Transport Development, Regional Concentration and Economic Growth

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Abstract

‘New Geographical Economy’ suggests an inverted-U-shaped relationship between transport costs and regional economic concentration. By using data on Chinese prefectures, this paper examines the relationship between transport development and economic concentration, to investigate the ‘point effect’ and ‘network effect’ of transport stocks and to gauge their relative magnitudes. The paper concludes the following: the development of urban roads leads to rising GDP shares in the city-proper for both manufacturing and service industries; major regional roads have the same effect. A ‘point effect’ is found for both urban roads and major regional roads in GDPs. There are spillover effects for both urban roads and major regional roads. Finally, different types of transport infrastructure have different economic impacts. The policy implication is that the urban–rural economic growth gap is likely to continue to increase with urban and regional transport development during the rapid urbanisation concurrently undertaken.

1. Introduction

Advances in spatial economics developed over the past couple of decades greatly enhance our understanding of the relationship between transport development and regional economic concentration and/or spatial agglomeration. Labelled the ‘New Economic Geography’, theoretical models incorporate imperfect competition, increasing returns and transport costs into the formation of economic activities in a spatial dimension and a fully fledged general equilibrium model emerges to explain why, how and when the economic activity may be aggregated in limited geographical areas (Behrens and Murata, 2007; Behrens and Thisse, 2007; Fujita and Thisse, 2009; Krugman, 1991a, 1991b; and Tabuchi, 1998).

Simplified on a two-region, two-sector and two-factor economy with spatial labour mobility, Krugman (1991a; 1991b) first
demonstrates the existence of multiple equilibria of firm locations, depending on the combination of increasing returns, transport costs and home market effect on demand and supply. More specifically, the relationship between transport costs and regional economic concentration exhibits an inverted-U-shaped curve (Combes and Lafourcade, 2001; Krugman, 1991a, 1991b; and Thisse, 2009). That is, if transport costs are sufficiently high, interregional shipping of manufacturing goods is discouraged and production remains dispersed in proximity to their markets. With falling shipping costs from transport development (when transport costs reach a threshold level) combined with increasing returns, both labour and capital are encouraged to concentrate in core regions that benefit from agglomerative economies and larger market sizes. This results in spatial concentration and inequality of economic activities. Facing increased competition along with rising negative externalities resulting from economic concentration, the transport cost decline may encourage firms to disperse from core regions into peripheral areas when transport costs are sufficiently low (Acs and Varga, 2002; Fujita et al., 1999; Krugman and Venables, 1995; and Puga, 1999). This ‘New Economic Geography’ model has huge policy implications in developing countries with insufficient transport provision. Put into a core–periphery framework, it implies that, as the concentration/agglomeration in city cores rises, so will regional inequality with transport development (Krugman, 1991a; and Mossay, 2006).

Despite rapid advances in the theoretical frontier, there are few empirical studies examining the relationship between transport costs and regional economic concentration/agglomeration. Faini, Giannini and Galli (1993) show that the transport investment causes rising regional gaps in Italy, while Glaeser (1997) suggests that falling transport costs in the US can explain the decreasing share of manufacturing jobs in city-core areas. Combes and Lafourcade (2001) conclude that the transport cost decline reinforces agglomeration at a regional level by using France as a case study.¹

In a region divided into a core and a periphery, the question about the relationship between transport costs (linking the core and the periphery) and regional concentration/inequality is linked to a widely studied subject on the effect of transport on economic growth.² This is through a ‘point effect’ and a ‘network effect’. The former relatively well-studied phenomenon refers to the local growth effects of transport; and the latter, found sporadically in the literature, refers to transport facilities whose effects are beyond the funding jurisdictions (Baird, 2005; Boarnet, 1998; and World Bank, 2009). Thus, in the case that falling transport costs cause further economic concentration in the core, we may find: an insignificant ‘point effect’ and/or a significantly positive ‘network effect’ of transport in the periphery, or both effects are positive but the ‘network effect’ is bigger in magnitude; and, an insignificant ‘network effect’ and a significant ‘point effect’ of transport in the core, or both effects are positive but the ‘point effect’ is bigger. Following this, it would not be surprising to see insignificant findings on the transport effect on economic growth if the spillover effect or ‘network effect’ is overlooked (Fernald, 1999; Gramlich, 1994; Pereira and Flores de Frutos, 1999; Tatom, 1993).³

The objective of this paper is to answer the following two interrelated research questions. The first is whether or not falling transport costs, due to massive transport investments throughout Chinese cities, lead to a rising concentration of economic activities in city-core (urban) areas, defined as the city-proper. The second question is whether or not there are positive spillovers for transport infrastructure and, if so, which types of
transport infrastructure. Those two questions are not completely independent of each other since the presence of positive spillovers may affect economic growth differently across regions.

