

Analysis of Economic Development in Urban Agglomerations by High-Speed Rail Network: Taking Beijing-Tianjin-Hebei City Cluster as an Example

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Abstract. With the increasing impact of the opening of high-speed railway on the inner city, many indicators within the city have changed significantly, which plays an important role in the impact of the city's economy. Therefore, this paper explores how the high-speed railway network affects intra-city economic development based on the changes in three indicators of city size, per capita disposable income of residents and the structure of the three industries, as reflected by the population flow in the Beijing-Tianjin-Hebei city cluster. It is found that the opening of high-speed railway has led to a "siphon phenomenon" in the Beijing-Tianjin-Hebei urban agglomeration, which has both advantages and disadvantages for the development of large cities and small and medium-sized cities; it has a positive effect on the increase of disposable income of the residents; and it also has a positive effect on the development of tertiary industry.

Keywords: high-speed rail, urban economy, population size, industrial structure.

1. Introduction

The significance of high-speed railways as the driving force behind China's transport network cannot be overlooked. Transport networks are essential for contemporary urban transportation, the movement of commodities and factors between cities, and the transformation and growth of regional economies brought about by changes in industrial scale. China's high-speed rail network has evolved from the country's first urban railway to its current state of perfection. It is necessary to demonstrate that the high-speed railway network has greatly accelerated the economic growth of urban agglomerations, in addition to its ongoing involvement in the exchange and transfer of goods and activity elements both within and between urban agglomerations. City cluster, as a huge carrier for the sustainable development and interconnection of the regional economy, is an inevitable product of the mature stage of urban development. It takes the form of a highly integrated city cluster with dense space, frequent economic exchanges, complementary public functions and reasonable industrial division of labour, centred on a small number of mega-cities and surrounded by a number of large, medium and small-sized cities, which are linked by transportation networks.

At present, most of the domestic and international studies on the relationship between transport networks and city clusters focus on the impact of high-speed railway networks on the regional economy of city clusters. The majority of these studies analyse the relationship between accessibility and the strength of economic ties within city clusters using the gravity model. Some also examine how the ongoing development of the high-speed rail network will impact the economic spatial structure of these clusters. In this study, the synergetic development of high-speed railway network on the economy of city clusters and the question of whether the entry of high-speed railway has continuously expanded the economic differences within city clusters have attracted great attention, while the Beijing-Tianjin wing, as a pioneer and demonstration area of China's Chinese-style modernisation and an important core area of the northern economy, has attracted great attention. The study of the economic development of the high-speed railway network within the city clusters of Beijing-Tianjin Hebei is also important for the economic development of other city clusters in China.

The study of the economic development generated by the high-speed railway network within the Beijing-Tianjin-Hebei city cluster also has important implications for other city clusters in China in terms of how they should enhance synergistic development and reduce the siphoning effect in the future.

2. Three Aspects of Analysis

2.1. The Impact of High-speed Rail Network Construction on the Development of the Inner Scale of the Beijing-Tianjin-Hebei Urban Agglomeration

In this paper, the city size is mainly reflected by the city population. In 2008, the Beijing-Tianjin-Hebei Intercity Railway was put into operation. The opening of high-speed railways drives inter-city population flow, and the difference in intercity population scale has a significant negative impact on coordinated economic development. The difference in urban population scale promotes the inter-city flow of labour factors, accelerates the agglomeration of factors in central cities and the outflow of factors in marginal cities, and further widens the gap in economic development between cities (as shown in Figure 1).

