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Heterogeneous Economic Impacts of Transportation Features on Prefecture-Level Chinese Cities

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Abstract

The present paper examines the heterogeneous economic impacts of transportation characteristics, with a consideration of spatial heterogeneity, across Chinese prefecture-level cities. Using data from 237 Chinese cities from 2000 to 2012, a random-parameters model is applied to account for the heterogeneity across these cities. The estimation results reveal significant variability across cities, with the computed impacts (elasticity values) of transportation-related features (highway and railway freight volumes, highway passenger volume, urbanization rate, public transit, paved roads, and highway congestion rate) varying significantly across cities. The impacts are mostly positive, except for highway congestion rate. A 1% increase in a city's highway and railway freight volumes would increase the city's gross product per capita from 0.0001% to 0.0972% and 0.0001% to 0.0254% across cities in China, respectively. While a 1% increase in highway congestion rate would decrease the city's gross product per capita by an average of 0.031%.

Keywords

Chinese Cities, Economic Growth, Heterogeneity, Highway, Railway, Freight, Random-Parameters Model

1. Introduction

Transportation infrastructure has been prioritized by both central and local Chinese governments since the eighth Five-Year plan (1991-1995) with the realization of significant role played in promoting economic development. Since then, transportation infrastructure continues to be an essential part of China's regional development policy. The total length of railway in operation has been increased from 57.8 thousand kilometers to 103.1 thousand kilometers since 1991 until 2013, while the length of highway has increased significantly from 1041.1 thousand kilometers (in 1991) to 4356.2 (in 2013) thousand kilometers (National Bureau of Statistics of China, 2013). China has made significant investment in transportation infrastructure development over the recent three decades, and the average growth rate was over 10% per year, since 1978. During the 2008-2009, China stimulated the economy by using 40% of the US$586 billion economic stimulus package devoted to infrastructure development. From the significant investments made to develop infrastructure, China achieves a substantial growth in her economic output. It is thus imperative to answer whether and to what extent the infrastructure investments contribute to the economic growth of the Chinese economy [1].

There is an abundant of international empirical evidence showing an affirmative answer with a wide range of elasticity estimates [2] [3] [4]. The variety could be attributed to varied econometric specifications with or without accounting for the time and spatial effects, the definitions and measures of public infrastructure, the estimation methodology as well as research contexts in terms of study period and geographical scales. The strand of literature (see **Table 1**) analyzes the effects of public infrastructure on private output, and has been brought to the limelight by the seminal paper of Aschauer [5]. The elasticity results in his

Table 1. Empirical evidence on the estimates of output elasticity of public/transport infrastructure.

Study	Aggregation Level	Data Type	Econometric method	Elasticity estimation
Aschauer [5]	National	Time series	Cobb-Douglas production function	The elasticity of non-military capital stock: 0.25 - 0.56
Brun *et al.* [27]	Sub-national	Panel data	Barro-type model	No impact of the length of roads on economic growth
Berndt and Hansson [8]	Swedish National Level	Time series	Dual cost function	The Public infrastructure on the productivity growth: 0.058 - 0.149
Chiara Del Bo adn Massimo Florio [28]	Sub-national (EU regions)	Panel data	Cobb-Douglas production function with Spatial Durbin Model	The output elasticity of transport infrastructure: 0.05
Demurger [16]	Sub-national (Provincial)	Panel data	Growth equation	Positive effect on per capital income over 1985-1998 for 24 provinces
Fleisher and Chen [29]	Sub-national (Provincial)	Panel data	Production function	Minor impact on provincial total factor productivity growth from 1978-1993
Fan and Zhang [30]	Sub-national (Provincial)	Panel data	Simultaneous equation system	The contribution of roads expenditure to the rural area agricultural sector productivity: 0.085
Kavanagh [10]	Ireland national level	Time series	Production function	The elasticity of public capital on output: 0.36
Ozbay *et al.* [20]	Sub-national (County)	Panel data	multiple regression	The elasticity of highway investment ranges from 0.02 to 0.21
Vijverberg, Fu and Vijverberg [12]	Sub-national (Provincial)	Panel data	Cost function with Maximum Likelihood estimation	The contribution of public infrastructure to the growth in labor productivity among industrial enterprises: 0.02 - 0.03
Zhang [13]	Sub-national (Provincial)	Panel data	Production function	The output elasticity of transport infrastructure: 0.11

paper range from 0.25 to 0.56, and the different types of public inputs are termed as the "core" infrastructure such as streets, highways, mass transits, and airports. These results are found to be consistent with other studies [6]-[11] which are carried out at both national and regional levels.

