The Different Impacts of High-speed Trains and Expressway on Chinese Population and Economic Spatial Distribution: An Empirical Study of Wuhan-Guangzhou Corridor

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Abstract: Improving transportation conditions has long been seen as a practical way for economic development in a certain region. From 2000, China has been expanding its expressway network and High-speed railway (HSR) network remarkably. However, studies about infrastructure's population and economic spatial reconstruction effects are still limited. Moreover, as expressway and HST have many different characteristics, their impacts on regional economic gross value and industrial distribution are consequently different. However, there have been few similar studies clarify the difference between them. This study aims to fill these gaps and furthermore studies the different regional effects led by expressway and HSR. The study firstly reviews literatures studying the relationship between infrastructure and economic development. And then, the study presents an empirical study of Wuhan-Guangzhou expressway and HST projects. Lastly, it discusses expressway and HSR's effects on population distribution, economic development and industry reconstruction separately.

Keywords: Expressway, High-speed Railway, Economy Distribution, Agglomeration Effect

1. INTRODUCTION

Many of previous studies have concerned the relationship between transportation improvement and regional economic development. Mainly, influences of transportation improvements on regional economic are classified into two aspects. Some studies focus on overall effects over the whole region. In American case, public capital investment makes a significant contribution to national output, productivity, growth, and international competitiveness (Munnell, 1992). Meanwhile, other researches focus on "agglomeration" and "dispersion" effects brought by infrastructure investments.

In the last decade, China has spent a lot on expressway and high-speed railway (HSR) construction to spur and improve national economic development to some extent. China has constructed 33,000 km expressway during the last five year plan. Besides, more than 10,000 km high-speed railway is in operation until 2012. The aim of Chinese high-speed trains (HST) development is ambitious at multiple scales. Apart from the direct impacts on time-space perception and the improvement of national economic performance, wider impacts of HST on urban and regional development are extensively claimed (Chen, 2012). However, the influence of infrastructure construction on economic prosperity and distribution is still very debatable.

In addition, as expressway and HST have many different characteristics, their impacts on regional economic gross value and industrial distribution are consequently different. However, there have been few similar studies clarify the difference between them. This paper aims to fill this gap by analyzing 8 cities' infrastructure construction progresses and their economic development in Wuhan-Guangzhou corridor.

The paper analyzes and furthermore compares the influences of expressway and HST in Wuhan-Guangzhou corridor in south China. It begins with a brief introduction about wider economy benefits and effects led by accessibility improvements. Main expressway projects between Wuhan and Guangzhou and Wuhan-Guangzhou HST project are also presented in Section 2. Research method and data sources are illustrated in Section 3. In Section 4, it presents an empirical study of Wuhan- Guangzhou expressway and HST projects' effects. And then a comparison is drawn to discuss the different effects of expressway and HSR on regional economy. The conclusions and suggestions for future work are given in Section 5.

2. LITERATURE REVIEW

2.1 Infrastructure's Effects on Regional Economy

Improving transportation conditions has long been seen as a practical way for economic development in a certain region. Macro-level studies of the effect of transportation infrastructure investment on regional economic growth have shown positive relationships between the level of public investment and the rate of private capital formation, employment and output growth (Berechman, 1994). Bonnafous (1987) studies the regional impact of TGV in France. His study is based on official statistical data and surveys which were carried out before and after TGV inauguration. The study shows that TGV connects Paris and Lyon region more tightly. Chen (2011) studies HST projects (IC125/225) impacts in Britain case by comparing regions connecting London by HST and other regions using traditional railway service. The study illustrates that regions served by HST enjoys faster economic growth and relatively more attractiveness for service industries dealing with information, especially knowledge-based industries (Chen, 2011). Commonly, agglomeration economies are positive externalities derived from the spatial concentration of economic activity. Transportation improvement can increase the scale and efficiency of spatial economic interactions by lowering travel times and improving connectivity. We might expect positive external effects via this progress (Mare *et al*., 2009).

