

DOCTORAL THESIS

Two essays on the economic impacts of high-speed railway in China

Chung, Man Kit

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**Two Essays on the Economic Impacts of High-speed
Railway in China**

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A thesis submitted in partial fulfillment of the requirements
for the degree of
Master of Philosophy

Principal Supervisor: Dr. CHENG Yuk Shing

Hong Kong Baptist University

August 2014

DECLARATION

I hereby declare that this thesis represents my own work which has been done after registration for the degree of MPhil at Hong Kong Baptist University, and has not been previously included in a thesis or dissertation submitted to this or any other institution for a degree, diploma or other qualifications.

Signature: _____

Date: August 2014

ABSTRACT

The thesis contains two essays on the economic impacts of high-speed railway (HSR) in China. Utilizing a unique data set of towns in Dongguan, a city in South China, it provides empirical evidence on whether HSR affects economic growth and efficiency or not. The first essay uses the generalized method of moments (GMM) to estimate a dynamic panel data model of the town economies. The empirical results suggest that both HSR and expressway have a positive impact on the general economic development of the towns. However, HSR does not have a significant effect on the development of the manufacturing sector, while expressway does in this regard. These findings lend indirect support to the common argument that HSR can benefit the tertiary sector, but not necessarily other sectors. The second essay investigates the relationship between the advent of HSR and productive efficiency of the manufacturing sector. Using a stochastic frontier approach, it provides empirical evidence that proximity to expressway, rather than to HSR, enhances the efficiency of industrial enterprises.

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Essay One

The Economic Impact of High-speed Railway: The Case of Dongguan

1. INTRODUCTION

Parallel to the “high-speed revolution” (*The Economist*, 2007) that swept the developed countries in the 2000s, China formulated an ambitious plan of building a high-speed railway (HSR) network in 2004. It is an essential part of her strategy to achieve the national goals of sustainable mobility, regional balance, and energy security. The nationwide construction of high-speed dedicated passenger lines (DPL) and the extensive upgrading of the conventional lines have aroused international attention (Takagi, 2011; Okada, 2007). They are expected to form the largest HSR network in the world by 2020. Significant increase in speed and capacity brought by this environmental-friendly technology (Chen, 2001) will not only eliminate the bottlenecks in the current railway network, but also lead to prominent spatial restructuring - most of the provincial capitals and major cities in the country are going to be accessible to Beijing within 8 hours by railways. Remarkable decrease in travel cost, and hence the enhancement in accessibility, is likely to generate the “shrinking continent” phenomena identified by Spiekermann and Wegerner (1994). Deepening integration among connected regions and cities will influence the spatial behaviours of various urban actors (Pol, 2003) and relocation of production factors (Blum, Haynes and Karlsson, 1997), potentially generating considerable benefits. City and regional governments are eager to seize the new opportunities offered by the assumed catalysing and facilitating functions

of improved train services (Pol, 2003) to strengthen competitiveness in the following decades. A comprehensive understanding of the possible economic effects led by the advent of HSR is undoubtedly necessary.

The contribution of transportation infrastructure to economic growth has long been recognised in the economics literature. Most studies analyse the impact of the stock of infrastructure measured by the amount of investment or the length of roads and railways (see, among others, Fan and Zhang, 2004; Demurger, 2001; Munnell, 1990; Aschauer, 1989) or the effect of distance from infrastructure on economic performance (see, among others, Banejee, Duflo and Qian, 2012). The analyses mostly focus on an aggregate economy, either a country or a region within a country. There are investigations of the impacts of HSR, but the assessments are less systematic and mostly conducted by picking up fragmented evidence on the changes in economic activities of selected sectors in selected cities along a HSR line in particular years. As reviewed in the next section, the literature on HSR suffers from a number of shortcomings.