Using Chinese provincial level data, few studies have examined the contribution of the aggregate public infrastructure to the productive performance [12], the spatial spillover effects of transport infrastructure [13] [14] as well as the poverty reduction effect [15]. Demurger [16] measures the transport endowment using the overall network density (incorporating road, railway and waterway) based on a panel data from 24 Chinese provinces (excluding municipalities) during 1985-1998, and shows that transport facilities are a key differentiating factor in explaining the growth gap. Hong, Chu and Wang [17] construct a provincial-level comprehensive index based on quantity and quality of railway, roadway, airport and seaport to show that the output elasticity of land transport (including roadway and railway) ranges from 0.554 to 2.757. The role of China's bullet trains to facilitate market integration and mitigate the cost of megacity growth is confirmed by Zheng and Kahn [18].

The present paper, with a regional focus on China, carries out a study using city-level annual data from 2000-2012 to gain a deep understanding of the heterogeneous impacts of varied transportation modes on city economic performance. Compared with existing studies, we explore the growth effects across varied-sized Chinese cities of both inter-city and intra-city transport networks. Highways and railways represent inter-city infrastructure and the public road network represents intra-city infrastructure. Accounting for possible unobserved heterogeneity, we use the random-parameters model [19] to shed light on the effect of transportation-related characteristics (including transportation freight and passenger volumes, public transit transportation, paved road, and highway congestion) on a city's economic growth. By so doing, we answer the question that to what degree transport infrastructure and which type of transport infrastructure matters for which specific city in China.

The present paper is structured in five sections. Section 2 describes the data, and the methodology is discussed in Section 3. The estimated results and discussions on the estimated parameters and elastic values are found in Section 4. The summary and conclusions are presented in Section 5.

2. Data

China consists of 34 provincial administrative units including 23 provinces, 5 autonomous regions, 4 municipalities, and 2 special economic zones. Subordinate to provinces are prefectures and each prefecture has at least one core city, some rural counties, and several county-level cities. The current number of Chinese prefecture cities is 289, however, due to the unavailability of consistent data across all the cities, only 237 prefecture cities are considered in the present study. Thus, the analysis is carried out using data from prefecture-level city, which includes both the urban and rural administrative areas.

The prefecture-level data during the period of 2000-2012 are collected from a number of sources including China City Statistical Yearbook (various years 2000-2013), CEIC, China Data Online and Wind Financial Database. We include the gross city product (GCP), total population, price indices, and physical measures of transport infrastructure-related characteristics, investment, and employment in the model. Specifically, the gross city product per capita is defined as the ratio of the gross city product over the city total population. The labor participation rate is measured as the ratio of the number of employees over the total population. We use the fixed asset investment as a proxy for physical capital. The inter-city infrastructure development is measured by the freight or passenger volumes for both the highway and railway. And the intra-city infrastructure development is defined using the area of paved roads within the city and the public transportation unit per ten thousand people. We also control for the urbanization rate measured as the number of urban population over the city total population as well as the congestion rate defined as the total number of vehicles over the area of paved roads to avoid the potential missing variables biasedness. The descriptive statistics of the significant variables used in the final model are presented in Table 2.

3. Methodological Approach

To examine the economic impacts of highway and railway across the selected cities in China, a methodological procedure that accounts for unobserved heterogeneity across cities will be appropriate. In the past, a number of statistical methods have been used to carry out this type of investigation including ordinary least square regression models, and fixed-effects model [5] [6] [20]. However, in recent years, a new methodological approach, a random-parameters regression model has been applied for the first time in economic impact analysis of transportation infrastructure expenditure to capture unobserved heterogeneity across observations and also heterogeneity across observations and time. This new me-

Table 2. Descriptive statistics of selected variables.

Variable Description	Mean	Std. dev.	Min	Max
Highway freight volumes (in ten thousands)	6343.2	6992.5	9.0	95,009.0
Railway freight volumes (in ten thousands)	1166.9	1950.3	4.9	30,009.0
Paved roads (in km^2)	1204.6	1756.3	6.0	21,490.0
Highway passenger volume (in ten thousands)	7674.6	11,701.6	82.0	179,369.0
Fixed asset investment (in millions of 2010$USD)	8.63	13.2	0.08	150.1
Urbanization rate	0.54	0.52	0.08	0.90
Public transportation unit per ten thousand people	60.4	45.5	19.3	525.6
Industrial sector's contribution to gross city product (in millions of 2010$USD)	6.8	14.4	0.06	218.7
Service sector's contribution to gross city product (in millions of 2010$USD)	8.3	12.2	0.09	126.8
Highway congestion rate	4.24	5.95	0.27	37.12
Labor participation rate	0.71	0.02	0.68	0.74

thod has been shown to be more statistically robust compared to the previous statistical methods (ordinary least squares regression, fixed- and random-effects models). Furthermore, the random-parameters regression model is able to account for unobserved heterogeneity across observations compared to the previous statistical methods. Thus in the present paper, we will follow the random-parameters regression model as derived and applied to investigate the economic impacts of transportation infrastructure expenditures starting with the following equation:

$$LnY_{k,t} = \beta_0 + \beta_k LnX_{k,t} + \varepsilon_{k,t} \quad (1)$$

where $Y_{k,t}$ is the gross city's product (GCP) per capita (in 2010 USD) for city k at year t, $X_{k,t}$ is a vector of the independent variables (highway freight volume, railway freight volume, the area of paved roads, highway passenger volumes, fixed asset investment, urbanization rate, public transportation unit per ten thousand people, industrial sector's contribution to gross city product, highway congestion rate, and labor participation rate) for city k in time t, β_k is a vector of estimable parameters, and $\varepsilon_{k,t}$ are normally distributed random disturbances.