These two questions are examined by using Chinese prefecture cities. The reasons for choosing Chinese prefecture cities are three-fold. First, Chinese prefecture cities are administratively divided into city-proper and non-city-proper areas. This geographical division and its differences in economic development status make Chinese cities the best fit for a core–periphery model. Secondly, there are data available reflecting development and transport stocks in the city-proper and non-city-proper. This enables us to investigate explicitly if development of regional roads leads to an increase in economic concentration in the city-proper and, related to this question, if there is a positive spillover effect of regional roads in built-up areas. Thirdly, perhaps equally important if not more so, extraordinary economic success and massive transport construction through China in general and Chinese cities in particular, make Chinese cities an ideal place to examine the relationship between transport and economic growth as well as transport effects on economic development. Given the remarkable growth in China, there are few studies on the issue in question.4

The paper is organised as follows. Section 2 describes cities and their importance, which is followed by the model and data in section 3. Section 4 presents the data, an empirical model and the results. The final remarks and conclusions are presented in section 5.

2. Chinese Cities and Their Development

The uniqueness of the administrative arrangement of cities is reflected in their division between city-proper and non-city-proper areas. The diqu is the entire administrative area of the city. Usually at the geographical heart of diqus is the city-proper, called shiqu,5 which is surrounded by suburban and rural areas (Figure 1). Non-city-proper areas are the areas outside the city-proper. Thus a diqu is made up of a city-proper (shiqu) and non-city-proper. The city-proper is composed of city districts, while the non-city-proper is divided into city districts, city-level cities and counties.

At the heart of a city-proper are built-up areas, in which economic activities are concentrated. For instance, the city-proper accounts for only 14.14 per cent of total city areas, but is home to more than half of the non-agricultural population, close to half of a city’s total GDP in both manufacturing and service industries. The city-proper contains built-up areas that are home to the majority of, if not all, the non-agricultural population and non-agricultural GDP. Less than 9 per cent of the city-proper is built-up, suggesting a high intensity level of human activities there. The city-proper has a much larger geographical coverage than the conventional core–periphery model suggests and there are issues associated with using this area to proximate the core mainly because of the large portion of undeveloped land there. We argue that this may not be an issue mainly because we focus on non-agricultural GDP that is primarily produced from built-up areas. In addition, we should take into consideration data availability and the city-proper’s boundaries that are much more stable than built-up areas.6

The city-proper expands in two different ways. One way is by combining and merging sub-city administrative units. Shanghai, for instance, combined Jinshan county and Shihua district into Jianshan district in 1997 and merged Nanshi district and Huangpu district in 2000. The other way is through upgrading counties to
districts. For example, Shanghai changed the following units from county to city district: Songjian in 1998; Qingpu in 1999; Nanhui and Fengxian in 2001. Many other cities like Beijing, Guangzhou, Nanjing and Hangzhou have adjusted administrative units in their city-proper in the past couple of decades. Such instances of merging and levelling-up represent the Chinese version of urban annexation.

Chinese cities are dominant in the national economy and their dominance increases with urbanisation and industrialisation. In 2004, there were 287 cities. The administrative areas cover nearly half of the country (48.86 per cent) while city-proper areas consume only 6.09 per cent of national land. This means that, on average, the non-city-proper is seven times bigger than the city-proper. The total GDP generated from all city-proper areas increased from 36 per cent in 1990 to 57.35 per cent in 2004 and then to 63.2 per cent in 2006. The average annual growth rate of the city-proper’s GDP was about twice as high as that of the national economy. The importance of all city-proper areas to the non-agrarian economies is even more striking. For instance, about 71.5 per cent of manufacturing GDP was produced from city-proper areas.

Massive numbers of rural–urban migrants move to the city-proper in the process of rapid urbanisation. Urban residents in city-proper areas grew from 150.38 million in 1990 to 215.8 million in 2000 and further to 275.77 million in 2004. Population growth in city-proper areas would be more impressive if the estimated 150–250 million floating population living primarily in city-proper areas were taken into account.

Although the direction of causal-effect relationships between infrastructure
provision and economic growth is debatable, the fact is that massive infrastructure investments have accompanied rapid urban economic growth, particularly since the 1990s. The scale of investments in infrastructure such as highways has been unprecedented in recent decades. From 1996 to 2004, for instance, the total length of highways increased from 3400 km to 34 300 km, classified roads (first and second class interregional roads) increased from 108 769 km to 265 237 km. Annual growth rates of highways and classified roads were 33.45 per cent and 11.79 per cent respectively.\(^9\) Total paved urban roads grew from 94 820 km in 1990 to 159 617 km in 2000 and further to 259 740 km in 2008. The annual growth rate of urban paved roads rose from 5.35 per cent between 1990 and 2000 to 6.27 per cent between 2000 and 2008.

Other types of interregional transport networks have also shown impressive growth. The average annual completed railroad construction was approximately 600 km between 1980 and 1995, but jumped to around 1300 km between 1995 and 2005.\(^{10}\) The number of airports increased from 82 in 1985, to 139 in 1995 and further to 152 in 2008. Finally, the growth of intra-city transport network was unprecedented. Total paved urban roads grew from 94 820 km in 1990, to 159 617 km in 2000 and further to 259 740 km in 2008.

