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Analysis of Preconditions for Innovative Transport High-Speed Rail Construction Based on Agglomeration Risks and Achievement

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Abstract:

In the article, the questions of the value of high-speed transport are considered. It is proved that systems HSR actively developed in the world. New lines successfully accustom to the most different conditions, and offered new transport possibilities can be adapted for concrete material and non-material requirements which differ in the different countries and regions. Additional approaches to an estimation of future volume of passenger traffic HSR, in particular, on the basis of gravitational model and the ABC-ANALYSIS are offered. All estimations, positions and article conclusions are considered with reference to project HSR "Zhengzhou – Jinan".

Keywords*: High-speed railway, Passenger transportation, Forming of demand for transportation, Conurbation, ABC-ANALYSIS, HSR Zhengzhou – Jinan.*

I. INTRODUCTION

Recently, the mass media has become more and more confident in the possibility of implementing the Zhengzhou Jinan high-speed railway project, and more and more attention has been paid attention to the project. According to preliminary estimates, investments in the project could amount to up to 7 billion dollars. It is assumed that the trains will reach speeds of up to 350 km/h, and the travel time from capitals of Henan to Shandong will be 1.5 hours [1]. What opportunities and risks will this project bring to the provinces in particular and to China as a whole?

In their papers, the authors have already noted that for the vast territories, the role of high-speed railways (HSR) can hardly be overestimated, since they, on the one hand, fully meet the requirements of the modern global economy and, on the other hand, lead to positive effects of scale and growth of regional economies. However, the viability of the HSR project is based on pragmatic expectations of the social and economic needs of local agents. What matters in one country may not make sense in another, and therefore, the success of the HSR is not just about counting passenger-kilometers, but about achieving effective mobility. And this is where expert-intuitive methods may yield more adequate results than calculating

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flows and payback than calculating flows and payback on the basis of rational expectations.

II. COUNTRY SPECIFICS ORGANIZATION OF HIGH-SPEED RAILWAY

After analysis, the practical experience in Europe shows that the share of railway passenger volume will be doubled or more after the opening of HSR (Fig.1). Continuing to talk about the rationality of the Japanese system is currently the most profitable high-speed rail system in the world. It annually saves about 400 million hours of travel time, which corresponds to 4 billion dollars. Over the past 47 years there has not been a single accident on the high-speed lines of Japan, and the maximum delays were only 41 seconds [2]. High-speed railways in Japan are characterized by high population density, difficult geographical conditions during construction (mountainous terrain) and high seismic hazard during operation, a huge amount of precipitation (twice as much as in London), a large number of stations integrated into the high-speed passenger service, etc. And it is clear that it is not possible to use Japan's unique experience - a country with the large territory and population. The situation in the two provinces in particular, is aggravated by the complicated terrain. For example, one of the main arguments of the opponents of the HSR is that it is impossible to overcome the yellow river. Our country is primarily interested in the experience of other countries in adapting the development of high-speed railroads to various infrastructure needs. It is necessary to analyze the progress of the high-speed rail network in the countries which has large territories [3].

The four largest countries in the world in terms of territory in descending order of total area are Russia, Canada, the United States, and China. Today, Russia has a strong innovative potential in the field of high-speed traffic for the countries which has large territory. Suffice it to say that today the total length of HSR in this country is 800 km and by 2030 it is planned to develop the Russian high-speed rail network with the length of about 11 000 km and passenger traffic will be 23.3 million people. The country's high-speed transport was the key to the success of the rapid development of Russia's economy, which became the country with the longest length of high-speed roads, but also with a coherent technological system and high ability to integrate.