The estimation of Equation (1) by the ordinary least square approach has two distinct issues. First, it is possible that higher GCP generates higher freight volumes in highway and railway, while it is expected also that higher freight volumes in highway and railway would promote growth in city outputs. Thus, the gross product and freight volumes could be endogenous and violates the fundamental assumption underpinning the ordinary least squares estimation, resulting in biased coefficient estimates. This concern is resolved in the present study by adopting instrumental variable procedure whereby highway and railway freight volumes are regressed against exogenous variables and the predicted values are used as variables in the estimation of Equation (1). The second issue with the estimation is that each of the cities will produce 13 observations from 2000-2012, and these 13 observations are likely to share unobserved effects resulting in serially correlated data, thus, violating one of the OLS assumptions of no serial correlation. This issue can be resolved by allowing the constant term to vary across observations [21] [22]. Therefore, the use of the random-parameters model allows all estimable parameters to be fixed for each individual city but to vary across cities[1].

To include random parameters in Equation (1), the city-specific estimable parameter is written as,

$$\beta_k = \beta + \varphi_k \quad (2)$$

where β_k is a parameter estimated for city k, β is fixed across city, and φ_k is a randomly distributed term (for each city k) that can take on an extensive variety of distributions including the log-normal, beta, normal, and so on. Equation (1) can be estimated, with such random parameters (since β_k varies across

[1]Simple fixed and random effects models are also estimated, in addition to a finite mixture model. However, likelihood ratio tests clearly indicate that a full random-parameters approach provides a superior statistical fit to the data.

cities according to the random term as shown in Equation (2)), with maximum likelihood techniques. However, the maximum likelihood estimation of random-parameters regression model is computationally complex. Simulation-based likelihood methods are proven to be more appropriate, and an approach that employs Halton draws has more efficient distribution of draws than purely random draws [23]. Thus, for the present study's estimation of the random-parameters model, we use Halton draws in NLOGIT 5.

To interpret estimation findings, the elasticity of gross city product per capita (GCPPC) with respect to each independent variable is defined as,

$$\beta_k = \frac{\mathrm{d}LnY_k}{\mathrm{d}LnX_k} \tag{3}$$

where LnY_k and LnX_k are the log-linearized forms of per capita gross city product and control variables for the k^{th} city.

4. Estimation Results

The estimated results are illustrated in Table 3[2] and the detailed estimation for each specific city[3] is reported in Tables 4(a)-(d). Turning to specific variables, highway freight volume is found to be statistically significant with a lognormal distribution and the expected positive sign, indicating that an increase in highway freight volume increases gross city product per capita (GCPPC). The average elasticity for highway freight volume across cities is 0.016 (as shown in Table 3), showing that a 1% increase in highway freight volume would increase a city's gross product per capita, on average, by 0.016% and the impact varies across the selected cities in China. And it can be observed that the computed elasticity values vary significantly across different tier of cities[4] shown in Tables 4(a)-(d). For example, highway freight volume generates the highest impact in the city of Shenzhen (Table 4(a)) and the lowest impact value in the cities of Zhangzhou in Fujian province (Table 4(c)) and Ji'an in Jiangxi Province (Table 4(d)). The average elasticity for highway freight volume is 0.03, 0.01, 0.01 and 0.02 for the 1st, 2nd, 3rd and 4th tier cities in China. This indicates the growth impacts of highway are larger in the first and the fourth tier cities.

The parameter for railway freight volume is found to be statistically significant with a positive impact on the GCPPC. The average is 0.005 and ranges from 0.0001 to 0.0307 across the selected cities. In Table 4(c) and Table 4(d), it shows that a 1% increase in railway freight volume increases GCPPC by 0.0001% in the city of An Qing in Anhui province, Rizhao in Shandong province, Zhuzhou in Hunan province, Mianyang in Sichuan province, Zibo in Shandong province and Chaozhou in Guangdong province. In comparison, the economic growth will rise by 0.031 in the city of Qinhuangdao in Hebei province. It appears that

[2]Detailed estimated parameters for the 237 cities are available upon requests.
[3]The cities in Table 4(a) & Table 4(b) are labelled with the upper case letters denoting the province and the lower case letters denoting the city names.
[4]The subdivisions of the 1st-, 2nd-, 3rd-, and 4th-tier cities are based on the definitions given by the Institute of Finance and Trade Economics, Chinese Academy of Social Sciences.