The massive amount of infrastructure construction is attributed to enormous fixed asset investments. On average, fixed asset investment accounted for 30.3 per cent of GDP in 1979–1990, 36.1 per cent in 1990–2000 and 49.5 per cent in 2001–07. The share of infrastructure investments in total fixed asset investments grew from 8.3 per cent 1990 to more than 14 per cent in 2004.\(^{11}\)

These massive transport investments are associated with economic and fiscal decentralisation and with land financing. Economic and fiscal decentralisation created fierce local competition and local economic performance became a dominant factor in determining the fate of local officials. Transport was often used as a vehicle to improve the investment environment. Land financing served as an important mechanism in financing transport infrastructure, particularly urban roads. Both the scope and scale of land-based urban infrastructure financing across Chinese cities was outstanding. Anecdotal evidence reveals that some cities relied 100 per cent on land financing for urban roads in urban spatial expansion (Ding and Song, 2009). The ability for local governments to rely on land to finance urban infrastructure is rooted in China’s land institutes governing land use and land allocation. According to the Chinese constitution, rural, collectively owned land is prohibited from land development. State-owned land in cities (including county-level cities) and towns is subject to the Land Use Rights system in which private users and developers can purchase usage rights for fixed periods of time (Ding, 2007). City municipal governments acting as the state’s representative exercise their institutionalised monopoly power in taking land from peasants at prices much lower than what is charged to developers through land leasing.\(^{12}\) Land conveyance fees can be 10–20 times greater than what is paid to peasants in land taking (Lichtenberg and Ding, 2009). The monopoly behaviour in land taking and land leasing brings enormous off-budgetary land revenues to city governments. The land revenues on average are equivalent to 40–60 per cent of total retained tax revenues.

3. The Model and Data

This section presents a simple model in a city-region setting, fitting into the reality of Chinese cities that are composed of an
urban core (\( u \)) (referring to the city-proper) and its surrounding rural areas (referring to the non-city-proper) (\( r \)). Economic output in the city-proper or in the non-city-proper is produced according to a conventional production function that is extended to include transport stock (\( T \)). The output function is defined as

\[
Q_u = A F(L_u, K_u, T_u, T_r)
\]

and

\[
Q_r = A F(L_r, K_r, T_u, T_r)
\]

where, \( Q \) denotes economic output measured by GDP; \( L \) and \( K \) denote labour and capital inputs respectively; \( T \) denotes transport stock; and \( A \) captures the impact of technology.\(^{13}\)

The model can capture both ‘point effect’ and ‘network effect’. The ‘point effect’ is captured by the properties of \( \frac{\Delta Q_u}{\Delta T_u} > 0 \) and \( \frac{\Delta Q_r}{\Delta T_r} > 0 \), implying that transport investments in the city-proper or in the non-city-proper contribute to economic growth in areas with transport improvement. The ‘network effect’ is captured by \( \frac{\Delta Q_u}{\Delta T_r} > 0 \) and \( \frac{\Delta Q_r}{\Delta T_u} > 0 \), implying that the transport effect reaches beyond funding jurisdictions.

The economic concentration in the city-proper is then defined as

\[
Q^c = \frac{Q_u}{Q_u + Q_r} = f(A, L_u, K_u, L_r, K_r, T_u, T_r)
\]

where, \( Q^c \) denotes the share of economic output in the city-proper.

The economic concentration in the city-proper will increase with urban transport stock as long as the following relations\(^{14}\) hold

(i) \( Q_r \frac{\partial Q_u}{\partial T_u} > Q_u \frac{\partial Q_r}{\partial T_u} \)

and

(ii) \( Q_r \frac{\partial Q_u}{\partial T_r} > Q_u \frac{\partial Q_r}{\partial T_r} \)

The relation of (i) says that the economic share in the city-proper rises with urban transport when the marginal point effect exceeds the marginal network effect after discounting for the relative sizes of the economy on development. The relation of (ii) reveals that the economic share in the city-proper rises with the non-city-proper transport when the marginal network effect exceeds the marginal point effect, again after discounting for the relative sizes of the economy.

A reduced model of (2), which is a first-order Taylor series, is specified as

\[
q = \beta_0 + \beta_1 T_u + \beta_2 T_r + \beta_3 X + \varepsilon
\]

where, \( q \) denotes the manufacturing, or tertiary GDP share, of the city-proper; \( X \) is a vector of control variables capturing labour and capital inputs, \( \varepsilon \) is a normally distributed error term; and \( \beta \)s are parameters to be estimated.

It is expected that \( \beta_1 > 0 \) because urban transport development will enhance the urbanisation process. According to New Economic Geography theory, \( \beta_2 \) can be either positive or negative, depending on the status of economic development. Given overall relative underdevelopment, it is expected that \( \beta_2 \geq 0 \), implying that an improvement in regional transport will facilitate rising economic concentration in the city-proper.

In fact, the sign of \( \beta_2 \) links the point effect to the network effect. If a transport facility demonstrates both a positive point effect and network effect, their relative magnitude suggests different regional dynamics of economic growth. In a core–periphery
model, if the point effect of transport is bigger than the network effect, an improvement in transport accessibility in the core areas will result in rising concentration there. The rising economic concentration in the core areas will occur if the network effect of transport in the peripheral areas is bigger than its point effect.