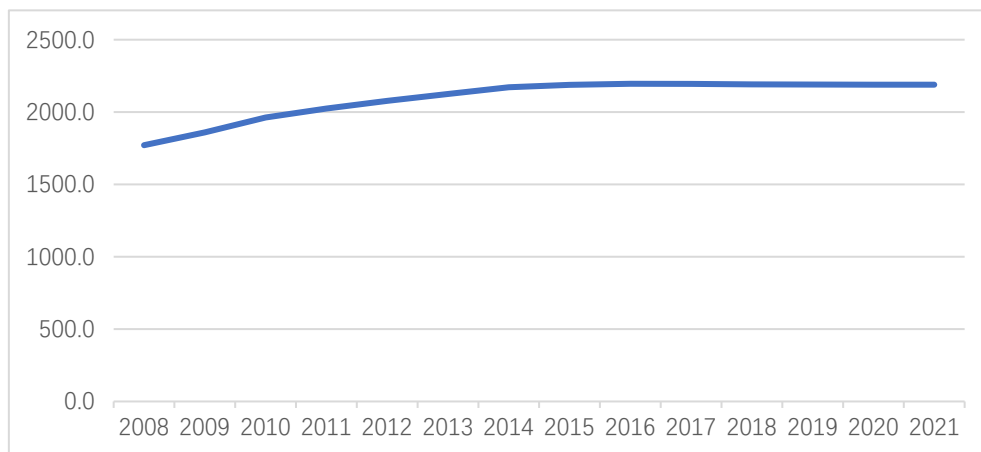


Fig. 1 Change of resident population in Beijing (Picture Credit: Original)

In the study of Zhang Kun et al., it is found that the opening of high-speed rail can produce a polarisation effect and diffusion effect on the coordination of economic development. The polarisation effect mainly shows that the high-speed railway makes the economic resources gather from the peripheral cities to the central cities, and leads to the widening of the gap between cities. The diffusion effect means that the development of high-speed rail can radiate the central city to drive the development of peripheral cities and narrow the regional gap [1]. Cities within the size difference are conducive to promoting regional economic agglomeration development, formed the centre of city agglomeration - linkage development pattern of the peripheral city, the central city is produced by the scale of development has positive spillover effects on the peripheral city development, formed a benign economic coordinated development path. In the initial agglomeration stage, the construction of high-speed railways improves the level of urban accessibility, promotes the flow of labour force, information and other factors, and affects the industrial layout and knowledge spillover effect of the city by stimulating investment and increasing employment [2]. However, after 2016, Tianjin's population showed an outflow trend, and after 2018, the growth rate of major cities in Hebei Province slowed down and showed an outflow trend (as shown in Figure 2). In the urban agglomeration with the capital circle as the core, over time, Beijing is more able to attract more people from the surrounding central cities, so the population flows in reverse, and the siphon effect is obvious enough. The opening of high-speed rail enhances the flow of production factors between cities and can have a positive effect on urban development. However, the opening of high-speed rail between central and peripheral cities may have both advantages and disadvantages for the coordinated development of cities and may be a "double-edged sword" for the development of peripheral cities.

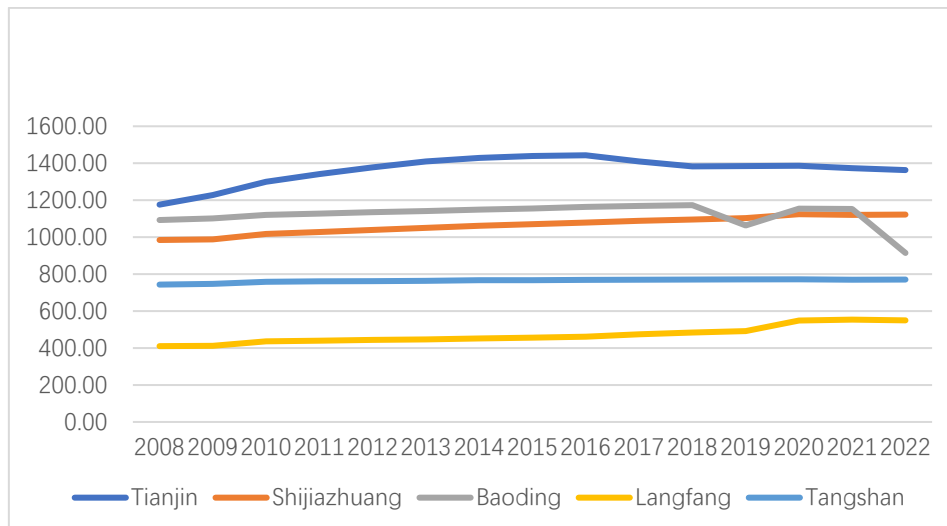


Fig. 2 Changes in resident populations in other major cities (Picture Credit: Original)

The scale difference will affect the coordinated economic development between cities, which is determined by the location conditions between cities, development endowment and other factors. As an important modern transportation infrastructure, the planning of high-speed rail is independent of the scale of a single city, and its externality is strong. Therefore, the opening of high-speed rail has been given high hopes for urban development, hoping to inject new impetus into urban development. However, the result is that the opening of high-speed rail has an obvious "siphon effect" on the coordinated development of cities, and the population agglomeration and economic agglomeration have not produced the spillover effect of coordinated growth.