The current study represents an attempt to evaluate the economic impact of HSR vigorously. We use a dynamic panel regression to find out the impact of a HSR line using a unique data set of Dongguan, a famous city in South China. It is chosen for several reasons. First, the city is located in the middle of the Guangzhou-Shenzhen Railway, which was a pioneer of China's experiment in upgrading conventional lines. Since 1998, the trains on this line have been operating at a maximum speed of 200 km/hr, making it qualified to be a HSR by European standard.¹ China's DPLs have been introduced after 2008, rendering meaningful evaluation of their impact difficult. Second, as a major export

¹ After the train crash in Wezhou in July 2011, the maximum operating speed on this line was reduced to 160 km/h (*Hong Kong Commercial News*, 2011).

processing centre with huge amount of imports and exports, development of transport infrastructure is vital to its success. The impact of transport facilities can easily be distinguished. Third, the data set covers 32 towns in Dongguan throughout the period of 2001-2011, thus providing sufficient variations across locations and over time for an econometric study to discern various effects. It also contains other variables that allow us to separate the impacts of other factors, such as the distance of a town from the entrance of expressway and the degree of outward-orientation, thus making our findings about HSR more reliable. Fourth, our data set contains information about the whole economy of the towns as well as the manufacturing sector of the towns, thus allowing us to draw inferences for different sectors. Lastly, the advantage of using town-level data is obvious. We can identify the distance of a town from a specific infrastructure (an expressway or HSR line) and thus can measure the decaying impact of infrastructure on towns further away from the stations. This cannot be done using more aggregate data (such as data of provinces and countries). Firm-level data can be even better in this regard, but the cost of data collection is often too high.

The remainder of the paper is organized as follows. Section 2 is literature review. Section 3 gives an overview of the economic characteristics and infrastructure development in Dongguan City. By exploring their potential relationships, we formulate various testable hypotheses. Section 4 delineates the conceptual and methodological framework for rigorous quantitative analysis of the impacts of HSR services and expressways on the development of general economy and industrial sector among the townships in the City, followed by a description of the data set. Empirical findings are reported and discussed in section 5. The last section concludes with policy recommendations.

2. LITERATURE REVIEW

There have been debates on whether the availability of HSR service would bring along positive or negative effects to a city. The empirical evidences in this regard are mixed. The survey of Bonnafous (1987) finds that tourism of certain towns can be benefited from the rising number of day-return journeys and the development of new tourist packages after the opening of TGV Southeast in France, but hotels in some cities suffer from a sharp decrease of stays. Similar development is observed along with the opening of TGV Atlantic (Masson and Petiot, 2009). Some studies even suggest that fiercer regional competition triggered by more convenient HSR services can drain urban activities from the locations with unfavourable conditions, leading to the “straw effect” (Ja and Konami, 2002; Hood, 2006). Sanuki (1980) reports that the Shinkansen has severely weakened the central-city functions (e.g. clustering of head offices and financial firms) of Nagoya, the largest intermediate city between Tokyo and Kyoto-Osaka-Kobe regions. Okabe (1980) illustrates that, while the effect of HSR on retail business is somewhat marginal, signs of polarization of wholesale activities towards the principal cities pose a challenge to the medium and small intermediate municipalities along the line.

The variety of findings leads to two different arguments. First, Plassard (1991) and Vickerman (1997) suggest that HSR might create some “tunnel” effects, leading to the concentration of economic activities at the two terminals of the HSR line and hollowing out of cities in-between them. Taking this into account, Whitelegg and Holzapfel (1993) conclude that HSR exerts net negative socio-economic effects (also see Givoni, 2006). The second argument is that how much a region can gain from a HSR connection depends on whether the

respective governments and firms have adopted an appropriate strategy to utilize the new infrastructure (Ampe, 1995). In particular, how the railway station area is developed is one of the determining elements (Bertolini & Spit, 1998). In other words, HSR connection is a necessary instead of sufficient condition for generating economic impacts. Many studies tend to agree to this view but they do not provide rigorous quantitative analysis to detect the spatial and temporal impacts (Preston and Wall, 2008). As will be explained later, our study will try to overcome this problem.

Although these studies have deepened our understanding of various possible impacts of HSR, they have serious limitations. The first drawback of the previous studies is related to the measurement of economic impacts. An abundance of literature, despite variations in cases and periods, finds some apparent evidence on the contribution of HSR infrastructure to urban growth or even revitalization of transitional economies (Pol, 2003; Bernkopf, 2009). However, they mainly focus on the effects of HSR on population and employment growth rather than the eventual impact on economic output. For instance, the investigation of Brotchie (1991), based on the work of Hirota (1984), indicates that cities with stations enjoy higher population growth and more rapid expansion in the employment of retail, industrial, construction and wholesaling sectors after the presence of Tokaido Shinkansen, and the results are consistent with those findings of Amano and Nakagawa (1990), according to Haynes (1997). The analysis of Sands (1993), which is based on the findings of Nakamura and Ueda (1989), also suggests that regions connected to Joetsu and Tohoku Shinkansen are more likely to experience an increase in population rather than a decrease, and the effect is further secured with availability of expressway infrastructure.