Based on a dataset of Chinese prefecture cities for the period of 1996–2004, we use a 2SLS model to estimate the impact of transport development on regional economic concentration. Since there are cities without a non-city-proper or with missing variables, an unbalanced panel of 1984 observations is used in the estimation. Actual observations are further reduced (from 1921 to 1951) mainly because of a zero value for independent variables in a log format and missing data.15

Data used in the analyses come from two different sources. One is from China’s city statistics yearbooks, which publish major economic indicators such as GDP by primary, secondary (manufacturing) and tertiary sectors in both city-proper (shiqu) and city administrative areas (diqu). The other data source is from data records maintained by China’s Ministry of Land and Resources. The data provide land areas used for transport.

There are two types of transport infrastructure. One is an urban paved road that primarily serves the city-proper. The other is transport infrastructure that serves both the city-proper and the non-city-proper. This type of transport infrastructure includes highways or major regional roads, railroads, airports and ports. All transport variables include stock and density measures. The former is used in the estimation of (1) and the latter is used in (3). Density measures that normalise transport stock variables by areas are introduced to deal with the heteroscedasticity problem. Even rural roads in many ways serve the city-proper too, by serving as a bridge for economic connections between the city-proper and the non-city-proper. So urban roads are used as a proxy for \( T_u \) while variables used as proxies for \( T_r \) include major road, rural road, railroad, airport and port.

As city built-up areas are expanding, there are periodic adjustments of city-proper boundaries. For instance, Beijing’s city-proper increased from 6996 to 12 574 square km in 2001–02, whereas Shanghai increased its city-proper by one-third in 2000–01. Chongqing more than doubled its city-proper in 1997–98 (from 6067 to 12 447 square km). The largest adjustment in terms of percentage relates to the Suqian city of Jiangsu. Its city-proper increased from 136 to 2110 square km in 2003–04. To capture the impact of an expanded city-proper, a dummy variable is created.

Descriptive statistics show that the city-proper plays a dominant role in economic activities. On average, the city-proper contained 46.25 per cent of total GDP, 51.28 per cent of manufacturing GDP and 51.32 per cent of services GDP in 2004 on a fraction of diqu land (18.36 per cent). The city-proper also houses about 55 per cent of all the registered non-agricultural population and one-third of the total population. There are no statistical data on GDP produced by built-up areas. Since the non-agricultural population is concentrated in built-up areas, the share of non-agricultural population over total population in the city-proper can be used to account indirectly for the economic importance of built-up areas to the city-proper. About 8.29 per cent of land is built up and 61.26 per cent of the total population is non-agricultural population in the city-proper.

The growth rate of the manufacturing sector in city-proper areas appears to be similar to that in non-city-proper areas.
The former enjoyed an annual growth rate of 15.22 per cent, slightly greater than the 14.33 per cent of the latter. There is a significant difference in the growth rates of service GDP, however. The annual rate of service GDP in the city-proper is 14.76 per cent, much higher than that of 9.78 per cent in the non-city-proper. The annual growth rate of major roads in the city-proper was 14.10 per cent, matching the GDP growth rate. In contrast, major roads in the city-proper were expanded only at 4.56 per cent annually (Table 1).

In estimating (1), transport stocks are measured by total land area used in each type of transport infrastructure (urban roads, major regional roads, rural roads and railroads). Since there are significant numbers of cities without airports and/or ports, dummy variables are created to capture the effect of airports and ports on economic outputs in city-proper and non-city-proper areas. Two types of dummy variable are included in the estimation. One is to indicate if there is an airport or a port and the other type is to indicate if there is a major physical expansion of airport or port.

Hausman tests indicate rejecting the hypothesis of no correlation between city and the independent variable at a 5 per cent significance level in all specifications.

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Table 1. Descriptive statistics (N = 1984)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing GDP in city-proper (1 million RMB)</td>
<td>10 602.52</td>
<td>21 472.87</td>
</tr>
<tr>
<td>Manufacturing GDP in non-city-proper (1 million RMB)</td>
<td>9 049.93</td>
<td>10 960.40</td>
</tr>
<tr>
<td>Tertiary GDP in city-proper (1 million RMB)</td>
<td>9 253.14</td>
<td>22 902.69</td>
</tr>
<tr>
<td>Tertiary GDP in non-city-proper (10 000 RMB)</td>
<td>6 433.87</td>
<td>6 885.55</td>
</tr>
<tr>
<td>Non-agricultural population in city-proper (1 million persons)</td>
<td>72.66</td>
<td>103.64</td>
</tr>
<tr>
<td>Non-agricultural population in non-city-proper (1 million persons)</td>
<td>51.94</td>
<td>37.89</td>
</tr>
<tr>
<td>Urban road (square km)</td>
<td>6.71</td>
<td>11.34</td>
</tr>
<tr>
<td>Major regional road (square km)</td>
<td>49.11</td>
<td>33.46</td>
</tr>
<tr>
<td>Rural road (square km)</td>
<td>121.97</td>
<td>109.03</td>
</tr>
<tr>
<td>Railroad (square km)</td>
<td>11.02</td>
<td>9.96</td>
</tr>
<tr>
<td>Airport dummy</td>
<td>0.62</td>
<td>0.48</td>
</tr>
<tr>
<td>Airport growth dummy</td>
<td>0.08</td>
<td>0.28</td>
</tr>
<tr>
<td>Port dummy</td>
<td>0.62</td>
<td>0.49</td>
</tr>
<tr>
<td>Port growth dummy</td>
<td>0.06</td>
<td>0.24</td>
</tr>
<tr>
<td>Manufacturing share in city-proper</td>
<td>48.73</td>
<td>23.35</td>
</tr>
<tr>
<td>Tertiary share in city-proper (percentage)</td>
<td>48.75</td>
<td>22.40</td>
</tr>
<tr>
<td>Urban road density (square km/square km) by 1/1000</td>
<td>89.53</td>
<td>44.75</td>
</tr>
<tr>
<td>Major regional road density (square km/square km) by 1/1000</td>
<td>4.57</td>
<td>2.89</td>
</tr>
<tr>
<td>Rural road density (square km/square km) by 1/1000</td>
<td>10.52</td>
<td>7.90</td>
</tr>
<tr>
<td>Railroad density (square km/square km) by 1/1000</td>
<td>0.92</td>
<td>0.67</td>
</tr>
<tr>
<td>Airport density (square km/square km) by 1/1000</td>
<td>0.14</td>
<td>0.34</td>
</tr>
<tr>
<td>Port density (square km/square km) by 1/1000</td>
<td>0.07</td>
<td>0.17</td>
</tr>
<tr>
<td>Boundary expansion dummy of city-proper by 1/1000</td>
<td>26.71</td>
<td>187.32</td>
</tr>
</tbody>
</table>

