%. The reasons are that the China HSR kicked off in 2008 and Hefei-Nanjing, Beijing-Tianjin inter-city and JiaoJi passenger rail line put into operation. China’s railway passenger transport industry was improved to a certain extent by the operation of HSR. By comparing the productivity growth changes of rail industry and HSR, the TFP growth level of HSR is higher than the level of rail industry and the change of the HSR productivity growth is more stable in good development trend. The average value of the HSR productivity growth is much higher than the overall level of the railway industry. Comparing the significant advantage of technological advances with common rail HSR, we conclude that the reform is effective. Therefore, this paper proposes the following suggestions to ensure the sustainable development for the HSR industry.

2) Suggestions

The results show that the technology enhances the productivity growth and has a great impact on the railway industry. While China's HSR technology has reached the international advanced level in many aspects, we still need to further strengthen the cooperation with other countries for technological exchanges in order to improve the HSR technology and equipment level. Although the HSR technology has been mature, we pay attention to the following areas in order to ensure the sustainable development of HSR. According to the research in the railway industry, we find that the annual capital investments of HSR have increased substantially in recent years. The debt financing of HSR construction is a main financing source, but the debt financing will result in huge financial costs.

Therefore, the public financing and private capital injection can broaden the financing channels. Not only can the funding gap of emergency be solved, but also the innovation of railway system can be promoted to develop very well. With the arrival of HSR era, the speed upgrade hastened the birth of the service concept change and passengers put forward higher request to the service level. Therefore, in order to ensure the sustainable development of HSR, improving service quality management at all levels such as e-commerce services for HSR, train tickets booking through the internet and implementation of mixed operating model is an important part of operational management for enhancing the HSR operation. The HSR operation safety, advanced technology, reliable quality of the equipment scientific operation and management, high-quality workforce are five essential elements. And these five factors are inseparable from strong talent support. The railway industry need to bring up a large number of railway personnel who are master of the theory, top technology level, innovation and practical ability.
CONCLUSION

This paper combined with the characteristics of railway transportation industry in China to set input and output parameters independently by using the Solow residual method to construct a measure of production efficiency. By comparing the analysis of the empirical calculation of the TFP growth rate about the passenger railway industry and HSR in the past decade, we conclude that the HSR development will enhance the greater productivity of China's railway industry, but we need to pay attention to development issues and propose reasonable suggestions for the realization of the sustainable development of the HSR.

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REFERENCES