The Impact Analysis of Highway on Henan Economic Development

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Keywords: Highway, Intercity accessibility, Intercity economic impact index, Response sensitivity, Radiant ability, Spatial distribution, Difference analysis.

Abstract. City economic growth is not only affected by economic development policy environment and its own economic condition, but its geographical location and the economic development of adjacent cities also play an important role. the developed regions play a certain leading role in the economic development of neighboring regions through effective traffic. This paper designs an intercity economic impact index by using the intercity accessibility coming from the highway network as the weight, to study the impact of highway on city economic development. The results show that the response sensitivity of city economy is proportional to the highway mileage increase, and the responsiveness has significant difference among cities, and the influences are tending to be stable. The radiant ability of the capital city Zhengzhou in the regional economic development is gradually increasing but the radiation effects on the adjacent cities, as Kaifeng and Xuchang are not fully exerted. Zhengzhou economic agglomeration characteristics is gradually obvious, the tendencies of the intercity economic impact index and the economic development are obviously different. The aggregation characteristics of the economic impact index of Zhengzhou is gradually decreasing, but aggregation speed is gradually increasing. The distributions of highway influences are tending to be balanced.

Introduction

Transportation is the basic industry of the national economy, closely related to the regional economic and social development. The development and improvement of highway network signify that road transportation has been entering the modern traffic era, promoting the status of the highway in the comprehensive transportation system, constituting the regional blood and lifeline. A perfect highway network system could not only improve the regional transportation level, promote the regional economic development, shorten the distance between cities to adapt the pursuit of the modern people in the speed and efficiency, but also impact on the regional economic industry structure [1,2].

The impact of highway construction on regional economic development has attracted the attention of many scholars. At present, the domestic researches mainly focus on the suitability evaluation and space optimization method of highway network [3-8], the spatial distribution and evolution pattern of the city accessibilities coming from highway network, the impacts on regional economic industry structure, reasonably improving the highway economic belt[9-15], and so on. In General, there is less research on the impact difference analysis of highway network on regional economic development.

Regional economic distribution status and change pattern are the main indicator of regional economic development. This paper designs an intercity economic impact index by using the intercity accessibility coming from the highway network as the weight, using Henan province as an example to study the impact of highway construction on city economic development, compares the spatial relationship between the highway construction and the impacts, in order to provide a scientific reference for improving the highway network system, and planning an effective regional economic development policy.
Data and Research Methods

**Data.** The operation of the first highway line, Lankao to Luoyang section of Lianhuo national highways, marked the Henan transportation was run into high-speed traffic era. Since 2004, the province’s highway network has been rapidly developed, by the end of 2016, the highway mileage is up to 6600 km, basically formed a sound highway traffic network with 9 vertical and 12 horizontal national highways as the framework. In 2002 the province's economy entered the fast lane of development, GDP has maintained double-digit growth rate, from 55.33 billion yuan in 2002 to 349.38 billion yuan in 2016, an increase of more than 6 times [16].

Based on the processes of highway network construction and economic development, the paper evenly divide the 12 years (early 2004 - early 2016) into 3 time stages, and 4 time sections to study the impact of highway constructions on city economic development, in order to explore their spatial-temporal characteristics and evolution patterns.

The spatial data of the study are from the Henan highway spatial database and meta-database. The time distance is based on the weighted average of the empirical traveling time on lines and intersections from the corresponding years[19]. The shortest distance between cities is calculated by NEDS algorithm [16,17]. The city economic data are from the Henan Province Statistical Yearbook.

**The intercity accessibility.** The intercity accessibility coming from the highway network describes the convenience degree of transportation between adjacent cities. In highway network, there are many possibilities of connection between adjacent cities. Only the routes within the time thresholds are considered in the study. The time thresholds usually are set to be the shortest traveling time between cities on an ordinary traffic network. The two routes are considered to be the same, if their repetition rate is greater than 50%.

In the highway network, the accessibility $A_{ij}$ from city $j$ to city $i$ is defined as the sum of the inverse of time distance from city $j$ to city $i$ for all routes, on which the traveling times are less than the time threshold, and do not travel through the third city.

$$A_{ij} = \sum T_{r}^{-1},$$  \hspace{1cm} (1)

The larger $A_{ij}$ means better traffic convenience degree from city $j$ to city $i$, sometimes $A_{ij} \neq A_{ji}$.

**Intercity economic impact index.** The operation of the intercity highway shortens the time (cost) distance between cities, and strengthens the interaction, makes the regional economic development tend to be integrated.

The intercity economic impact index $TE_{i}$ of $i$, is defined as the intercity accessibility weighted average of the economic indicators of all adjacent cities in geographic topology.

$$TE_{i} = \sum_{j=1}^{n} \frac{E_{j} A_{ij}}{A_{ij}},$$  \hspace{1cm} (2)

Where $E_{j}$ is the economic indicator of $j$, the impact factors of economic development $j$ to $i$. The larger $TE_{i}$ means the greater impact $j$ to $i$.