Notes: It is an unbalanced panel since the number of prefecture cities grew from 240 in 1999 to 263 in 2000, 269 in 2001, 279 in 2002, 286 in 2003 and 287 in 2004. There were four county-level cities in the data sample that were reclassified as prefecture-level cities between 1999 and 2000. In addition, a few observations are lost due to missing data.
of equations. Hausman tests cannot reject the hypothesis of no correlation between year-specific unobservables and the independent variable. Thus, all specifications of these equations were estimated by using city fixed effects, not period fixed effects.

Two eminent estimation issues arise. The first issue is related to the endogeneity of transport stocks to economic growth or output (Fernald, 1999; Gramlich, 1994; Tatom, 1993). The presence of endogenous variables can cause biased estimates. Preliminary analysis shows that urban roads and major regional roads show a strong correlation with economic growth so that only urban road and major regional road variables are treated as endogenous. Their one-year lagged values are used as the instrument variables in the 2SLS estimator with city-specific fixed effect. The Durbin–Wu–Hausman (DWH) test rejects the null hypothesis of unbiased and consistent estimates of the OLS estimator for both urban road and major regional road variables since the DWH value is 6.44 for the former and −3.41 for the latter. Thus our discussion will be focused on the estimated results from the 2SLS model. We recognise that capital stock variables are omitted and fixed capital investments are not a good proxy since they represent flows. Potential estimate problems caused by this omitted variable are dealt with by the instrumental variables in the 2SLS estimation with city fixed effect, which can help to correct for unobserved heterogeneities across cities and omitted variables.

The second issue is related to potential correlation between error terms in (1) since GDP in the city core is not completely independent of GDP in the non-city-proper in the same city. An alternative way to estimate (1) is to use the seemingly unrelated regression (SUR). This issue is addressed by the instrumental variables with city-specific fixed effect that corrects unobserved heterogeneities across cities. Thus the 2SLS estimates are reported and discussed in the paper.

4. Estimate Results

Table 2 reports estimated results, which show that the models perform well, explaining the majority of the variance of the dependent variables largely because of the control of city-specific fixed effects. Economic output grows with non-agricultural population.16 The coefficients of the population variable show that a 1 per cent increase in non-agricultural population increases GDP in the city-proper by 0.30–0.34 per cent and 0.85–0.99 per cent in the non-city-proper. The coefficients of the boundary change dummy variable show that a physical expansion of the city-proper significantly increases GDPs in the city-proper and shrink GDPs in the non-city-proper only marginally, for both the manufacturing and the tertiary sector.

The coefficients of the transport variables indicate an aggregated effect on economic output. Interpreting the coefficients of transport variables suggests the following findings. First, urban roads generate the expected results. Manufacturing GDPs in both the city-proper and non-city-proper increase along with urban roads and the magnitudes of their coefficients show that the effect of urban roads is bigger in the city-proper than in non-city-proper. Those coefficients say that a 1 per cent increase in urban roads is associated with a 0.57 per cent increase in manufacturing GDP in the city-proper; and that a 1 per cent increase in urban roads is associated with a 0.25 per cent increase in manufacturing GDP in the non-city-proper. A similar conclusion is obtained for the tertiary economy. The magnitudes of the coefficients of urban roads say that a 1 per cent of increase in urban
Table 2. The 2SLS estimates of economic output