There are obvious differences in population scale, economic scale and land area scale among cities, and the scale factor is of great significance in the coordinated economic development between cities [1]. The opening of high-speed rail has a promoting significance for the development of urban scale. However, with the passing of time, the long-term siphon effect in urban agglomerations has become more and more obvious, resulting in the continuous expansion of the scale of central cities and the continuous downturn of non-central cities. The convenience of high-speed rail makes talents more inclined to flow to big cities, which further intensifies the competitive pressure of big cities and makes small and medium-sized cities face the dilemma of brain drain, resulting in economic losses. Secondly, cities along the route have obtained development opportunities, but these opportunities are more obtained by big cities, and peripheral cities are often faced with the risk of being marginalised.

2.2. The Impact of the Construction of High-speed Rail Network on the Economic Scale within the Beijing-Tianjin-Hebei City Cluster

Whether or not high-speed rail plays a huge role in economic growth is a topic of debate among many foreign scholars. Scholars summarised the studies on the impacts of HSR on non-transportation economic development before 2009 and found that many of the findings indicated that HSR had little economic impact, and even concluded that HSR created no economic value and that the indirect economic benefits of HSR were shaped by the redistribution of economic activity [3]. It is worth noting that this summary only includes developed countries. How high-speed rail has affected developing countries in the last decade, especially China as one of the world's largest economies, still deserves further exploration. Moreover, there is heterogeneity in the impact of HSR on cities, and domestic scholars generally agree that HSR strengthens the economic power of most HSR cities and increases the economic gap with non-HSR cities [4].

Deming Liu used the geographically weighted regression model to make the spatial and temporal distribution of geographically weighted regression coefficients of per capita disposable income of urban residents in Beijing-Tianjin-Hebei urban agglomeration in the era of general-speed railroads (2007) and the era of high-speed railroads (2020), as shown in Figure 3 [5].