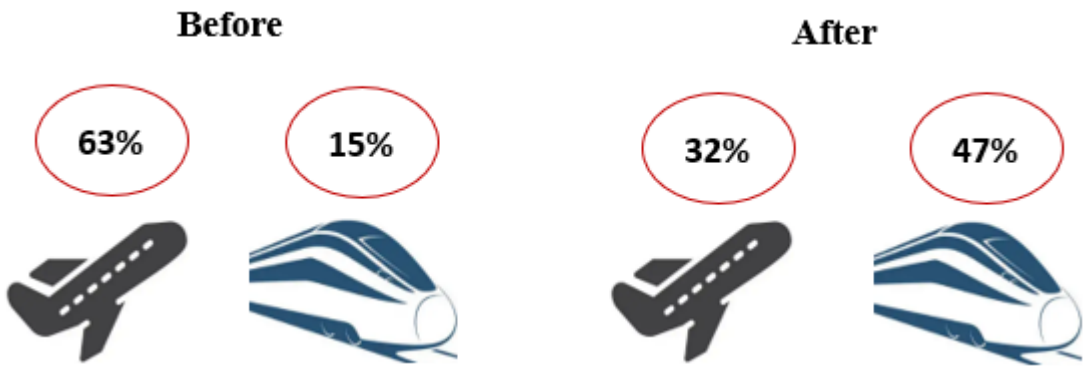

Fig 1: share of passenger traffic in different modes of transport before and after the introduction of the HSR in the direction Moscow – St-Petersburg [4]

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However, following the Russian model of developing a high-speed network that connects the country from north to south and from east to west is not an unambiguous solution for the successful development of domestic high-speed railways. Moreover, it is not only a question of the regularities of human settlement and distribution of productive forces. The extreme unevenness of the population distribution in Russia, the focus of the planned HSR system is on only a few regions, groups of cities or even pairs of cities. In this configuration, high-speed rail will be crucial for the development of regional and national economies, primarily agglomeration effects. The agglomeration effect is a complex placement factor, which expresses itself in the fact that compactly placed facilities.

III. APPROACHES TO ESTIMATING DEMAND FOR HIGH-SPEED RAILWAY

There are various approaches to determining of demand for passenger transportation. The main mathematical form of describing the transport demand of the population is an inter district correspondence matrix. However, its construction requires considerable time-consuming surveys. Scientists Zhuravskaya M., Tarasyan V., Omarova Z. used methods of mass service theory [5]. They found that the curves of probability distribution of passenger trips obey the Poisson law Efimov S.[6] identified three main groups of parameters affecting the level of passenger transportation demand: transport mobility of the population, the number of population and economic development of regions. At the same time, he noted that recently there has been a change in the main factors affecting the level of demand. Along with the existing requirements to the timetable and travel time, the requirements to the passengers' satisfaction with the quality of the trip and comfort are growing. And scientists at the University of Hannover have ranked the factors affecting demand by degree of importance (Fig 2) [7].

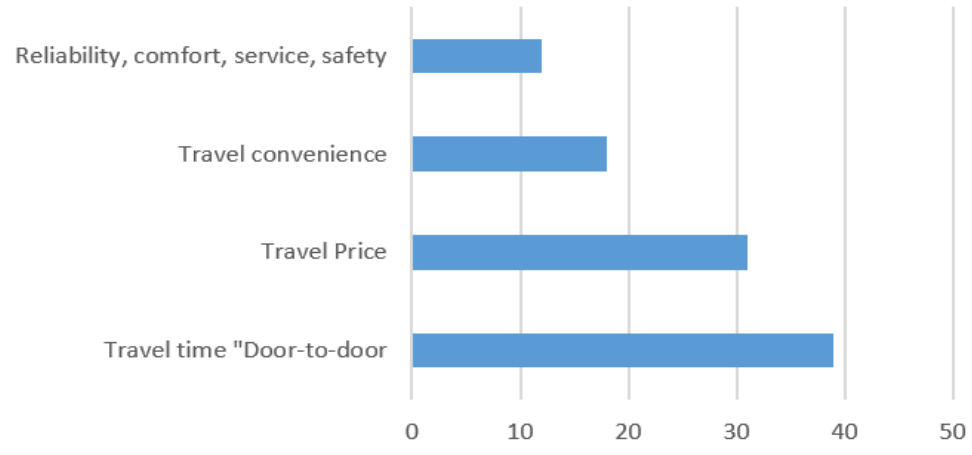

Fig 2: influence factors that depend on the distribution of transportation by modes of transport.