<table>
<thead>
<tr>
<th>Variable</th>
<th>Log(manufacturing GDP)</th>
<th>Log(service GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>City-proper (n = 1923)</td>
<td>Non-city-proper (n = 1922)</td>
</tr>
<tr>
<td></td>
<td>Coefficient</td>
<td>T-statistic</td>
</tr>
<tr>
<td>C</td>
<td>797.53</td>
<td>11.62</td>
</tr>
<tr>
<td>Log(non-agricultural population of city-proper)</td>
<td>33.90</td>
<td>7.92</td>
</tr>
<tr>
<td>Log(non-agricultural population of non-city-proper)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log(urban road)</td>
<td>57.30</td>
<td>14.14</td>
</tr>
<tr>
<td>Log(major regional road)</td>
<td>64.82</td>
<td>6.70</td>
</tr>
<tr>
<td>Log(rural road)</td>
<td>13.07</td>
<td>0.96</td>
</tr>
<tr>
<td>Log(railroad)</td>
<td>0.07</td>
<td>0.02</td>
</tr>
<tr>
<td>Airport dummy</td>
<td>12.00</td>
<td>0.25</td>
</tr>
<tr>
<td>Airport growth dummy</td>
<td>5.75</td>
<td>1.59</td>
</tr>
<tr>
<td>Port dummy</td>
<td>3.51</td>
<td>0.57</td>
</tr>
<tr>
<td>Port growth dummy</td>
<td>0.98</td>
<td>0.28</td>
</tr>
<tr>
<td>Dummy variable for boundary change in city-proper</td>
<td>5.38</td>
<td>1.98</td>
</tr>
</tbody>
</table>

\[ R^2 \] 0.97 0.96 0.98 0.97  
\[ Adjusted R^2 \] 0.97 0.97 0.97 0.96

Notes: All coefficients are in 1/100 for illustration purpose. * denotes significantly different from zero at the 10 per cent significance level; ** denotes significantly different from zero at the 5 per cent significance level; *** denotes significantly different from zero at the 1 per cent significance level.
roads in the city-proper is associated with a 0.49 per cent increase in tertiary GDP in the city-proper; and that a 1 per cent of increase in urban roads in the city-proper is associated with a 0.22 per cent increase in tertiary GDP in the non-city-proper. Secondly, the signs and magnitudes of the coefficients of urban roads lead to the following conclusions: urban transport does affect urban GDP (the point effect); there is a positive spillover effect of urban transport (the network effect), meaning that the rural non-agricultural economy benefits from transport in urban built-up areas; and, the point effect seems to be larger than the network effect as implied by their elasticities.

There are mixed results on regional transport stocks. For major regional roads, expected results are generated. Manufacturing GDPs in both city-proper and non-city-proper areas increase along with major regional roads and the magnitudes of their coefficients show that the effect of major regional roads is bigger in the city-proper than in the non-city-proper. Those coefficients say that a 1 per cent increase in major regional roads is associated with a 0.65 per cent increase in manufacturing GDP in the city-proper; and that a 1 per cent increase in major regional roads is associated with a 0.39 per cent increase in manufacturing GDP in the non-city-proper. A similar conclusion is obtained for the tertiary economy. The magnitudes of the coefficients of major regional roads say that a 1 per cent increase in major regional roads in the city-proper is associated with a 0.87 per cent increase in tertiary GDP in the city-proper; and that a one per cent of increase in major regional roads in the city-proper is associated with a 0.57 per cent increase in tertiary GDP in the non-city-proper. Secondly, the signs and magnitudes of the coefficients of major regional roads lead to the conclusions that: major regional roads do affect urban GDP (the point effect); there is a positive spillover effect of major regional roads (the network effect), meaning that the rural non-agricultural economy benefits from transport in urban built-up areas; and, the network effect seems to be larger than the point effect as implied by their elasticities.

Rural roads have a significant coefficient with a wrong sign in the non-city-proper for both manufacturing and service industries and a significant and positive coefficient for the manufacturing sector in the city-proper. A further examination shows that this wrong sign for rural roads may be due to: the fact that some rural roads are upgraded to major regional roads, so that rural roads can decrease; and, multicollinearity between rural roads and major regional roads. Railroads contribute little to GDPs, which is not unexpected since railroads serve areas that are much larger than city administrative boundaries and need much longer time to construct so that their effects may not be observed in the short run. The airport dummy variable produces a significant and positive coefficient in the non-city-proper for the manufacturing economy, while the port dummy is not significant at all for all cases. The physical growth of the airport seems to be more important than the presence of an airport itself. The growth dummy variable of airports contributes to manufacturing GDP in the non-city-proper and tertiary GDP in the city-proper. The growth dummy variable of ports is not significant at all.

In sum, four main conclusions can be drawn from the results shown in Table 2. First, there are mixed results on the point effect of transport stocks on economic outputs. Both urban roads and major regional roads may contribute to economic growth, but other types of transport such as rural roads, railroads, airports and ports may not. Secondly, there are mixed results on the network effect of transport stocks on
economic outputs too. These spillover effects are manifested in urban roads and major regional roads, not in other types of transport. Thirdly, major regional roads tend to have larger effects (both point effect and network effect) than urban roads. Fourthly, at an aggregated level, the effect differences between manufacturing and service industries seem not to be substantial. It should be noted that the magnitude of the effects of both urban roads and major regional roads seems to be big, particularly for major regional roads. This may be attributed to the endogeneity of transport development and will be addressed by using the 2SLS estimator.