Besides researches about whole regional development, some studies notice that transportation improvement, especially HST, may also give rise to regional inequality, although this agglomeration trend is still under debate. “Home market effect” is raised by Krugman (1980), which illustrates large markets are disproportionately attractive for firms producing with increasing returns to scale. This "home market effect" makes large cities and developed areas naturally more attractive for industrial and commercial development. Since improving transportation conditions actually expand their markets, more developed cities become more attractive. Furthermore, improving accessibility might fail to raise the share of industry in a region due to the "hub shadow" and fiercer competition from outside (Puga, 2008). All these studies indicate infrastructure investments aggravate regional inequality. On the contrary, based on simple supply-driven econometric model and simulations of various hypothetical scenarios, scholars find that Japanese HST – Shinkansen network expansion leads to regional dispersion from developed regions to some extent. But building Shinkansen cannot simply resolve the problem of excessive agglomeration, when we take 'long-run' effect concerning production capability into account (Sasaki *et al*., 1997).

Even studies about the impacts of a certain infrastructure project on regional economic growth are indefinite, fewer scholars study effect distinctions led by different transportation modes. Yet, as expressway and HST service are much different in speed, accessibility, capacity, function, etc., discriminating their impacts is necessary. Expressway improves cargo's mobility more than improving people's mobility, while HST does the contrary. Some scholars conclude when workers are immobile, falling transport costs first lead to agglomeration, but firms might eventually spread out (Puga, 2008). This is similar to the impacts of expressway. Nevertheless, when firms and workers are mobile, falling transport costs tend to spur agglomeration, increasing regional inequalities (Puga, 2008). This situation is generally similar to the situation in a region which is served by both expressway and HST service.

The linkage between infrastructure and economic growth is multiple and complex (Ghosh *et al*., 2004). It is difficult to identify whether a specific regional economic growth period is benefited from transportation amelioration or from other aspects, such as policy change, technological improvement, etc. Therefore, in a certain case, it is difficult to attribute the economic growth to infrastructure. Most of the studies are either theoretical researches or empirical studies.

2.2 Main Expressway Projects in Wuhan-Guangzhou Corridor

Table 1. Open time of Jingzhu Expressway in Wuhan-Guangzhou section

Section	Open time
Wuhan-Yueyang	09/28/2002
Yueyang-Changsha	11/30/2002
Changsha-Xiangtan	12/15/1996
Xiangtan-Hengyang	12/26/2000
Hengyang-Shaoguan	12/28/2001
Shaoguan-Guangzhou	11/12/2003

Since the open of Hujia Expressway connecting Shanghai downtown and Jiading in 1988, China has rapidly expanded its expressway network. Generally, Chinese expressway development process could be divided into two phase. Before 1997, China only has 4,735km expressway. Since 1998, according to the implementation of “National Trunk Highway System Plan", which was drew up by the Ministry of Communications in 1993, Chinese expressway network expanded highly significantly. Until 2004, Chinese expressway length has expanded to 34,000 km, which is only less than American network in the world (Wang, 2006). In 2011, it increased to 84,900 km. “National Trunk Highway System Plan" planed 5 vertical and 7 horizontal expressways connecting all cities which have more than one million population and most cities which have 500,000 population in China (Cai, 2008). Among these 12 expressways, as a vertical line, Jingzhu (Beijing-Zhuhai) expressway connects Chinese capital city – Beijing and Zhuhai at the south shore of China. This line passes through Beijing, Hebei, Henan, Hubei, Hunan and Guangdong provinces, which covers the Wuhan-Guangzhou corridor. Moreover, Jingzhu expressway between Wuhan and Guangzhou was completed segmentally into 6 sections: Wuhan-Yueyang, Yueyang- Changsha, Changsha-Xiangtan, Xiangtan-Hengyang, Hengyang-Shaoguan and Shaoguan-Guangzhou. (Table.1) Main cities and their locations are described in Figure 1. As the expressway and HSR are almost parallel in Wuhan-Guangzhou corridor, they could be shown in Figure 1 also.

Figure 1. Main cities in Wuhan-Guangzhou corridor

2.3 Introduction of Wuhan-Guangzhou HST

“The intermediate and Long-term Plan for Railway network” was firstly published in 2004 by the Ministry of Railways. This plan was later revised in 2008. It described Chinese railway network blueprint up to 2020. Planning to expand the whole railway network, the plan emphasizes the development of passenger dedicated lines (PDLs) most of which are standardized as high-speed railways (Chen, 2011). It plans 4 vertical and 4 horizontal PDL lines which include Beijing-Wuhan-Guangzhou-Shenzhen HSR, which was completed segmentally also. While Wuhan-Guangzhou HSR (Wu-Guang HSR) was opened in December 26, 2009, other parts of Beijing-Shenzhen HSR was opened in December, 2012. Wu-Guang HSR connects two of the largest cities in south China in 4 hours at the speed of 300 km/h.