The passenger reacts particularly sharply to changes in the time of the trip, as well as in its cost. These two factors translate the magnitude need for transportation in solvent demand for it. Dependencies between the need (potential demand) for transportation, its time and price are so unambiguous that they can be represented by the gravitation model and described by the following regularity [8]:

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$$Fij = \frac{\alpha * P_i * P_j}{R_{ij}^n}$$

Where Fij is the passenger flow between settlements (cities); a, n are empirical constants;

P ij - population of cities, people; R ij - distance between settlements, km.

Thus, the transport flow, summed over all modes of transport, is proportional to the number of inhabitants of these cities and inversely proportional to the square of the distance (at n = 2) between them.

IV. POSSIBILITIES FOR THE APPLICATION OF A GRAVITY MODEL FOR THE PREDICTION OF THE HSR

The authors of this study used the gravity model as a behavioral model to study the demand for high-speed passenger transportation between Jinan and Zhengzhou, because the significant element of gravity model - distance between settlements R ij = V.t fits well in the high-speed concept [9-10].

The relevant, HSR of China were selected for the analysis. Well recommended high speed connections in China (7 directions), Japan (5), Europe (8) as well as existing and planned high speed connections in Russian Federation (6). The calculation results have been sorted using the ABC method [11-12], and the results of the calculations were sorted on the basis of the ABC method and summrised in TABLE I.

TABLE I. DEFINITION OF ABC GROUPS FOR PASSENGER FLOWS

ROUTES HSR		**FIJ**	**%FIJ**	**Σ%FIJ**	**GROUPS**
BEIJING	TIANJIN	148.27	26.30	26.30	
CHANGCHUN	JILIN	121.34	21.52	47.82	
CHONGQING	CHENGDU	76.74	13.61	61.44	A
SHANGHAI	NANJING	53.31	9.46	70.89	
NANCHANG	JIUJIANG	42.56	7.55	78.44	
SHANGHAI	BEIJING	20.98	3.72	82.16	
SHANGHAI	CHONGQING	17.87	3.17	85.33	
TOKYO	SHIN-OSAKA	14.54	2.58	87.91	
MOSCOW	ST-PETERSBURG	12.76	2.26	90.18	B
MOSCOW	NOVGOROD	9.79	1.74	91.91	
SHIN-OSAKA	HAKATA	7.83	1.39	93.30	
EKATERINBURG	CHELYABINSK	6.90	1.22	94.53	
BERLIN	MUNICH	5.15	0.91	95.44	C
BARCELONA	MADRID	4.37	0.78	96.21	

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NOVGOROD	KAZAN	3.66	0.65	96.86	
EKATERINBURG	TYUMEN	3.30	0.59	97.45	
BRUSSELS	PARIS	2.31	0.41	97.86	
VENICE	ROME	2.12	0.38	98.24	
HAMBURG	STUTTGART	1.98	0.35	98.59	
PARIS	ZURICH	1.88	0.33	98.92	
KAZAN	EKATERINBURG	1.84	0.33	99.25	
BOLOGNA	NAPOLI	1.28	0.23	99.47	
TAKASAKI	KANAZAWA	1.07	0.19	99.66	
OMIYA	NIIGATA	0.79	0.14	99.80	
TOKYO	SHIN-AOMORI	0.56	0.10	99.90	
VALENCE	MARSEILLE	0.55	0.10	100.00	
ROUTES HSR		FIJ	%FIJ	Σ%FIJ	GROUPS

V. THE MEDIUM-TERM PREREQUISITES FOR JUSTIFYING A NEW TYPE OF HIGH-SPEED CONNECTION BETWEEN JINAN AND ZHENGZHOU

Zhengzhou and Jinan are the two main cities in the central area of China. The distance between them is less than 380 kilometres, which could be a formation of the Zhengzhou - Jinan conurbation.