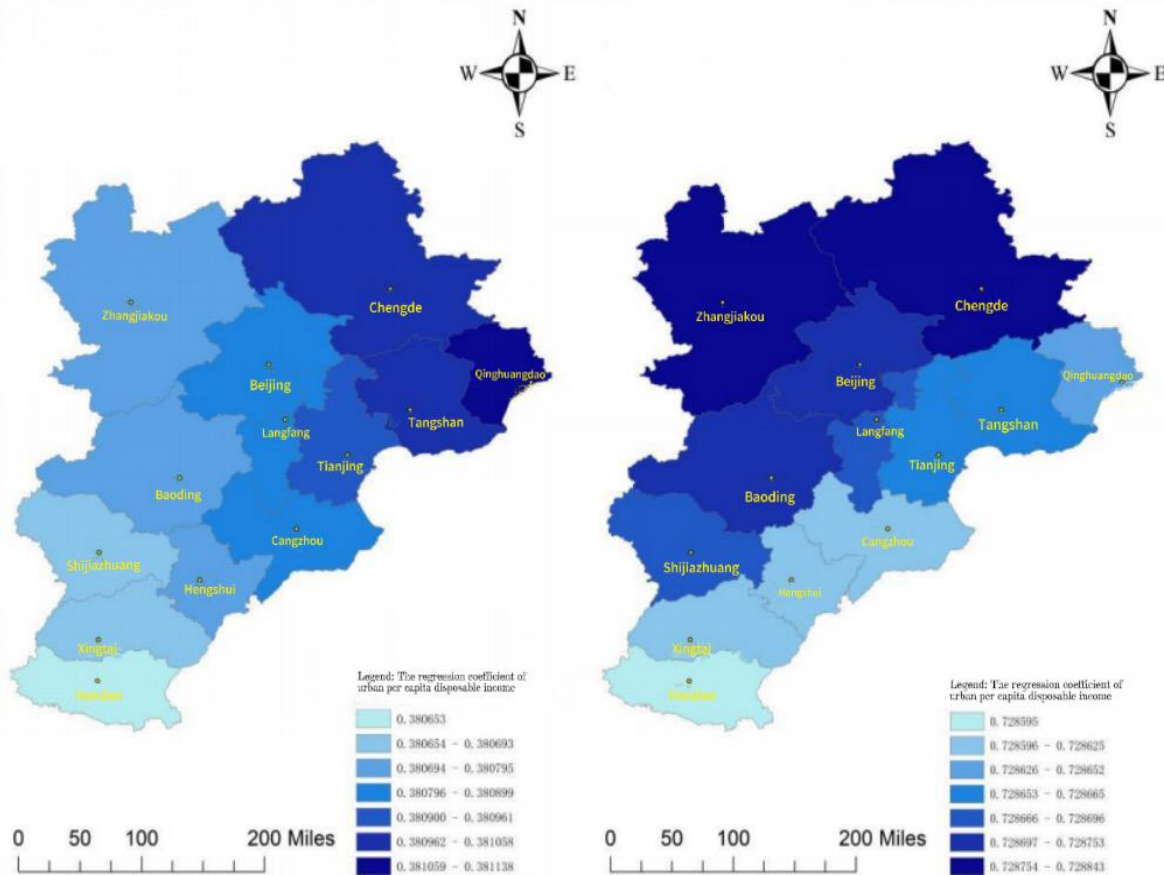


Fig. 3 Regression analysis chart of the general-speed railway era and the high-speed railway era in the Beijing-Tianjin-Hebei urban agglomeration [5]

In this geographically weighted regression model, the total economic volume of each city in the Beijing-Tianjin-Hebei city cluster is the dependent variable, and the disposable income per capita of urban residents is the independent variable, and the larger the regression coefficient is, the more related the two variables are. As shown in Figure 3, the regression coefficients of per capita disposable income of urban residents in the Beijing-Tianjin-Hebei city cluster in the era of the general-speed railroad are all positive, which represents that the influence of per capita disposable income of urban residents on the economic development of the Beijing-Tianjin-Hebei city cluster is positive. Along with the increase in economic aggregate, the level of residents' income has also gained different degrees of improvement.

The regression coefficient of per capita disposable income of urban residents in the era of high-speed railroad shows a trend of increasing from southwest to northeast, with the highest value appearing in Qinhuangdao City, which together with its neighbouring cities, including Chengde, Tangshan, Tianjin and other cities, forms a high-value agglomeration area. The minimum value of the regression coefficient appears in Handan City, and the low-value agglomeration area is mainly concentrated in the Ji'an area, which indicates that the income level of the residents in this area cannot keep up with the pace of economic development. In the era of high-speed rail, the regression coefficient of per capita disposable income of urban residents has been greatly improved compared with that in the era of the general railroad, which indicates that the influence of the element of residents' income on the regional economic development is on the rise and that raising the residents' income has become an important part of the development of the national economy that cannot be ignored. The distribution pattern of regression coefficients has also changed significantly compared with the era of the universal railroad, and the area of high-value aggregation has been shifted from the eastern coastal area to the western inland area. It shows that the construction of the high-speed railroad has improved the income level of the residents of inland cities. The highest value appears in Zhangjiakou, which has a very significant increase in residents' income with the opening of the

Beijing-Zhangjiakou high-speed railway and the preparation for the Winter Olympics, among other reasons. Moreover, the residents' income of coastal cities such as Tangshan, Tianjin and Qinhuangdao have different degrees of stalling phenomenon after entering the high-speed rail era, and no longer show obvious leading advantages.