Table 3. Random-parameters model estimation results (All random parameters are normally distributed).

Variable Description	Parameter Estimate	*t*-Statistic
Constant	1.882 (0.153)	29.937 (6.100)
Log of highway freight volumes (in ten thousands)	0.016 (0.041)	6.298 (10.575)
Log of railway freight volumes (in ten thousands)	0.005 (0.019)	2.989 (4.087)
Log of paved roads (in km^2)	0.007 (0.006)	1.309 (13.774)
Log of highway passenger volume (in ten thousands)	0.017 (0.056)	4.673 (5.323)
Log of fixed asset investment (in millions of 2010$USD)	0.051 (0.029)	7.837 (5.015)
Log of urbanization rate	0.313 (0.307)	7.296 (6.516)
Log of public transportation unit per person	0.021 (0.007)	6.541 (22.617)
Log of highway congestion rate	−0.031 (0.300)	-5.870 (23.048)
Log of labor participation rate	3.110 (0.406)	18.883 (6.387)
Log of industrial sector's contribution to gross city product	0.127 (0.016)	17.143 (18.128)
Log of service sector's contribution to gross city product	0.362 (0.101)	9.545 (9.102)
Number of observations	3081	
Log-likelihood at zero $LL(0)$	−4067.839	
Log-likelihood at convergence $LL(\boldsymbol{\beta})$	−802.681	
$\rho^2\left[1-LL(\boldsymbol{\beta})/LL(0)\right]$	0.803	

Note: Value in parenthesis is the standard deviation of parameter distribution for parameter estimate and t-statistic.

Table 4. (a) Elasticities of highway and railway freight volumes in Tier 1 cities; (b) Elasticities of highway and railway freight volumes in Tier 2 cities; (c) Elasticities of highway and railway freight volumes in Tier 3 cities; (d) Elasticities of highway and railway freight volumes in Tier 4 cities.

(a)

City	Highway Freight Volume Output Elasticity (HFVOE)	Railway Freight Volume Output Elasticity (RFVOE)
Beijing	0.0069	0.0069
Tianjin	0.0110	0.0110
Shanghai	0.0172	0.0019
Guangzhou	0.0197	0.0062
Shenzhen	0.0972	0.0064

(b)

City	HFVOE	RFVOE	City	HFVOE	RFVOE	City	HFVOE	RFVOE
HBshijiazhuang	0.0039	0.0039	JSsuzhou	0.0172	0.0039	HN zhengzhou	0.0247	0.0092
HBtangshan	0.0005	0.0005	ZJhangzhou	0.0036	0.0099	HB wuhan	0.0080	0.0052
SXtaiyuan	0.0182	0.0182	ZJningbo	0.0129	0.0237	HuN changsha	0.0089	0.0008
NMGhohhot	0.0622	0.0065	AHhefei	0.0018	0.0030	GX nanning	0.0152	0.0068
NMGbaotou	0.0252	0.0079	FJfuzhou	0.0016	0.0074	Chongqing	0.0157	0.0087
LNshenyang	0.0104	0.0037	FJxiamen	0.0206	0.0165	SC chengdu	0.0046	0.0071
LNdalian	0.0052	0.0064	FJquanzhou	0.0004	0.0116	GZ guiyang	0.0048	0.0076
JLchangchun	0.0099	0.0096	JXnanchang	0.0134	0.0010	YN kunming	0.0417	0.0242
HLJharbin	0.0141	0.0021	SDjinan	0.0144	0.0042	ShX xian	0.0447	0.0009
JSnanjing	0.0007	0.0002	SDqingdao	0.0011	0.0124	GS lanzhou	0.0125	0.0035
JSwuxi	0.0257	0.0053	SDyantai	0.0065	0.0064	XJ urumqi	0.0187	0.0221

(c)