Jinan is slightly smaller than Zhengzhou in terms of population. At the end of 2021, according to Henan and Shandong Bureau of Statistics, Zhenzhou had 10.35 millions residents, while Jinan had 8.90 million residents [13]. It is interesting that the growth rates of the two cities are almost identical - the increase is about 1% per year (Fig 3). In fact, both cities in recent years have grown primarily at the expense of migrants. At the same time, the flow of migrants to Jinan was no less than to Zhengzhou. The natural increase in both cities is gradually increasing. In Jinan in 2015 the figures of natural and migratory growth were almost equal (Fig 4-5).

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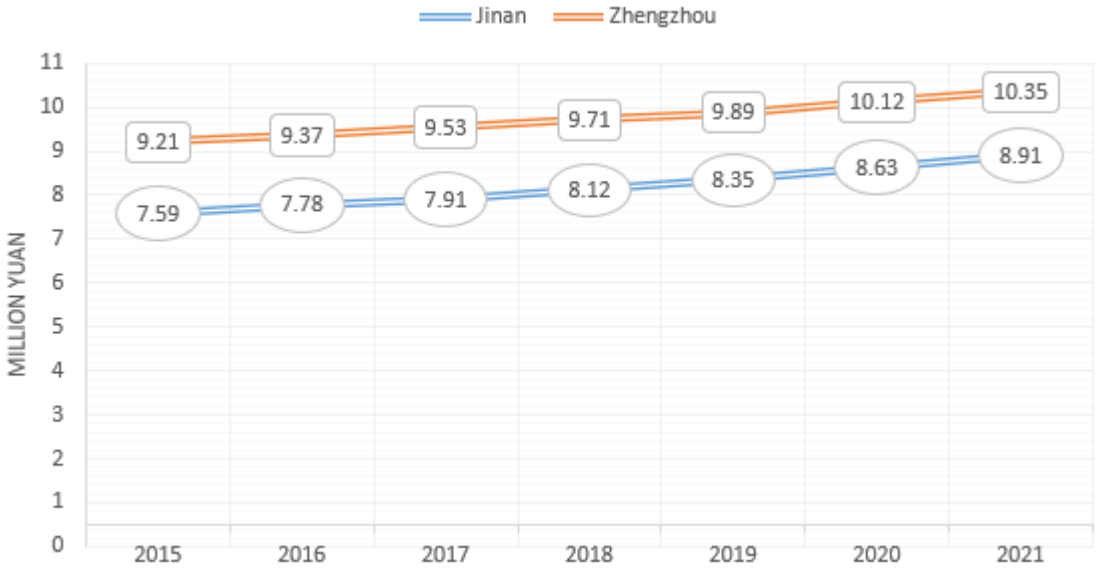

Fig 3: population growth in Jinan and Zhengzhou [14]