2.3. Impact on the Development of the Proportion of Industrial Structure within the City Cluster

Due to the different allocation of production factors, the industrial structure of different regions will also change. Therefore, eventually, the continuous development of the HSR network also plays a role in the different enterprise standings and industrial structure changes within the region. The opening of high-speed rail will also improve the industrial structure and industrial distribution of the cities in the Beijing-Tianjin-Hebei region, increasing the possibility of enterprises investing in different cities in the Beijing-Tianjin-Hebei region or building factories across the region, thus optimising the capital structure of the Beijing-Tianjin-Hebei region [6]. Therefore, the changes in the proportion of the three industrial structures in the Beijing-Tianjin-Hebei city cluster since the opening and operation of the high-speed railway are taken as an important example to explore the developmental changes of the high-speed railway network on the industrial structure within the city cluster.

According to the analysis of Huang Kaidi et al. exploring the effect of high-speed rail accessibility on the economic development of the Beijing-Tianjin-Hebei city cluster, it can be concluded that the primary industry is not significantly affected by the spatial accessibility of high-speed rail; the development of the secondary industry in the city cluster is negatively affected by the spatial accessibility of high-speed rail on the whole; and the accessibility of high-speed rail network has a positive impact on the development of the tertiary industry [7]. After collecting the data on the proportion of the three industrial structures in the main areas of Beijing-Tianjin-Hebei after the opening of the high-speed railway, Figures 4, 5, 6, and 7 of the trends of the three structural industrial changes from 2008 to 2018 are made [8-11]. Analysing the figures, it can be found that on the whole of Beijing-Tianjin-Hebei urban agglomeration, the proportion of primary industry has been decreasing year by year, but the rate of decrease is not too big, and Beijing, Tianjin, Hebei and other regions also show this trend; the proportion of secondary industry in the urban agglomeration as a whole and in each region show a year-on-year trend of decreasing and the rate of decrease is bigger than that of the primary industry. The tertiary industry in both the Beijing-Tianjin-Hebei urban agglomeration and the regions of Beijing, Tianjin, and Hebei, all show an upward trend. In the tertiary industry, both in the Beijing-Tianjin-Hebei city cluster and in the regions of Beijing, Tianjin and Hebei, there is a rising trend.

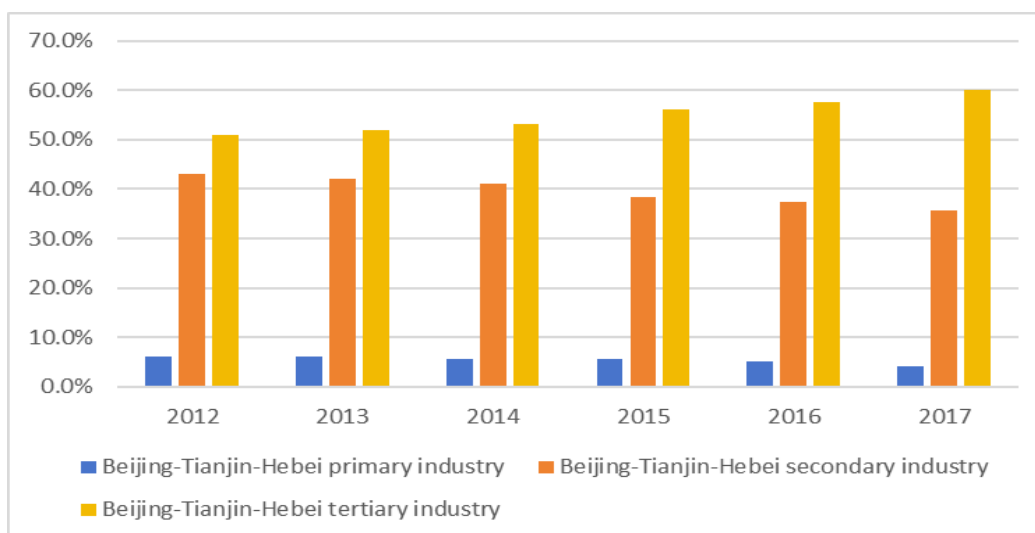


Fig. 4 Ratio of the three industries in Beijing-Tianjin-Hebei, 2012-2017 (Picture Credit: Original)