Importantly, it should be pointed out that the relative magnitudes of urban road and major regional road variables obtained from the production function approach imply that the development of both urban roads and major regional roads tends to increase the level of concentration of economic activities in the city-proper. This conclusion is consistent with the one from Table 2, saying that economic development favours city-proper areas; and a dynamic balance in the economic relationship between city-proper and non-city-proper areas changes partly because an improvement in major regional roads increases the mobility of economic factors and partly because an improvement in urban roads may enhance agglomerative economies in the city-proper. Thus, at the window of the study period, the way in which Chinese cities develop shows that falling transport costs as a result of improvements to urban roads and major regional roads cause an increase in the economic concentration of the manufacturing and service sectors in the city-proper.

The mixed results in general and the insignificance of some of them can be explained. It seems likely that facilities outside the city-proper (rural roads) and major ports/airports were constructed as the city grew, but had much more capacity than the city needed. A single port can facilitate a large range of city sizes and in some cases is independent of city growth, as it expands to ship goods not necessarily coming from or going to the city. Moreover, a single rural road usually has a minimum capacity, which can handle a lot of rural expansion before it reaches its level of service constraint. Further, the insignificance of railroads may be due to the facts that a long time-period is needed for construction, segmentation in services is less likely if not completely impossible, and there are non-economic reasons such as national defence behind their spatial alignment. The insignificance of rural roads may be due to the wide coverage and traffic dominance of major regional roads. The insignificance or mixed results of airports and ports may be due to the lumpiness of their construction and investments. Of course, these explanations are questionable and need further verification, which is a subject of future studies.

Table 3 shows the 2SLS estimated results. Again, the Durbin–Wu–Hausman tests suggest that both urban roads and major regional roads demonstrate strong endogeneity with the errors and the 2SLS estimator outperforms the OLS estimator by generating unbiased and consistent coefficients. As with the previous models, we use one-year lagged values that are IVs for the urban road and major regional road variables. Thus the 2SLS estimates with city-specific fixed effects are reported. Given the wide variation in the size of cities, all transport variables are normalised by area to deal with the heteroscedasticity issue.

Overall, the model fits the data well, with more than 94 per cent of variance of the dependent variable explained for both the manufacturing and tertiary sectors. For the manufacturing sector, as expected, a change in administrative boundaries will alter the
economic relationship between the city-proper and non-city-proper. An adjustment of administrative boundaries of city-proper areas increases the manufacturing concentration level in the city-proper. This also holds for tertiary industries: an expansion of the city-proper results in a higher concentration of tertiary GDP.

For the manufacturing sector, only urban roads, major regional roads and rural roads have significant coefficients with expected signs. The coefficient of the urban road density variable suggests that a 1 per cent increase in urban road density will increase manufacturing GDP share of the city-proper by 0.095 per cent. The coefficient of the major regional road variable shows that a 1 per cent increase in major regional roads is associated with a 0.144 per cent increase in the manufacturing GDP share in the city-proper.18 Rural roads demonstrate a positive effect on manufacturing concentration in the city-proper, with a much smaller elasticity value of 0.061, compared with that of the major regional road variable. Railroads, airports and ports all have insignificant coefficients.

Tertiary economies show a similar effect from transport development. The estimated coefficients indicate that: a 1 per cent increase in urban road density is associated with a 0.11 per cent increase in tertiary GDP share in the city-proper; a 1 per cent increase in major regional roads is associated with a 0.094 increase in tertiary GDP share in city-proper; and a 1 per cent in rural regional road density is associated with a 0.175 per cent increase in tertiary GDP share in the city-proper. Again, railroads, airports and ports have little effect on the tertiary GDP share in the city-proper. Table 3 leads us to conclude that the development of urban roads and regional roads tends to raise concentration levels of non-agricultural economic activities in the city-proper, with mixed results on regional transport since the effect of railroads, airports and ports is not found. Tables 2 and 3 present consistent evidence on the positive effect of urban roads and major regional roads, and mixed evidence on other transport variables such as rural roads and airports.

5. Final Remarks and Conclusions

The unique administrative arrangement between city-proper and non-city-proper

<table>
<thead>
<tr>
<th>Variable</th>
<th>Manufacturing</th>
<th></th>
<th>Tertiary</th>
<th></th>
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<tr>
<td></td>
<td>Coefficient</td>
<td>T-statistic</td>
<td>Coefficient</td>
<td>T-statistic</td>
</tr>
<tr>
<td>C</td>
<td>0.27***</td>
<td>11.60</td>
<td>0.29***</td>
<td>14.49</td>
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<tr>
<td>Urban road density</td>
<td>0.52***</td>
<td>3.07</td>
<td>0.64***</td>
<td>4.92</td>
</tr>
<tr>
<td>Major road density</td>
<td>15.07***</td>
<td>1.97</td>
<td>5.08***</td>
<td>3.20</td>
</tr>
<tr>
<td>Rural road density</td>
<td>6.66***</td>
<td>2.76</td>
<td>8.51***</td>
<td>3.97</td>
</tr>
<tr>
<td>Railroad density</td>
<td>32.15</td>
<td>1.34</td>
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<td>0.71</td>
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<tr>
<td>Airport density</td>
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<td>1.17</td>
<td>17.14</td>
<td>0.39</td>
</tr>
<tr>
<td>Port density</td>
<td>-34.66</td>
<td>-0.79</td>
<td>46.29</td>
<td>0.94</td>
</tr>
<tr>
<td>Dummy variable for administrative boundary change in city-proper</td>
<td>0.06***</td>
<td>7.47</td>
<td>0.05***</td>
<td>7.67</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.94</td>
<td></td>
<td>0.95</td>
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<tr>
<td>Adjusted $R^2$</td>
<td>0.93</td>
<td></td>
<td>0.95</td>
<td></td>
</tr>
</tbody>
</table>
areas in China provides an ideal case to examine the relationship between transport development and agglomeration in city cores. Given the underdeveloped status of its economy and historically lagged infrastructure provision, if the ‘New Economic Geography’ theory holds, it is expected that massive infrastructure investments in the past two decades in China will have led to rising economic concentration in city-proper areas. This paper provides supporting evidence for this. That is to say, as transport cost declines, factor inputs such as labour, firms and investments are all attracted to core areas, leading to rising core–periphery/rural–urban gaps. Estimated results, however, also show that not all types of transport have the predicted effects on economic development. Only urban roads and major regional roads demonstrate the predicted outcomes. This may be due to a combination of the relatively short period studied, long construction times and the lagged effects of some types of infrastructure.