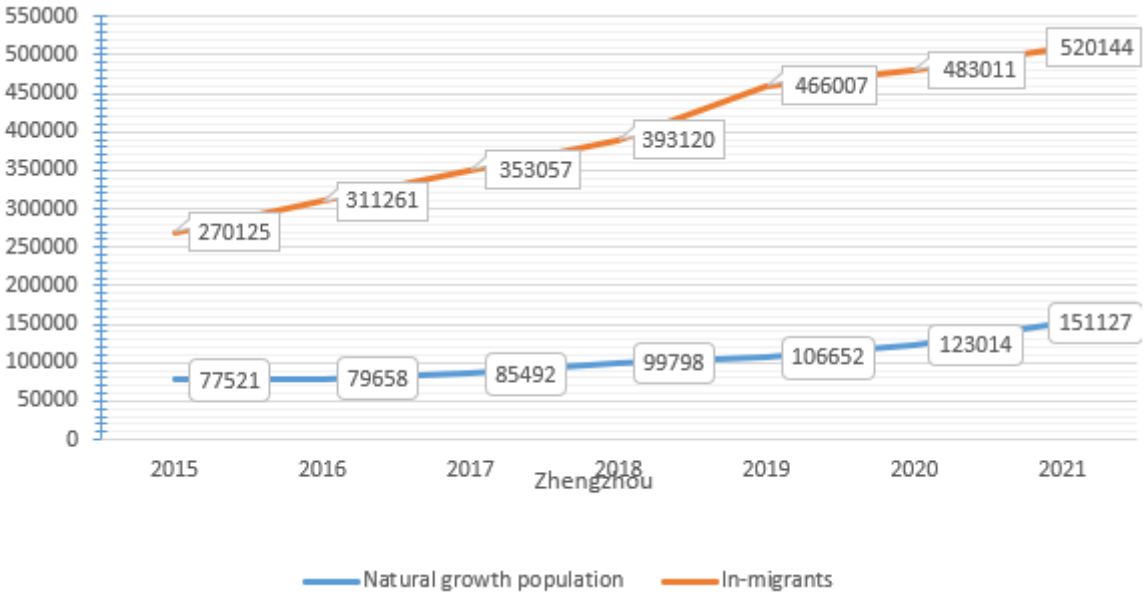

Fig 4: comparison of migration and natural increase in Zhengzhou [14]

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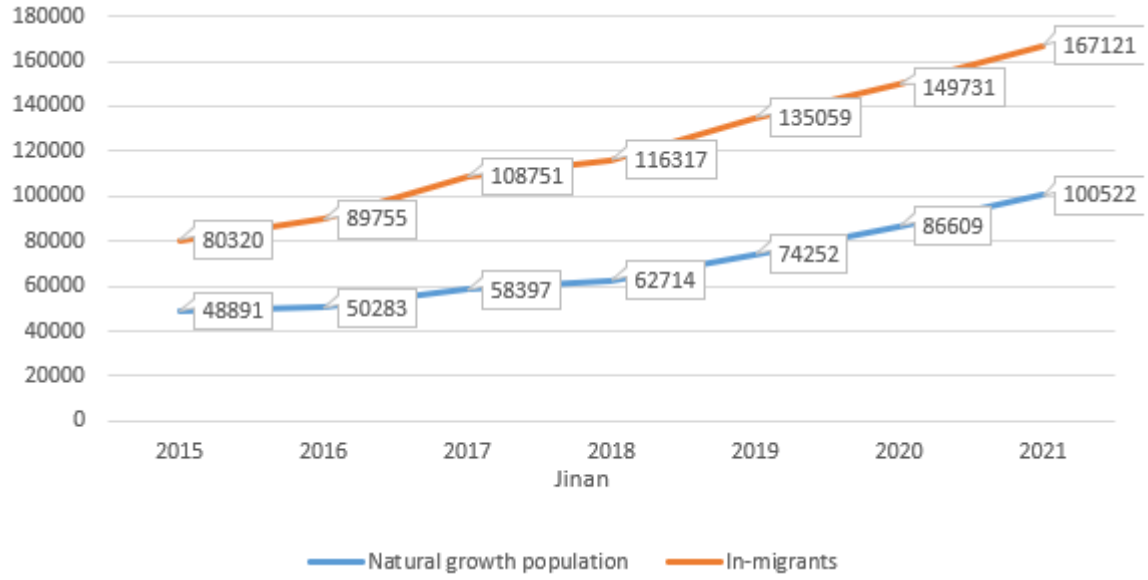

Fig 5: comparison of migration and natural increase in Jinan [14]

Let's look at the revenues of the budgets of cities. In ten years, budgets has more than doubled. In last seven years, the budget of Zhengzhou and Jinan's have grown by more than 1.5 times, by 148% and 153%. The budget growth of both cities also has a positive impact on the development of the HSR (Fig 6).