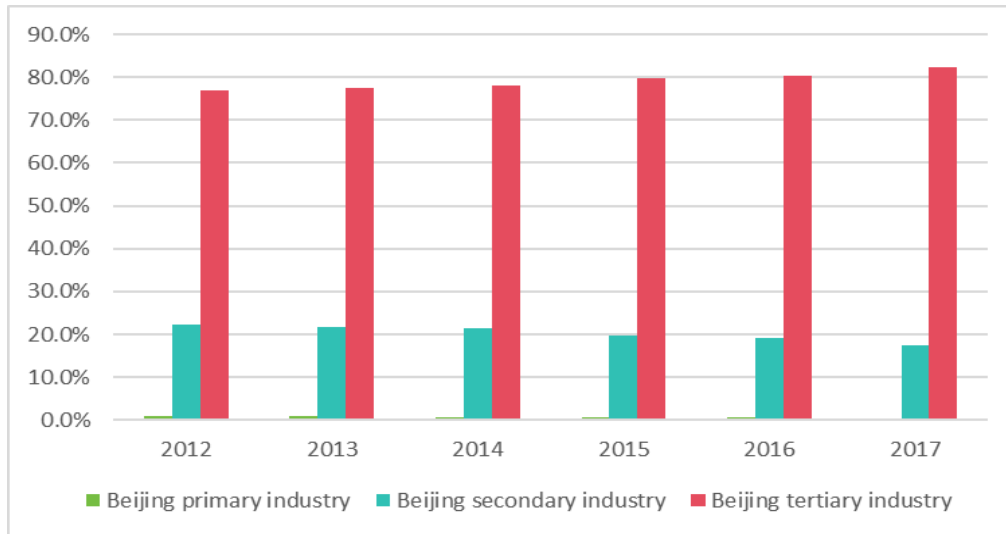


Fig. 5 Ratio of the three industries in Beijing, 2012-2017 (Picture Credit: Original)

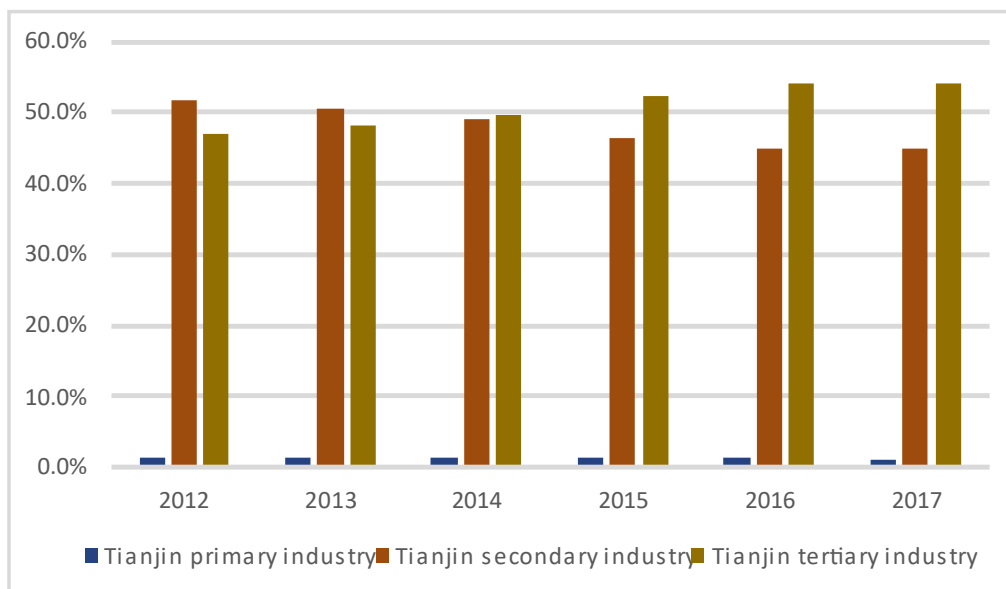


Fig. 6 Ratio of the three industries in Tianjin, 2012-2017 (Picture Credit: Original)