City	HFVOE	RFVOE	City	HFVOE	RFVOE	City	HFVOE	RFVOE
HBqinhuangdao	0.0307	0.0307	ZJlishui	0.0065	0.0091	HB yichang	0.0166	0.0100
HBhandan	0.0181	0.0181	AHwuhu	0.0292	0.0012	HB xiangfan	0.0094	0.0058
HBxingtai	0.0289	0.0289	AHbengbu	0.0046	0.0071	HuB jingzhou	0.0083	0.0037
HBbaoding	0.0081	0.0081	AHhuainan	0.0111	0.0039	HuN zhuzhou	0.0205	0.0001
HBchengde	0.0100	0.0100	AHmaanshan	0.0140	0.0174	HuN xiangtan	0.0284	0.0046
HBcangzhou	0.0125	0.0125	AHanqing	0.0203	0.0001	HuN hengyang	0.0009	0.0032
HBlangfang	0.0152	0.0152	FJzhangzhou	0.0001	0.0149	HuN yueyang	0.0051	0.0038
SXdatong	0.0033	0.0033	JXjingdezhen	0.0177	0.0020	HuN changde	0.0159	0.0158
LNanshan	0.0181	0.0099	JXjiujiang	0.0055	0.0088	HuN chenzhou	0.0051	0.0043
LNfushun	0.0302	0.0069	JXxinyu	0.0334	0.0026	GD shantou	0.0141	0.0030
LNbenxi	0.0170	0.0021	JXganzhou	0.0091	0.0072	GD zhanjiang	0.0167	0.0078
LNdandong	0.0071	0.0013	SDzibo	0.0206	0.0001	GD maoming	0.0047	0.0034
JLjilin	0.0140	0.0012	SDzaozhuang	0.0185	0.0018	GD zhaoqing	0.0076	0.0014
HLJqiqihar	0.0186	0.0011	SDdongying	0.0285	0.0170	GD huizhou	0.0027	0.0064
HLJdaqing	0.0305	0.0089	SDweifang	0.0121	0.0084	GD meizhou	0.0266	0.0004
HLJmudanjiang	0.0055	0.0042	SDjining	0.0032	0.0014	GD qingyuan	0.0212	0.0007
JSxuzhou	0.0007	0.0019	SDtaian	0.0040	0.0073	GX liuzhou	0.0505	0.0095
JSchangzhou	0.0239	0.0048	SDweihai	0.0158	0.0135	GX beihai	0.0170	0.0028
JSnantong	0.0013	0.0182	SDrizhao	0.0217	0.0001	GX yulin	0.0236	0.0064
JSlianyungang	0.0131	0.0011	SDlinyi	0.0180	0.0048	HaN haikou	0.0094	0.0211
JShuaian	0.0188	0.0048	SDdezhou	0.0155	0.0095	SC deyang	0.0204	0.0061
JSyancheng	0.0086	0.0007	SDliaocheng	0.0095	0.0025	SC mianyang	0.0049	0.0001
JSyangzhou	0.0090	0.0035	SDbinzhou	0.0034	0.0135	SC yibin	0.0115	0.0019
JSzhenjiang	0.0245	0.0069	HNkaifeng	0.0044	0.0036	GZ zunyi	0.0519	0.0133
JStaizhou	0.0050	0.0033	HNluoyang	0.0073	0.0066	ShX baoji	0.0293	0.0169
ZJwenzhou	0.0122	0.0039	HNpingdingshan	0.0049	0.0101	ShX yanan	0.0103	0.0063
ZJjiaxing	0.0335	0.0063	HNanyang	0.0226	0.0063	GS tianshui	0.0233	0.0137
ZJshaoxing	0.0078	0.0047	HNxinxiang	0.0124	0.0056	QH xining	0.0107	0.0058
ZJjinhua	0.0034	0.0046	HNjiangzuo	0.0115	0.0107	NX yinchuan	0.0152	0.0163
ZJquzhou	0.0090	0.0035	HNxuchang	0.0112	0.0190			

(d)

City	HFVOE	RFVOE	City	HFVOE	RFVOE	City	HFVOE	RFVOE
HBzhangjiakou	0.0078	0.0078	AHliuan	0.0157	0.0201	HuN huaihua	0.0146	0.0083
HBhengshui	0.0057	0.0057	AHhaozhou	0.0085	0.0030	HuN loudi	0.0034	0.0020
SXyangquan	0.0172	0.0172	AHxuancheng	0.0053	0.0092	GD shaoguan	0.0123	0.0027
SXchangzhi	0.0031	0.0031	FJsanming	0.0105	0.0003	GD chaozhou	0.0164	0.0001
SXjincheng	0.0150	0.0150	FJnanping	0.0044	0.0051	GX guizhou	0.0097	0.0012