**Economic growth type index.** City economic growth is mainly affected by the economic development policy environment, its economic situation, geographical location and so on. In the same economic development policy environment, the city economic growth type index is defined as the contribution rate of the intercity economic impact index to Gross Domestic Product

$$E_{i} \alpha = \frac{TE_{i}}{E_{i}},$$  \hspace{1cm} (3)

$E_{i} \alpha \leq 0.5$ means the economic development of $i$ is mainly driven by its own economic development, the city plays a leading role in the economic development of adjacent cities, known as the economic radiating type city, otherwise called the economy radiated city.

**Centrality characteristics.** The construction of highway network has promoted the economic communication in the region, and the economic development of the city has certain relativity with the
location of the city. The regional economic center \( GC \) and intercity economic impact center respectively are defined as GDP and the intercity economic impact indices weighted average of city geographic coordinates,

\[
EC = \left( \sum_{i} x_i \right) \left( \sum_{i} y_i \right), TEC = \left( \sum_{i} TE_i x_i \right) \left( \sum_{i} TE_i y_i \right)
\]

(4)

where \((x_i, y_i)\) is the geographic coordinates of \( i \).

The Economic Development Impact Analysis of Highway Network in Henan Province

Spatial-temporal evolution of highway network. During the 12 years from 2004 to 2016, Henan highway network has got considerable development, the highway mileage has increased from 680km in 2004 to 6600km in 2016, increased by nearly 10 times, the average annual growth in the first stage is highest up to 464\%, followed by the second 33\% and third stages 28\% (Figure 1).

Intercity economic impact index analysis. First, based on the highway network and the corresponding time-consuming empirical data of each time section, the intercity accessibilities are calculated by using Eq.1, then, using Eq. 2 and the city GDPs of the corresponding year, calculate the intercity economic impact indices, the results are shown in Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>ZZ</th>
<th>KF</th>
<th>LY</th>
<th>PDS</th>
<th>AY</th>
<th>HB</th>
<th>XX</th>
<th>JZ</th>
<th>PY</th>
<th>XC</th>
<th>LH</th>
<th>SMX</th>
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<td>GDP</td>
<td>6.48</td>
<td>4.73</td>
<td>6.36</td>
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<td>5.29</td>
<td>1.43</td>
<td>5.47</td>
<td>3.39</td>
<td>3.55</td>
<td>4.47</td>
<td>2.51</td>
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<td>10.65</td>
<td>8.11</td>
<td>7.80</td>
<td>10.60</td>
<td>8.26</td>
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<tr>
<td></td>
<td>TE</td>
<td>4.71</td>
<td>6.50</td>
<td>3.46</td>
<td>5.17</td>
<td>2.03</td>
<td>5.01</td>
<td>4.29</td>
<td>5.37</td>
<td>4.91</td>
<td>5.29</td>
<td>2.72</td>
<td>6.90</td>
<td>5.52</td>
<td>5.56</td>
<td>9.07</td>
<td>5.08</td>
<td>6.47</td>
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<tr>
<td></td>
<td>TPa</td>
<td>0.73</td>
<td>1.37</td>
<td>0.54</td>
<td>1.06</td>
<td>0.38</td>
<td>3.51</td>
<td>0.78</td>
<td>1.59</td>
<td>1.38</td>
<td>1.18</td>
<td>2.90</td>
<td>3.12</td>
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<td>0.69</td>
<td>1.16</td>
<td>0.48</td>
<td>0.78</td>
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<tr>
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<td>6.50</td>
<td>4.99</td>
<td>5.39</td>
<td>1.45</td>
<td>5.58</td>
<td>3.45</td>
<td>3.61</td>
<td>4.54</td>
<td>2.56</td>
<td>2.23</td>
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<td>7.99</td>
<td>10.81</td>
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<td>1.14</td>
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<td>1.51</td>
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<td>1.19</td>
<td>0.45</td>
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<tr>
<td>2012</td>
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<td>7.35</td>
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<td>3.58</td>
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<td>0.77</td>
<td>1.11</td>
<td>0.51</td>
<td>0.81</td>
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<tr>
<td>2016</td>
<td>GDP</td>
<td>7.60</td>
<td>5.14</td>
<td>6.96</td>
<td>5.41</td>
<td>5.79</td>
<td>1.62</td>
<td>6.04</td>
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The change rate of intercity economic impact indices reflects the response sensitivity of regional economic development to highway construction. As showed in Table 1, the responsiveness is gradually reducing in the 3 stages of the study.

From the spatial distribution, in the first stage, the responsiveness in the west and the peripheral area is higher than that in the east, and shows the trend of west high east low. Compared with the previous stage, in the second stage, the responsiveness shows the opposite trend. In the third period, for the operation of Zhengmin highway and Jixi highway increased the relation of Zhoukou and
Shangqiu with the relative development of central cities, their responsiveness increase considerably, the rest cities tend to be balanced.