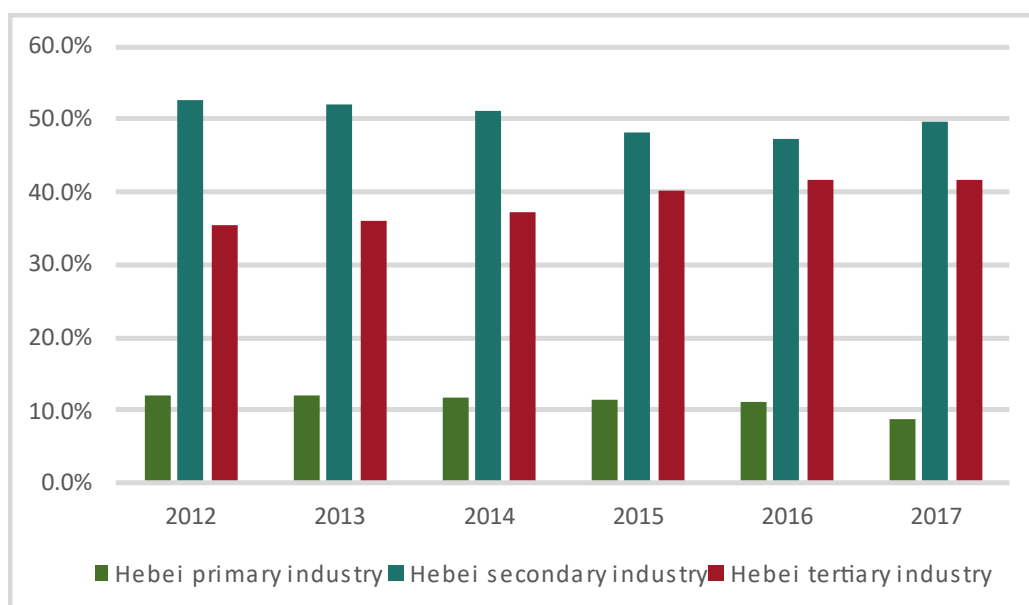


Fig. 7 Ratio of the three industries in Hebei, 2012-2017 (Picture Credit: Original)

Therefore, by combining the impact of the high-speed rail network accessibility on the structure of the three industries with the statistical data table of the ratio of the three industrial structures in the years after the opening of the high-speed rail network, this study can analyse that the high-speed rail network has brought about a positive impact on the structural change of the three industries in the Beijing-Tianjin-Hebei region. The agricultural production and manufacturing industry developed stably, while the modern service industry and cultural tourism, which started later, showed more favourable development momentum. Moreover, in the structure of the three industries, especially for the tertiary industry, the factor of labour is a very important influence factor, so the flow of people brought by the high-speed rail will have a greater role in promoting the development of the tertiary industry, especially the tourism industry. At the same time, the high-speed railway also promotes commercial activities such as business travelling and conferences in various regions of Beijing-Tianjin-Hebei [12]. It can be seen that the tertiary industry has gradually become the support and guarantee system for the economy of the Beijing-Tianjin-Hebei region and an important engine of economic growth. Therefore, through the opening of high-speed rail to Beijing-Tianjin-Hebei industrial transfer accelerated, has basically formed a "Beijing-Tianjin research and development, Hebei manufacturing, Beijing research and development, Tianjin-Hebei transformation" of the spatial layout. The three cities of Beijing, Tianjin, and Hebei Province give full play to their own comparative advantages, clear industrial division of labour system, the formation of industrial synergistic agglomeration based on Beijing, radiation Tianjin and Hebei [13].

3. Suggestions

The high-speed rail network has a heterogeneous impact on the coordinated economic development within urban agglomerations, which gives people a revelation that the dividend of high-speed rail is not a generalized system of preferences, and it is necessary to better play the positive effect of the high-speed rail network [14]. Local governments should make appropriate interventions, especially in the economic activities within

Urban agglomerations, focus on guiding labour, capital, technology and other production factors from core cities to peripheral cities, could orderly guide the industrial transfer of central cities to surrounding small and medium-sized cities, relieving some functions of central cities, alleviating the "big city disease", and avoiding the impact of small and medium-sized cities from siphoning effect. At the same time, small and medium-sized cities should focus on optimizing the business environment and improving their own industrial capacity, so as to absorb talents and realize the positive flow of population. Secondly, the positive effects of high-speed rail networks should be better released, administrative boundary barriers should be further weakened, factors of production should be promoted more efficiently across regions, and the ability of developed regions to radiate and drive less developed regions should be improved, so as to enhance the level of coordinated economic development within urban agglomerations.