Continued

SXshuozhou	0.0251	0.0251	FJlongyan	0.0122	0.0031	GX fangchenggang	0.0506	0.0030
SXjinzhong	0.0081	0.0081	FJningde	0.0388	0.0010	GX qinzhou	0.0320	0.0062
SXyuncheng	0.0304	0.0005	JXpingxiang	0.0062	0.0019	GX guigang	0.0038	0.0127
SXxinzhou	0.0093	0.0056	JXyingtan	0.0401	0.0027	HaN sanya	0.0701	0.0114
SXlinfen	0.0126	0.0129	JXjian	0.0001	0.0116	SC zigong	0.0372	0.0018
NMGwuhai	0.0338	0.0130	JXyichun	0.0106	0.0063	SC panzhihua	0.0340	0.0125
NMGchifeng	0.0226	0.0089	JXfuzhou	0.0149	0.0040	SC guangyuan	0.0083	0.0093
LNchaoyang	0.0176	0.0090	JXshangrao	0.0254	0.0134	SC suining	0.0149	0.0015
LNhuludao	0.0178	0.0121	SDlaiwu	0.0166	0.0006	SC neijiang	0.0045	0.0191
JLsiping	0.0014	0.0032	SDheze	0.0087	0.0192	SC leshan	0.0267	0.0060
JLliaoyuan	0.0232	0.0066	HNhebi	0.0176	0.0014	SC nanchong	0.0022	0.0037
JLtonghua	0.0046	0.0042	HNluohe	0.0127	0.0038	SC meishan	0.0083	0.0080
JLbaishan	0.0086	0.0048	HNsanmenxia	0.0076	0.0007	SC guangan	0.0144	0.0042
JLsongyuan	0.0080	0.0061	HNnanyang	0.0070	0.0048	SC dazhou	0.0005	0.0117
JLbaicheng	0.0040	0.0022	HNshangqiu	0.0052	0.0213	SC ziyang	0.0105	0.0040
HLJjixi	0.0123	0.0008	HNxinyang	0.0076	0.0009	GZ liupanshui	0.0504	0.0033
HLJhegang	0.0295	0.0031	HNzhoukou	0.0091	0.0009	GZ anshun	0.0052	0.0205
HLJshuangyashan	0.0328	0.0056	HNzhumadian	0.0172	0.0044	YN qujing	0.0003	0.0217
HLJyichun	0.0231	0.0044	HBhuangshi	0.0058	0.0054	YN yuxi	0.0222	0.0023
HLJjiamusi	0.0377	0.0006	HBshiyan	0.0070	0.0062	ShX tongzhou	0.0334	0.0023
HLJqitaihe	0.0162	0.0129	HBezhou	0.0428	0.0029	ShX xianyang	0.0053	0.0067
HLJheihe	0.0040	0.0149	HBjingmen	0.0004	0.0070	ShX hanzhong	0.0169	0.0107
HLJsuihua	0.0112	0.0089	HBxiaogan	0.0029	0.0050	ShX yulin	0.0104	0.0031
JSsuqian	0.0037	0.0081	HuBhuanggang	0.0125	0.0055	GS jiayuguan	0.0823	0.0140
AHhuaibei	0.0321	0.0003	HuBxianning	0.0010	0.0043	GS jinchang	0.0435	0.0212
AHtongling	0.0309	0.0065	HuBsuizhou	0.0086	0.0004	GS baiyin	0.0219	0.0081
AHhuangshan	0.0115	0.0011	HuNshaoyang	0.0214	0.0117	NX shizuishan	0.0100	0.0254
AHchuzhou	0.0012	0.0028	HuNzhangjiajie	0.0254	0.0026	NX wuzhong	0.0410	0.0198
AHfuyang	0.0103	0.0061	HuNyiyang	0.0064	0.0048			
AHsuzhou	0.0151	0.0091	HuNyongzhou	0.0026	0.0131			

while railway significantly contributes to city's economic development, though on average, it generates a smaller economic impact compared to highway. This result is consistent in direction with previous studies [19] [24] suggesting that for short distances and having flexibility of time in mind, highway is relatively a more effective way to transport freight; thus, the lower economic impact from railways compared to highways. In addition, the railway impact in the 1st tier of Chinese cities has been the lowest (0.0065) compared with the 2nd tier cities (0.0079). The contribution of railway is found to be approximately the same in the 3rd (0.0072) and the 4th tier cities (0.0073).

Highway passenger volume, which indicates the number of people commuting from one place to another along the highway network, is found to produce a statistically significant random parameter. The average elasticity is 0.017 with respect to GCPPC, with values ranging from 0.0001 to 0.1415 across cities. It can be observed that highway passenger volume significantly impacts a city's gross product, and if this variable is ignored in the economic impacts analysis of transportation at the city's level, the impacts from the other transportation variables would be upward biased.

The area of paved roads produces a positive and statistically significant effect, indicating that intra-city infrastructure can also be considered as an important factor in determining a city's gross product, ostensibly by providing mobility and accessibility resulting in economic productivity. A 1% increase in paved road area in a city would increase GCPPC by an average of 0.007%, and this impact varies significantly from 0.00001% to 0.0233% across the selected 237 cities in China. Similarly, the number of public transportation units per person in a city, an alternative measure of intra-city infrastructure, is found to be statistically significant and the sign is positive as well. A 1% increase in public transportation unit per person would increase gross city product per capita, on average, by 0.021%, and the impact varies from 0.012% to 0.034% across cities. From the computed impact value, the result indicates that an increase in public transportation units per person would facilitate mobility and would improve accessibility, thus enhancing economic activity in a city.