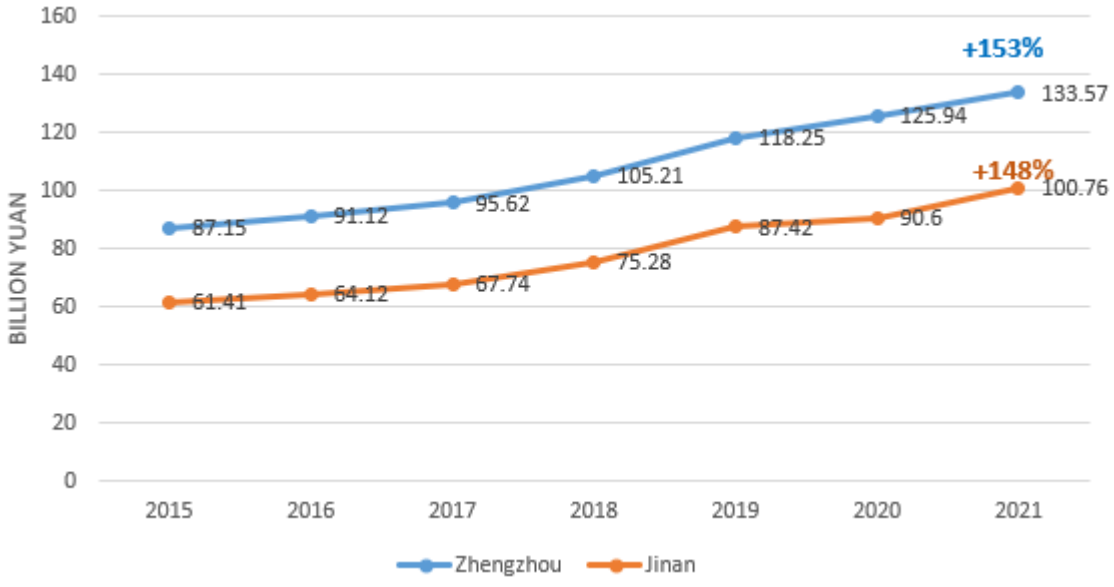

Fig 6: revenues of city budgets over the last seven years [14]

An analysis of salary shows that the average salary in Zhengzhou is one quarter higher than in Jinan (Fig 7).

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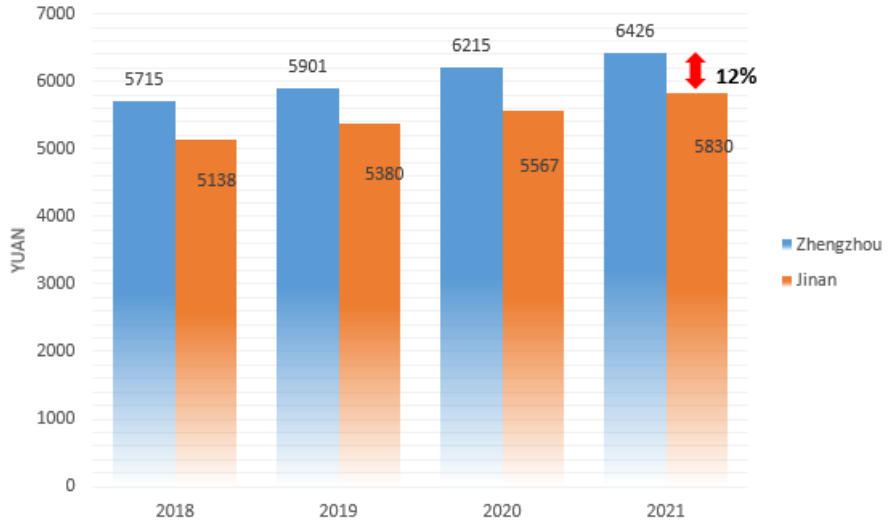

Fig 7: average salary in Zhengzhou and Jinan [14]

One of the indicators on which Zhengzhou and Jinan can be compared is retail space. In 2020 the ratio was as follows (Fig 8). The HSR can help create favourable conditions for Jinan residents to travel to Jinan for shopping.