In general, the response sensitivity of city economy is proportional to the highway mileage increase (see Figure 2), the operations of intercity highways effectively increase their economic linkage and the radiant ability of developed city, but this ability is trending to be stable.

![Image](image1.png)

**Figure 2.** The spatial distributions of the change rates of economic impact indices (stage1-stage3).

**Economic growth type analysis.** Using the corresponding economic data and Eq.3 and Table 1, the city Economic growth type are calculated, and the results are listed in the latter part of Table 1.

As showed in Table 1 and Figure 3, with the development and improvement of Henan highway network, the contribution rates of highway to the city economic are gradually expanding, have obvious central aggregation characteristics.

On the first and second time sections, the central city Zhengzhou, the northern city Anyang and southwestern city Nanyang are the economic radiating type city, the rest 15 cities are the economy radiated city. There are 11 cities their city economic growth type index are more than 1. On the third time section, the central city Zhengzhou and the northern city Anyang are the economic radiating type city, the rest 16 cities are the economy radiated city. There are 12 cities their city economic growth type index are more than 1. On the forth time section, the central city Zhengzhou is only one economic radiating type city, the rest 17 cities are the economy radiated city. There are 12 cities their city economic growth type index are more than 1.

![Image](image2.png)

**Figure 3.** The spatial distributions of economic impact indices (2004-2016).

Overall, in the 4 time sections of study, the central city Zhengzhou has been an economic radiating type city, plays a leading role to the province’s economy development, its influence force is gradually increasing.

Before 2008, Nanyang was the economic development center in the south and southwest of the province, and played a leading role in promoting the economic development of this region. Before 2012, Anyang was the economic development center in the north of the province, which promoted the economic development of this region. With the time passing, their influence on the provincial economic development is gradually decreasing.

According to city economic radiation theory, the economic radiant ability should reduce with the traffic distance extension, the cities closer to the developed city should get a greater impact than the other cities.

However, the city economic growth type indexes of Jiaozuo, Xinxiang, Kaifeng, Xuchang and Pingdingshan, which are adjacent to Zhengzhou (Figure 1), is more than 1 in the 4 time sections. In the same economic development environment, the reasons for this phenomenon can be divided into two categories, the first, there are good traffic conditions with the developed cities, but their own economic situation are poor, lack some necessary economic growth points, such as Kaifeng and Xuchang. The Second, their own economic situations are good, but the geographical environments
constraint linkage with the developed cities, reducing the radiation effects, such as Jiaozuo, Xinxiang and Pingdingshan.

**Centrality analysis of intercity economic impact index.** The centers of the city economic and economic impact indices are calculated by using Eq.4 on each time section, the results are showed in Figure 4.

![Figure 4. The center distributions of the city economic and economic impact indices.](image)

With the development and improvement of Henan highway network, Zhengzhou economic agglomeration characteristics is gradually obvious, the economic center of the province gradually moved from south to north to Zhengzhou, in the 3 stages, the aggregation speed is gradually increasing.

There are obviously difference between the distribution of the intercity economic impact index and the distribution of the economic development levels, the aggregation characteristics of economic impact index of Zhengzhou is gradually decreasing, aggregation speed also is gradually increasing, but the geographical position change little, the range is less than 2km. This shows that with the rapid development of the province's economy, the impact of highway network on each city economic development gradually become balanced, the spatial distribution of highway gradually tend to rationalize.

**Conclusion**

City economic growth is not only affected by economic development policy environment and their own economic conditions, but its geographical location and the economic development of adjacent cities also play an important role, the developed regions play a certain leading role in the economic development of neighboring regions through effective traffic. In order to fully study the impact of highway construction on city economic development, this paper designs an intercity economic impact index. The research shows that

1) The response sensitivity of city economy is proportional to the highway mileage increase, the responsiveness has significant difference among cities, the operations of intercity highways effectively increase their economic linkage and the radiant ability of developed city, but with time passing this ability is trending to be stable.

2) Before 2008, the provincial economy presented south, north and central three growth poles, respectively centered on Nanyang, Anyang and Zhengzhou, they played leading roles to the economic development of their region. However, with time passing, the role effects of north and south gradually became smaller, the effect of Zhengzhou becomes larger, the radiation effects of Zhengzhou on the adjacent cities, as Kaifeng and Xuchang are not fully exerted.

3) With the development and improvement of Henan highway network, Zhengzhou economic agglomeration characteristics is gradually obvious, the economic center of the province gradually move from south to north to Zhengzhou, the tendencies of the intercity economic impact index and the economic development levels are obviously different. The aggregation characteristics of the economic impact index of Zhengzhou is gradually decreasing, but aggregation speed is gradually increasing. The distributions of highway influences are tending to be balanced.
Acknowledgement

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References