3. METHODOLOGY

3.1 Research Design

The first step of the research design is separating variables - proving that the corridor was influenced by Jingzhu Expressway and Wu-Guang HSR only from 2002 to 2011. As before, most parts of expressway connecting Wuhan and Guangzhou were completed around 2002 when the first expressway completion climax came in China. Meanwhile, only a few other expressway projects linking the corridor and other areas were completed until 2009, when the second expressway open climax arrived. Regard to HSR, in 2009, Wuhan-Guangzhou HSR is the second completed HSR project in China. Since Beijing-Wuhan and Guangzhou-Shenzhen HSR were operated in late 2012, Wuhan-Guangzhou HSR line is also isolated in Chinese HSR network. These time gaps led Wuhan-Guangzhou corridor only benefited from a single expressway from 2002 to 2009 and a single HSR from 2010 to 2011, which are beneficial for empirical studies. Particularly, as the expressway between Wuhan and Guangzhou were mostly opened around 2002, we simply suppose all sections were operated at the end of 2002. Similarly, the HSR service was opened at the end of 2009. To simplify the discussion, we only choose four years' data. Data in 2002 indicates the situation before expressway open. Data in 2004 and 2009 separately shows expressway's short term and long term effects. The comparison of data in 2009 and 2011 illustrates HSR's impacts in the region.

Secondly, to illustrate economic and spatial distribution, a classification of cities in the corridor is necessary. Six cities locate between Wuhan and Guangzhou – Xianning, Yueyang, Changsha, Hengyang, Chenzhou and Shaoguan, which are mostly influenced by Wuhan-Guangzhou expressway and HSR. The distance between any two adjacent cities is approximately 150km. A reasonable classification of these cities is necessary. According to Walter Christaller's centrality theory which considers city's production, transportation, and commercial centralization, these cities can be divided into three levels. Wuhan and Guangzhou are national and regional central cities (RC, first-tier city); Changsha is a provincial central city (PC, second-tier city); other cities are ordinary cities (OC, third-tier city) (Zhang, 1999). This hierarchy classification result is identical with their administrative level and economic grades. While Wuhan and Guangzhou are vice-provincial city, Changsha is an ordinary provincial capital city. Others are prefecture-level cities.

At last, to describe the effects of infrastructure on regional economy, generally we need to answer two questions in two aspects. Firstly, is the infrastructure project beneficial for economy and population accumulation of the whole region? Setting other cities in Hubei, Hunan and Guangdong provinces as a control group, we could see overall effects led by infrastructure in Wuhan-Guangzhou corridor. In this comparison, we could simply compare 8 corridor cities' data with the whole provincial data, as the provincial data is the sum or weighted average of 8 corridor cities' data and other control group's cities' data. Secondly, does infrastructure aggravate regional inequality in the region where it serves? Analyzing each city's data, we could conclude population, gross regional production and industrial structure distribution evolution processes in Wuhan-Guangzhou corridor.

3.2 Variables and Data Source

Regional population and economy distribution patterns are key elements to describe spatial imbalance. Economists have traditionally explained spatial differences in production, employment and income (Puga, 2008). In this paper, due to lack of data, we set population, gross regional production (GRP) to describe the most notable social and economy condition. More specifically, in UK case, HST cities enjoy faster growth in service industries dealing with information, especially knowledge-based industries (Chen, 2011). Therefore, industrial added value (IAV), the tertiary industrial added value (TAV) and High-tech industrial added value (HAV) are set to explain industrial structure evolution progress in Wuhan- Guangzhou corridor. All city data are derived from cities' statistic yearbook. Data in Wuhan-Guangzhou corridor are calculated from eight cities' independent data. Data in Hubei, Hunan and Guangdong provinces are taken from Macrochina database. (Table.2)

Table 2. Variables and data source

Aspect	Specific index	Data source
Society	Population	
Economy strength	Gross regional production (GRP)	City: City's statistic yearbook
Industrial structure	Industrial added value (IAV)	Regional: Calculation of cities' data
	Tertiary industrial added value (TAV)	Province: Macrochina database
	High-tech industrial added value (HAV)	

4. RESULTS

4.1 Effects on Population Distribution

Table 3 shows the population change in Wuhan-Guangzhou corridor from 2002 to 2011. As a whole, the proportion of 8 corridor cities' population in three provinces' total population decreased 0.27% from 2002 to 2004 when we discuss the short term effect of expressway, while the proportion increased 0.79% from 2002 to 2009 when we look at its long term effect. However, comparing to 0.56% ratio increment from 2009 to 2011 in only two years, the effect of expressway on population migration is slight. Both expressway and HSR attract more residents in places it serves. But HSR's influence is rapid and notable, while the effect of expressway is not so obvious.