Another problem of the previous studies lies in the methodology. Most studies compare certain indicators before and after the introduction of HSR services, without controlling other factors that would affect the economic performance. With obvious missing variables, the relationship between the provision of HSR services and the expansion of the economy is dubious (Preston and Wall, 2008; Sands, 1993).² A more rigorous method and a more comprehensive assessment of the economic impact of HSR is much needed.

3. INFRASTRUCTURE AND ECONOMIC DEVELOPMENT OF DONGGUAN CITY

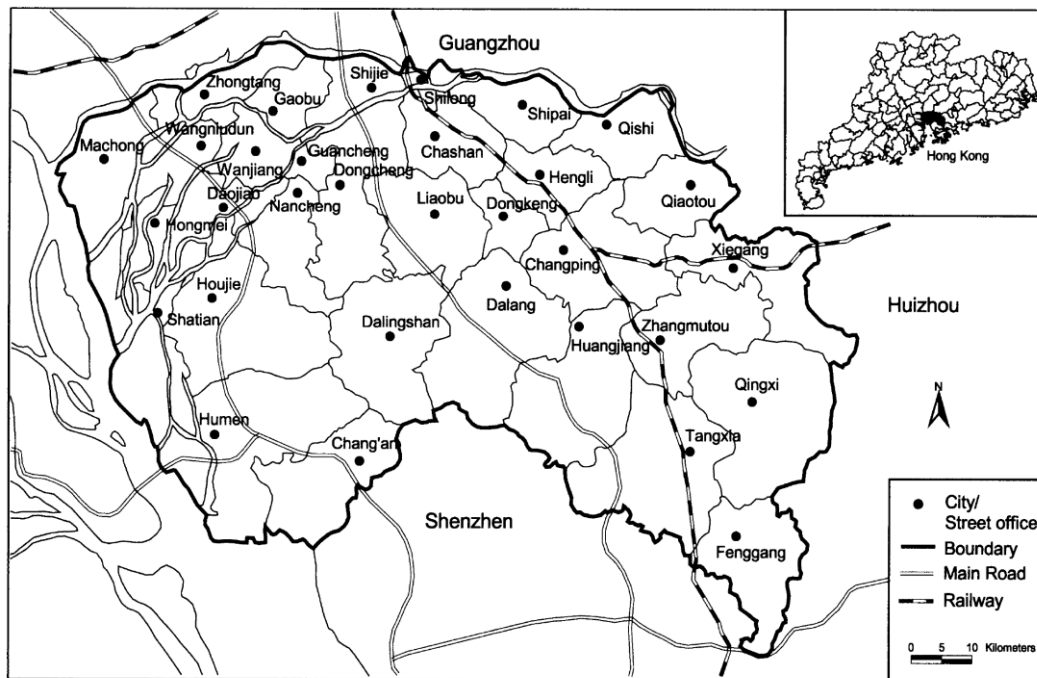
3.1. Characteristics of Dongguan's Economy and Transport Demand

Nowadays Dongguan is an international processing and assembling base known as the “World factory”. Agglomerates of industries among the 32 town-level administrative divisions together produce an incredible scale of outputs and supply a wide range of consumer goods to the global market. According to statistics, about one-fifth of woollen sweaters in the world are made on this 2,456 km² of land located between the most prosperous Chinese cities of Guangzhou and Shenzhen (*Xinhua Net*, 2007a). Just one town of Dalang produces more than 300 million sweaters every year (Kirstof, 2007). This city has also begun to play a significant role in the manufacturing of electronic and computer peripheral products since the dawn of the 21st Century. With a comprehensive industrial structure, 95% of all kinds of IT products in the world and parts for computer

² Nakamura and Ueda (1989) argue that it is possible for transportation infrastructure to just result in relocation of economic activities, rather than a net economic expansion. Haynes (1997) criticizes that the empirical literature has failed answer this important question.

assembling can be purchased within the city (Yang, 2004). It is claimed that about 70% of computer manufacturers around the globe would be affected if there is an obstruction on the expressway from the Dongguan to the Huanggang checkpoint lying on the boundary between Hong Kong and Shenzhen (*China Pictorial*, 2008).