With regard to non-transportation related variables, estimation results presented in Table 3 show that an increase in the labor participation rate (percentage of employable people in a city) increases the gross city product per capita. A 1% increase in labor participation rate would increase, on average, the GCPPC by 3.11% and the impact varies from 2.55% to 3.62% across cities, suggesting that labor participation rate, on average, has an elastic relationship with economic output in a city. The elasticity for fixed asset investment is found to vary from 0.007 to 0.103 across cities and a 1% increase in total fixed asset investments would increase gross city product per capita, on average, by 0.051% across cities. Urbanization rate, considered as the ratio of a city's urban population to the city's total population, is found to produce a statistically significant random parameter, and the average elasticity was 0.313, and varies from 0.002 to 1.042 across cities. This implies that in China the ongoing urbanization process significantly boosts local economic growth. The city's congestion rate, measured as the ratio of the number of buses and taxies divided by the city's area of paved roads at year-end, is also found to be statistically significant with a negative impact on a city's gross product. A 1% increase in highway congestion rate would reduce GCPPC, on average, by 0.031%. Industrial sector's contribution to a city's gross product per capita results in statistically significant random parameter. A 1% increase in industrial sector's contribution would increase, on average, a city's gross product by 0.127%, and the impact varies from 0.103% to 0.149% across cities. Finally, we show that a 1% contribution from the service sector would increase a city's gross product by 0.362%, and the economic impact varies from 0.148% to 0.51% across cities. The result indicates that the service sector's elasticity is relatively higher than that of the industrial's sector. This finding is also consistent with previous studies [25]-[30]. The preceding studies conclude that recent trends show that the service sector continues to be more innovative and productive compared to the industrial sector in many countries.

5. Conclusions

The present paper takes a renewed look at the relationship between transport and its effects on a city's economic growth considering the differentiated transportation modes and the varied local economic conditions. In the past, cross-city analyses of this topic, especially in China, did not receive adequate attention due to data limitations and the absence of a methodological framework that could account for unobserved heterogeneity across cities. This paper shows the first attempt to use a multi-city data base to estimate a random-parameters model to account for unobserved heterogeneity across cities and we are practically capable to answer that which means of transportation matters more in which city of China.

From policy perspective, the results also provide clear evidence showing that urbanization plays a significant positive role in growing the city, which are echoed in Chen *et al.* [31]. And we show that key transportation measures, which have not been considered in past economic impact studies, including highway and railway freight volumes, highway passenger volumes, congestion rate, public transportation, fixed asset investment clearly influence a city's gross product. However, the magnitude of the influence and the resulting impact on a city's growth with respect to transportation varies considerably across cities. Among highway and rail freight volumes, it is found that highway freight volume on average has a much larger effect on a city's economic output compared to railway freight volume. Among the cities, Shenzhen benefits most from its development of highway network while rail development is the growth engine for Qinhuangdao.

The findings of this paper generate rich policy implications in transportation infrastructure evaluations across Chinese cities. At the national level, the differences in elasticity values can enable the development of effective expenditure strategies for assigning weights to each mode in a multi-modal decision making process. At the regional policy level, the elasticity values estimated for highways and railways can be adopted to influence the distribution of transportation investment between inter- and intra-city transport networks.

References

[1] Barro, R.J. and Sala-i-Martin, X. (2004) Economic Growth. 2nd Edition, MIT Press, Cambridge.

[2] Romp, W.E. and De Haan, J. (2005) Public Capital and Economic Growth: A Criti-

cal Survey. *EIB Papers*, **10**, 41-70.

[3] Melo, P.C., Graham, D.J. and Brage-Ardao, R. (2013) The Productivity of Transport Infrastructure Investment: A Meta-Analysis of Empirical Evidence. *Regional Science and Urban Economics*, **43**, 695-706. https://doi.org/10.1016/j.regsciurbeco.2013.05.002

[4] Deng, T. (2013) Impacts of Transport Infrastructure on Productivity and Economic Growth: Recent Advances and Research Challenges. *Transport Reviews*, **33**, 686-699. https://doi.org/10.1080/01441647.2013.851745

[5] Aschauer, D.A. (1989) Is Public Expenditure Productive. *Journal of Monetary Economics*, **23**, 177-200. https://doi.org/10.1016/0304-3932(89)90047-0

[6] Munnell, A.H. and Cook, L.M. (1990) How Does Public Infrastructure Affect Regional Economic Performance. *New England Economic Review*, 11-33.

[7] Munnell, A.H. (1992) Policy Watch: Infrastructure Investment and Economic Growth. *The Journal of Economic Perspectives*, **6**, 189-198. https://doi.org/10.1257/jep.6.4.189

[8] Berndt, E.R. and Hansson, B. (1991) Measuring the Contribution of Public Infrastructure Capital in Sweden. *National Bureau of Economic Research*, **94**, 151-168. https://doi.org/10.3386/w3842

[9] Sanchez-Robles, B. (1998) Infrastructure Investment and Growth: Some Empirical Evidence. *Contemporary Economic Policy*, **16**, 98-108. https://doi.org/10.1111/j.1465-7287.1998.tb00504.x

[10] Kavanagh, C. (1997) Public Capital and Private Sector Productivity in Ireland, 1958-1990. *Journal of Economic Studies*, **24**, 72-94. https://doi.org/10.1108/01443589710156899