On the basis of data in Table 3, Table 4 could be derived to describe regional population migration trend in Wuhan-Guangzhou corridor. From 2009 to 2011, after HSR operation, population in Wuhan and Guangzhou increased 1.96% and 3.10% separately. Population agglomeration trend from ordinary cities to provincial and regional center cities was clear. As a contrary, expressway influences little on population inequality.

Table 3. Population distribution in Wuhan-Guangzhou corridor

	2002	2004	2009	2011
	Population (10 thousand)			
Wuhan(RC)	7681000	7859000	8355500	10020000
Xianning(OC)	2778400	2769800	2906300	2467900
Yueyang(OC)	5255400	5293500	5483400	5485300
Changsha(PC)	6268778	6290000	6642200	7090700
Hengyang(OC)	7096600	7189500	7398000	7166000
Chenzhou(OC)	4582400	4577100	4738600	4605200
Shaoguan(OC)	2809400	2884100	2850400	2850000
Guangzhou(RC)	9847600	9660600	10334500	12751401
Regional population	46319578	46523600	48708900	52436501
Total population (Hubei, Hunan & Guangdong)	214583800	218244600	217640000	228579500
Percentage of 8 corridor cities in 3 provinces	21.59%	21.32% (-0.27% compare to 2002)	22.38%(+0.79% compare to 2002)	22.94%(+0.56% compare to 2009)

Note: Population number is based on permanent resident amount.

Table 4. City population percentage and change in Wuhan-Guangzhou corridor

	2002	2004		2009		2011	
	Percentage in the region	Percentage in the region	Change 2002 -2004	Percentage in the region	Change 2002 -2009	Percentage in the region	Change 2009 -2011
Wuhan(RC)	16.58%	16.89%	**0.31%**	17.15%	**0.57%**	19.11%	***1.96%***
Xianning(OC)	6.00%	5.95%	-0.05%	5.97%	-0.03%	4.71%	-1.26%
Yueyang(OC)	11.35%	11.38%	**0.03%**	11.26%	-0.09%	10.46%	-0.80%
Changsha(PC)	13.53%	13.52%	-0.01%	13.64%	**0.11%**	13.52%	-0.12%
Hengyang(OC)	15.32%	15.45%	**0.13%**	15.19%	-0.13%	13.67%	-1.52%
Chenzhou(OC)	9.89%	9.84%	-0.05%	9.73%	-0.16%	8.78%	-0.95%
Shaoguan(OC)	6.07%	6.20%	0.13%	5.85%	-0.22%	5.44%	-0.41%
Guangzhou(RC)	21.26%	20.76%	-0.50%	21.22%	-0.04%	24.32%	***3.10%***
Regional population	100.00%	100.00%		100.00%		100.00%	

4.2 Effects on Economy Strength

Being similar to population analysis, infrastructure impacts on economy strength could be analyzed from two aspects. Firstly, Table 5 displays each city's GRP number and Wuhan-Guangzhou corridor region's GRP proportion in three provinces. Based on the GRP percentage of 8 corridor cities in 3 provinces, we could find that expressway promotes economic development in the long run (GRP proportion increased 1.03% from 2002 to 2009). However its short term economic promotion effect is not obvious. On the contrary, HSR clearly stimulates regional economy improvement notably even in a short period. Its operation led to 0.38% increment in GRP proportion in only two years time.