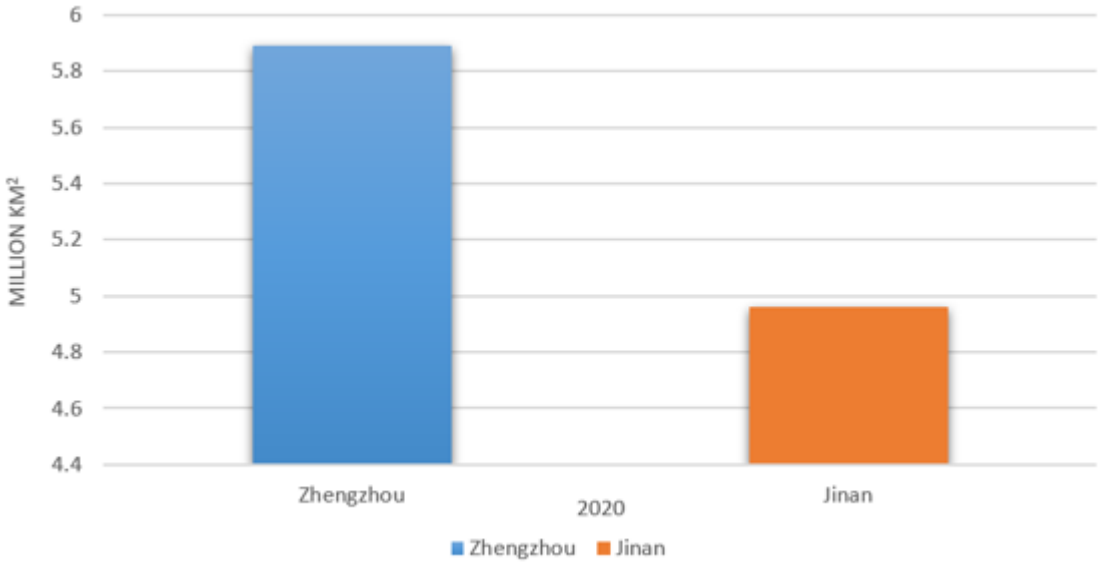

Fig 8: commercial squares of cities [14]

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VI. CONCLUSION

According to scholarly analysis, the Zhengzhou-Jinan high-speed railway will bring huge benefits to the two provincial capitals. Zhengzhou's one-hour metro area will continue to expand, which is of great significance to improve the structure of Chinese national road network, strengthen the location advantage of Henan Province's transportation, enhance regional exchanges and interactions, and promote high-quality economic development for both provincial capitals. Besides, it is an important part of the fast passenger transport network to build the Jinan metropolitan area, which will effectively improve the railway transport capacity and transport quality, thus meeting the needs of the sustainable and rapid development of the regional society and economy. By then, the railway train running time between Zhengzhou and Jinan will be shortened from the current 7 hours to about 2 hours, and will end the history of no direct high-speed railway between Henan and Shandong provinces, which is of great significance to promote the economic development of the city and facilitate the travel of the masses.

In this article we examined the prerequisites for creating a new type of transport route between Zhengzhou and Jinan. This is a new task, because for the last period this is the first time addressing the prerequisites rather than the project. A fundamentally important position in the evaluation of infrastructure projects of this type is, in our conviction, that the non-transport effect should prevail. Its nature, composition, and estimation methods. Here we would like to make one general point about its formation.

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