A by-product of this research is associated with the finding of spillover effects of transport development on regional economic growth. While both point effects and network effects are found for urban roads and major regional roads, estimated results suggest that urban roads have a larger point effect than network effect and that for major regional roads, the network effect is greater than the point effect. In other words, the city-proper benefits more from an improvement of both urban roads and major regional roads than does the non-city-proper. These findings are consistent with the positive relationship between falling transport costs and rising regional concentration in city cores.

China is in the process of rapid urbanisation that may also cause economic concentration in cities to rise. This understanding may be used to discount what is concluded in the paper about the positive evidence on the relationship between the transport cost decline and rising concentration in city cores. Because of controls on city-specific fixed effects and the high explanatory power of independent variables, the positive role of transport development (particularly urban roads and major regional roads) on city agglomeration cannot be denied. This leads to a profound policy implication. Transport development at the city level will help to promote city agglomeration and will enlarge rural–urban development gaps. One of the critical policy questions is how best to address the anticipated increasing gap between rural (non-city-proper) and city (city-proper) areas to maintain sustainable and stable growth trajectories. This is further complicated by the understanding that rising city agglomeration is justified by its own reasons even with the presence of negative consequences resulting from city size. The question is subject to future studies.

Notes
1. They also conclude that falling transport costs counterbalance the process of spatial concentration at the county level.
3. Tatom (1993) tested for stationarity and found no evidence of a positive public infrastructure effect. Boopen (2006) summarised negative views or insignificant findings of transport effects. A study by Holtz-Eakin (1994) also found no statistically significant relationship between the output and infrastructure, while work by Ghali (1998) provided evidence of overprovision of public capital in a number of developing countries.
in which positive infrastructure effects were less likely to be found.

4. Quantitative studies on the impacts of transport development on the regional economy in China are found only in Démerger’s work (2001).

5. It should be clarified that built-up areas are much smaller than the city-proper since it contains a lot of undeveloped land.

6. Data used are calculated from city samples used in regression analyses. There are cities excluded from the data samples for various reasons such as missing observations, no non-city-proper (in some cities, the city-proper covers the entire administrative area so that there is not an administrative division between the city-proper and the non-city-proper) and non-city status in the early years in the study period.

7. Unless specifically indicated otherwise, cities refer to preference cities in this paper.

8. There were 188 cities in 1990. So after discounting this trend, the increase of economic concentration in cities is striking. Source: http://www.china.com.cn/aboutchina/zhuanti/08jingzheng/2008-10/10/content_16596103_7.htm.

9. There were only 100 km of highways in 1988 and 500 km in 1990. Data sources: China Statistical Yearbooks, from 1997 to 2005.


12. Land conveyance fees used to be shared between the central and sub-national governments in the early 1990s when the Land Use Rights system was first introduced to the whole country. In the late 1990s, the central government stopped taking a share of land revenues.

13. Subscripts denote regions.

14. Those conditions are derived from

\[ \frac{\partial Q^s}{\partial T_u} = \frac{Q_r \frac{\partial Q_u}{\partial T_u} - Q_u \frac{\partial Q_r}{\partial T_u}}{(Q_u + Q_r)^2} > 0 \]

15. The number of cities increased from 218 in 1996 to 283 in 2004.

16. Data on fixed capital stocks are not included in the estimation of (1) for the two regions. First, there are not reliable data records on fixed capital stocks. Secondly, data on fixed capital investments represent flows rather than stocks and include transport development gauged by physical measures in the paper. The potential estimation problems arising from the missing fixed capital stock variable are recognised. The problems are dealt with by introducing instrumental variables with city-specific fixed effect.

17. For the manufacturing sector, the DWH value is 2.43 for urban roads and 1.93 for major regional roads. For the service sector, the value is 2.79 for urban roads and 2.31 for major regional roads. Thus the DWU tests show that the GMM estimates are unbiased and consistent by addressing the endogenous urban road and major regional road variables.

18. The elastic values are calculated at the mean value of variables using the estimated coefficients in Table 3.

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**References**