Table 5. GRP distribution in Wuhan-Guangzhou corridor

	2002	2004	2009	2011
	Gross Regional Production (10 thousand RMB yuan)			
Wuhan(RC)	14678000	18822400	45606200	65368100
Xianning(OC)	1425700	1802200	4184500	6521000
Yueyang(OC)	3941197	5413685	12721499	18994900
Changsha(PC)	9227729	12966593	37447641	56193285
Hengyang(OC)	3782200	5084400	11680146	17464000
Chenzhou(OC)	2885615	3984648	8432283	13464000
Shaoguan(OC)	2310213	3051035	5787525	8168058
Guangzhou(RC)	32039616	44505503	91382135	124234000
Corridor region GRP	70290270	95630464	217241929	310407343
Total GRP (Hubei, Hunan & Guangdong)	218667400	301397000	655033500	925121000
Percentage of 8 corridor cities in 3 provinces	32.14%	31.73% (-0.41% compare to 2002)	33.17%(+1.03% compare to 2002)	33.55%(+0.38% compare to 2009)

Secondly, regard to regional inequality, Table 6 is the distribution of GRP in 8 Wuhan-Guangzhou corridor cities. The proportion illustrates each city's economy strength among these 8 cities.

Table 6. City GRP percentage and change in Wuhan-Guangzhou corridor

	2002	2004		2009		2011	
	Percentage in the region	Percentage in the region	Change 2002 -2004	Percentage in the region	Change 2002 -2009	Percentage in the region	Change 2009 -2011
Wuhan(RC)	20.88%	19.68%	-1.20%	20.99%	**0.11%**	21.06%	***0.07%***
Xianning(OC)	2.03%	1.88%	-0.14%	1.93%	-0.10%	2.10%	***0.17%***
Yueyang(OC)	5.61%	5.66%	**0.05%**	5.86%	**0.25%**	6.12%	***0.26%***
Changsha(PC)	13.13%	13.56%	**0.43%**	17.24%	**4.11%**	18.10%	***0.87%***
Hengyang(OC)	5.38%	5.32%	-0.06%	5.38%	0.00%	5.63%	***0.25%***
Chenzhou(OC)	4.11%	4.17%	**0.06%**	3.88%	-0.22%	4.34%	***0.46%***
Shaoguan(OC)	3.29%	3.19%	-0.10%	2.66%	-0.62%	2.63%	-0.03%
Guangzhou(RC)	45.58%	46.54%	**0.96%**	42.06%	-3.52%	40.02%	-2.04%
Regional GRP	100.00%	100.00%		100.00%		100.00%	

Expressway firstly led the agglomeration trend towards Guangzhou which is the most competitive city in the region and Changsha - the provincial center city in Hunan. Although Wuhan had 1.20% decrease from 2002 to 2004, the trend of agglomeration in the whole region was still undeniable. However, data in 2009 shows that, in the long run, second-tier cities benefited most in expressway services. On one hand, Second-tier cities own relatively better technology and talent pool than third-tier cities do. On the other hand, firms could enjoy lower labor costs in second-tier cities rather than first-tier cities i.e. regional center cities. Combining with results in section 4.1, we could conclude that expressway does not remarkably improve people mobility. It stimulates agglomeration firstly and then leads to spread out eventually.

Data in 2011 shows dispersion effects of HSR in Wuhan-Guangzhou corridor. Also second-tier city (Changsha) benefited most, when almost all third-tier cities enjoyed more proportion in regional economy as well. As the discussion in section 2.1, this dispersion or agglomeration trend led by HSR is in much dispute. In Wuhan-Guangzhou corridor case, HSR mainly leads to dispersion and spillover effects.

4.3 Effects on Industrial Structure

In section 4.2, data in 2011 shows dispersion effects of HSR and expressway by GRP index. However, GRP number is not sufficient to reveal regional economic strength as the industrial structure may differ from these cities. According to Hunan statistic yearbook 2011, composition of gross domestic product by industry is 14% (primary industry), 48% (secondary industry) and 38% (tertiary industry). According to Guangdong statistic yearbook 2011, the share of secondary and tertiary industry in Guangdong is more than it in Hunan. Therefore, in this section, we mainly study secondary and tertiary industry variation trend in Wuhan-Guangzhou corridor to furthermore analyze regional economic inequality led by infrastructure.