[11] Carboni, O.A. and Medda, G. (2011) Government Spending and Growth in a Neoclassical Model. *Mathematics and Financial Economics*, **4**, 269-285. https://doi.org/10.1007/s11579-011-0045-2

[12] Vijverberg, W.P., Fu, F.C. and Vijverberg, C.P.C. (2011) Public Infrastructure as a Determinant of Productive Performance in China. *Journal of Productivity Analysis*, **36**, 91-111. https://doi.org/10.1007/s11123-011-0211-9

[13] Zhang, X. (2008) Transport Infrastructure, Spatial Spillover and Economic Growth: Evidence from China. *Frontiers of Economics in China*, **3**, 585-597. https://doi.org/10.1007/s11459-008-0029-1

[14] Yu, N., De Jong, M., Storm, S. and Mi, J. (2013) Spatial Spillover Effects of Transport Infrastructure: Evidence from Chinese Regions. *Journal of Transport Geography*, **28**, 56-66. https://doi.org/10.1016/j.jtrangeo.2012.10.009

[15] Fan, S.G. and Zhang, X. (2004) Infrastructure and Regional Economic Development in Rural China. *China Economic Review*, **15**, 203-214. https://doi.org/10.1016/j.chieco.2004.03.001

[16] Demurger, S. (2001) Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China. *Journal of Comparative Economics*, **29**, 95-117. https://doi.org/10.1006/jcec.2000.1693

[17] Hong, J., Chu, Z. and Wang, Q. (2011) Transport Infrastructure and Regional Economic Growth: Evidence from China. *Transportation*, **38**, 737-752. https://doi.org/10.1007/s11116-011-9349-6

[18] Zheng, S. and Kahn, M.E. (2013) China's Bullet Trains Facilitate Market Integration and Mitigate the Cost of Megacity Growth. *Proceedings of the National Academy of Sciences*, **110**, 1248-1253. https://doi.org/10.1073/pnas.1209247110

[19] Agbelie, B.R.D.K. (2014) An Empirical Analysis of Three Econometric Frameworks

for Evaluating Economic Impacts of Transportation Infrastructure Expenditures across Countries. *Transport Policy*, **35**, 304-310.
https://doi.org/10.1016/j.tranpol.2014.06.009

[20] Ozbay, K., Ozmen-Ertekin, D. and Berechman, J. (2007) Contribution of Transportation Investments to County Output. *Transport Policy*, **14**, 317-329.
https://doi.org/10.1016/j.tranpol.2007.03.004

[21] Washington, S.P., Karlaftis, M.G. and Mannering, F.L. (2011) Statistical and Econometric Methods for Transportation Data Analysis. 2nd Edition, Chapman and Hall, Boca Raton.

[22] Greene, H. (2012) Econometric Analysis, 7th Edition, Prentice-Hall, New York.

[23] Sonstegaard, M.H. (1992) Balance and Coordination for Road and Rail. *Transportation Research Part A*: *Policy and Practice*, **26**, 419-432.
https://doi.org/10.1016/0965-8564(92)90005-r

[24] Agbelie, B.R. (2013) Economic Impacts of Transportation Infrastructure Investment across Countries: An Empirical Analysis, Doctoral Dissertation. Purdue University, West Lafayette.

[25] Eichengreen, B. and Gupta, P. (2011) The Service Sector as India's Road to Economic Growth (No. w16757). *National Bureau of Economic Research*, **7**, 1-42.

[26] Pugno, M. (2006) The Service Paradox and Endogenous Economic Growth. *Structural Change and Economic Dynamics*, **17**, 99-115.
https://doi.org/10.1016/j.strueco.2005.02.003

[27] Brun, J.F., Combes, J.L. and Renard, M.F. (2002) Are There Spillover Effects between Coastal and Noncoastal Regions in China. *China Economic Review*, **13**, 161-169. https://doi.org/10.1016/S1043-951X(02)00070-6

[28] Del Bo, C.F. and Florio, M. (2012) Infrastructure and Growth in a Spatial Framework: Evidence from the EU Regions. *European Planning Studies*, **20**, 1393-1414.
https://doi.org/10.1080/09654313.2012.680587

[29] Chen, J. and Fleisher, B.M. (1996) Regional Income Inequality and Economic Growth in China. *Journal of Comparative Economics*, **22**, 141-164.
https://doi.org/10.1006/jcec.1996.0015

[30] Fan, S., Zhang, L. and Zhang, X. (2000) Growth, Inequality, and Poverty in Rural China: The Role of Public Investments. Environment and Production Technology Division Discussion Paper No. 66.

[31] Chen, Y., Salike, N., Luan, F.S. and He, M. (2006) Heterogeneous Effects of Inter- and Intra-City Transportation Infrastructure on Economic Growth: Evidence from Chinese Cities. *Cambridge Journal of Regions*, *Economy and Society*, **9**, 571-587.