High-speed rail plays an important role in reshaping the regional economic pattern and in strengthening the economic ties of neighbouring cities. In terms of the impact of HSR on the strength of economic ties between cities, it has produced two effects, namely "agglomeration" and "diffusion". The Beijing-Tianjin-Hebei city cluster plays more of a "gathering" role, and the high-speed railway strengthens the central position of Beijing, which makes the economic links between Beijing and its neighbouring cities become closer and closer, and produces a strong "siphon effect".

It is essential to promote the development of urban agglomerations towards diversified transportation hubs and multipolar economic centres. Regional transportation centres and regional economic centres have a high degree of overlap, and this trend will continue to strengthen in the future. The diversification of regional centres is conducive to the synergistic development of the regional economy, and emphasis should be placed on creating sub-centres or vice-centres outside of a single central city. The Beijing-Tianjin-Hebei urban agglomeration lacks a strong central city in southern Hebei, and the transportation hub has been weakened, so Shijiazhuang's development

strategy of "strong provincial capital" should be strongly supported to create a third tier of economic growth for Beijing-Tianjin-Hebei. Taking the construction of the high-speed rail as an opportunity to create a high-speed rail economic belt within the urban agglomeration, and close the economic ties between the cities along the high-speed rail. High-speed railways can greatly shorten the commuting time of the neighbouring cities and thus enhance the strength of economic ties between the cities. Therefore, the construction of high-speed railways can be taken as an opportunity to guide the cities along the line to strengthen industrial collaboration, optimise industrial layout and jointly build a high-speed railroad economic development belt. The state can also introduce relevant policies to support the development of high-speed railway economic belts, support the cities along the line to strengthen collaboration in industry transfer, labour mobility, etc., and promote the sharing of resources and complementary advantages. The focus is on the development of service-oriented industries such as building economy, tourism economy, commerce and logistics, which require high commuting time.

Therefore, taking Beijing-Tianjin-Hebei as an example, other cities in China can also learn from the planning of its high-speed railway network, so as to make the industrial structure within the urban agglomeration form a "centre-periphery" type; to improve the cohesion of the economic centre; and to increase the proportion of the tertiary industry. In addition, the Beijing-Tianjin-Hebei city cluster and other city clusters in China can also analyse the economic impact factors of high-speed rail on different regions to determine the characteristic industries and give full play to their competitive advantages. From the viewpoint of city clusters, large cities can take the initiative to transfer low-end industries to small and medium-sized cities in order to develop more tertiary industries such as service industries, etc., while small and medium-sized cities should selectively accept industries suitable for local development and optimise their own industrial layout.

4. Conclusion

The opening of high-speed rail has a promoting significance for the development of urban scale. However, with the passage of time, the long-term siphon effect in the urban agglomeration is also significant enough. As a result, the scale of central cities is expanding, and non-central cities continue to be depressed. Therefore, the development of urban agglomerations should pay attention to the heterogeneity of spillover effects between central cities and peripheral cities, timely adjust the coordinated development strategy, better balance regional economic development, and then lead the development of the whole country.

The impact of the construction of high-speed railroads on the income of the residents in the Beijing-Tianjin-Hebei city cluster is significant, and the role of the residents' income in the regional economy is becoming more and more obvious. Moreover, the high-speed railway plays an important role in balancing the regional income level, developing the inland economy and narrowing the gap between the western mountainous areas and the eastern coastal areas.

Through the above analysis of the industrial structure of the Beijing-Tianjin-Hebei region after the opening of the high-speed rail, it can be concluded that the city cluster shows that the primary and secondary industries tend to be marginalised, while the tertiary industry is booming towards the core. It shows the city cluster model of "centre-periphery", which is conducive to the professional division of labour, so that each industry cluster is independent of each other internally, while externally assisting each other to promote the growth of the regional economy within the city cluster.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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