Table 7 shows each city's Industrial added value (IAV) and its proportion in the region. It clearly illustrates expressway stimulated secondary industry transferring from Guangdong and Hubei provinces which is more developed to Hunan province, as all cities in Hunan increased its IVA proportion. Comparison of 2011 with 2009 shows that the trend of secondary industry transfer was furthermore accelerated by HSR, as in 2 years' time, IVA proportion in Hunan increased 7.82%. More specifically, Table 8 is city's High-tech industrial added value (HAV) and its share in the corridor. Because of data limitation, we could only study the trend from 2009 to 2011 in Hubei and Hunan provinces, which was influenced by HSR. The proportion of Changsha's HAV increased notably after HSR operation, while the share of Wuhan decreased a lot. The increasing rate of HAV in the second-tier city was much faster than IAV growth rate. This phenomenon illustrates HSR's strong spillover effects on knowledge based industries, which is identical with UK's situation studied by Chen (2011).

Table 9 gives each city's Tertiary industrial added value (TAV) and its proportion in the region. From the table, we could hardly conclude infrastructure's effect on tertiary industrial transfer. It might because tertiary industry includes lots of industries like banking, insurance and tourism, etc. The industry variety makes the study on tertiary industry needs to be furthermore specified.

Table 7. Industrial added value (IAV) distribution in Wuhan-Guangzhou corridor

	2002		2004		
	IAV	Percentage	IAV	Percentage	Change 2002-2004
Wuhan	365.04	21.30%	538.89	20.22%	-1.08%
Xianning	26.08	1.52%	36.21	1.36%	-0.16%
Yueyang	101.32	5.91%	173.64	6.52%	**0.60%**
Changsha	160.32	9.36%	271.89	10.20%	**0.85%**
Hengyang	50.33	2.94%	89.81	3.37%	**0.43%**
Chenzhou	42.18	2.46%	90.68	3.40%	**0.94%**
Shaoguan	66.14	3.86%	99.13	3.72%	-0.14%
Guangzhou	902.04	52.64%	1364.34	51.20%	-1.44%
Regional IAV	1713.45	100.00%	2664.59	100.00%	

	2009			2011		
	IAV	Percentage	Change 2002-2009	IAV	Percentage	Change 2009-2011
Wuhan	1656.14	21.67%	**1.44%**	2458.75	20.89%	-0.78%
Xianning	147.38	1.93%	**0.57%**	279.34	2.37%	***0.45%***
Yueyang	576.1	7.54%	**1.02%**	1076.7	9.15%	***1.61%***
Changsha	1158.21	15.15%	**4.95%**	2014.2	17.11%	***1.96%***
Hengyang	370.39	4.85%	**1.48%**	812.8	6.91%	***2.06%***
Chenzhou	311.08	4.07%	**0.67%**	737.3	6.26%	***2.19%***
Shaoguan	181.84	2.38%	-1.34%	243.03	2.06%	-0.31%
Guangzhou	3241.76	42.42%	-8.79%	4147.71	35.24%	-7.18%
Regional IAV	7642.9	100.00%		11769.83	100.00%	

Note: Unit of IAV is 100 million RMB yuan.

Table 8. High-tech industrial added value (HAV) distribution in Wuhan-Guangzhou corridor (6 cities)

	2007	2009		2011	
	HAV	HAV	Percentage Change 2007-2009	HAV	Percentage Change 2009-2011
Wuhan	474.8	711	-2.61%	1074	-7.93%
Xianning	9.08	14.34	0.00%	22.8	-0.12%
Yueyang	79.12	146.6	**1.41%**	291.2	***0.89%***
Changsha	272.5	453.1	**1.46%**	1020	***7.09%***
Hengyang	74.4	127.7	**0.66%**	228.3	-0.14%
Chenzhou	52.08	68.34	-0.92%	130.2	***0.21%***
Regional HAV	962	1521		2767	

Note: Unit of HAV is 100 million RMB yuan.

Table 9. Tertiary industrial added value (TAV) distribution in Wuhan-Guangzhou corridor

	2002		2004		
	TAV	Percentage	TAV	Percentage	Change 2002-2004
Wuhan	743.07	22.01%	950	21.66%	-0.35%
Xianning	50.48	1.50%	63.14	1.44%	-0.06%
Yueyang	159.71	4.73%	206.03	4.70%	-0.03%
Changsha	394.9	11.70%	512.95	11.70%	0.00%
Hengyang	158.43	4.69%	210.46	4.80%	**0.11%**
Chenzhou	120.4	3.57%	153.1	3.49%	-0.07%
Shaoguan	80.7	2.39%	107.09	2.44%	**0.05%**
Guangzhou	1668.55	49.42%	2182.6	49.77%	**0.35%**
Regional TAV	3376.24	100.00%	4385.37	100.00%	

	2009			2011		
	TAV	Percentage	Change 2002-2009	TAV	Percentage	Change 2009-2011
Wuhan	2269.42	20.54%	-1.12%	3303.48	21.62%	***1.08%***
Xianning	143.18	1.30%	-0.14%	224.05	1.47%	***0.17%***
Yueyang	433.16	3.92%	-0.78%	590.74	3.87%	-0.05%
Changsha	1671.78	15.13%	**3.44%**	2224.27	14.56%	-0.58%
Hengyang	427.2	3.87%	-0.93%	600.63	3.93%	***0.06%***
Chenzhou	300.6	2.72%	-0.77%	419.6	2.75%	***0.03%***
Shaoguan	255.9	2.32%	-0.13%	348.32	2.28%	-0.04%
Guangzhou	5545.56	50.20%	**0.43%**	7567.54	49.53%	-0.67%
Regional TAV	11046.8	100.00%		15278.63	100.00%	

Note: Unit of TAV is 100 million RMB yuan.

5. DISCUSSION, CONCLUSION AND LIMITATION

Section 4 uses empirical study to illustrate the linkage between infrastructure and regional population and economy. Though infrastructure plays notable role in regional development and distribution, regional population and economy is undeniably affected by many other factors. Therefore, according to econometric theory, this empirical study is not suitable for regression analysis, while variables' correlation study is meaningful.

Evidence shows that the linkage between expressway and population distribution is relative weak, while HSR improves regional attractiveness in the places where it serves. Moreover, HSR service accelerates regional imbalance in population distribution. The reason might be HSR is a more convenient way for people in relatively less developed areas to move to more developed regions to find higher wage jobs.

The study also discusses the relationship between infrastructure and regional economic development. Because expressway and HSR provides tighter connection among cities they pass by, both of them accelerate economy development in the region where they serve. However, their influence on regional economy distribution is different. While HSR mainly leads to dispersion effects, expressway's effect is more complex. Expressway firstly stimulates the agglomeration trend in the region. But second-tier cities enjoy most benefits in the long run. Second-tier cities might be benefit from relatively lower wage (compare to first-tier cities) and better economy foundation (compare to third-tier cities).

More specifically, secondary industry transfer from more developed areas to less developed areas is the main driving force for economic dispersion effects. Dividing industry structure more in detail, third-tier cities in Wuhan-Guangzhou corridor are mainly influenced by the arrival of traditional secondary industry, while second-tier city is benefited from high-tech industry introduction. The study furthermore discusses tertiary industry distribution movement. However, this trend is vague and somehow non-directional. Possibly it is because tertiary industry includes many aspects include banking, insurance and tourism. The influences led by infrastructure in Wuhan- Guangzhou corridor are concluded in Table 10.

There are still mainly four limitations of the study – time duration, tertiary industry classification, research design methods and index selection. At first, since Wuhan-Guangzhou HSR has operated for just 3 years, available data especially long-term data is limited in the study. HSR's long term effects should be furthermore studied. Secondly, infrastructure's influences on tertiary industry movement are still unclear. Future studies may moreover specify the tertiary industry and analysis its transfer trend. Thirdly, the research design is somehow limited, as it simply uses percentage to describe such a complicated problem. More detailed theoretical study on infrastructure projects' effects on economic development is necessary. The combination of theoretical and empirical studies is more persuasive to explain the different results led by infrastructure in different countries and regions. Lastly, the study only uses percentage change as the index to explain the phenomenon. However, more synthesized and simpler index can make the study more convincing.

Table 10. The influences led by infrastructure in Wuhan-Guangzhou corridor

		Expressway	HSR
Population	Whole region	Not significant	Make area it serves more attractive
	Regional inequality	Not significant	High agglomeration effect
Economy strength	Whole region	Accelerate economic development	Accelerate economic development
	Regional inequality	Short term: Agglomeration Long term: Dispersion Second-tier cities benefit most	High dispersion effect
Industrial structure	Secondary industry	Accelerate industry transfer from more developed area to less developed area	Accelerate industry transfer from more developed area to less developed area
	High-tech industry	-	Obvious high-tech spillover effect Second-tier cities benefit most
	Tertiary industry	Not clear	Not clear

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