Figure 3-1: Map of Dongguan City



Source: Yang (2007).

Cheap land and favourable geographical location are the keys for the incredible pace of industrialization in Dongguan after the implementation of economic reform. This city was once an important agricultural county, of which annual amount of grains handed to the Central ranked the third in the nation (*Lifeweek*, 2014). Abundant endowment of land resources allowed Dongguan to host Hong Kong-funded factories escaping from the rising labour cost and land price in the British colony at that time. Owing to the limited supply of land and rapid urbanization, Shenzhen was unwilling to develop itself into a base for the low-value added outward processing and compensation trade. The proximity of

Dongguan made itself another choice for Hong Kong industrialists who were hurrying for compressing the cost of expanding production scale or maintaining products' competitiveness (Tuan and Ng 2003; pp.755), as long as transportation was convenient enough for timely shipment (Guo and Zhu, 2003).

Dongguan and Hong Kong were soon economically integrated under the famous “front shop, back factory” model. While the headquarters of the firms in Hong Kong retained the functions of order processing and coordination of manufacturing activities in the Mainland, manufacturing procedures were handed over to the factories in Dongguan (Chan, 2010). Spanning from 1978 to 1995, 80% of Dongguan's actually utilized foreign investment came from Hong Kong and about two-third of the workers in Dongguan were employed by Hong Kong-invested enterprises (Guo and Zhu, 2003; pp.376). The factories originated from Hong Kong, particularly those established at early years, were mainly engaged in low-tech consumer goods manufacturing (Li, 2008). This was due to the fact that the major purpose of investments in Dongguan was to increase cost advantage in competing for purchasing orders from foreign brand companies. The lack of skilled labour also prevented Hong Kong entrepreneurs from further transferring any complicated working procedures to the city. Although Hong Kong investments extended to the relatively more capital-intensive and higher-skilled sectors starting from the 1990s,³ the firms in those sectors still stayed in the low-

³ Actually, even if skilled labour are sufficient, efforts of upper-level government on fostering industrial upgrading are still likely to be hindered by the vested interest. One of the most salient features of the administrative system of Dongguan City is the absence of county-level organizations as a legacy of its history as a county of Huiyang Prefecture and later as a county-level city until 1988. While the municipal government is mainly responsible for strategic decisions and monitoring, the subdistricts (*Jiedao* 街道) and townships under its direct management are offered greater autonomy in implementing policies and developing economy (Han et al., 2010). For instance, the townships allow the villages to adopt a land system which is different from a normal village in other places of China (*Beijing Times*, 2013). All or part of the land originally allocated to the households in villager groups can be recentralized into the hands of collectives to

end segments in the global value chain and their functions were generally limited to assembling and processing (Airriess, 2008).

As a production enclave, factories in Dongguan relied heavily on international supply chains of raw materials and foreign markets. Hong Kong was once the only city in the PRD region to provide the subordinate factories with efficient business services as well as well-established marketing channels, playing the role of international connector. Even though the influence of Hong Kong entrepreneurs in southern China was gradually reduced from the late 1990s, Hong Kong continues to be the major centre facilitating the inflow and outflow of completed goods and intermediate products in the region (Guo and Zhu, 2003). First, the arrival of industrialists from Taiwan at Dongguan⁴ further strengthened the status of Hong Kong as a “service-city core” (Tuan and Ng, 2003). While hosting branches or regional headquarters of some Taiwan enterprises to function as finance controlling centres,⁵ Hong Kong has been a gateway facilitating the flow of people and goods across the Strait.⁶ Second, the rise of re-imports of

construct plants and factories for rental. When the industrial enterprises earn any income from processing activities, they are obliged to pay a certain proportion to the townships and villages. The fee collected has to be spent on local infrastructure is a major source of funds for the town-level and village-level institutions, and all the members in the villager groups can share a considerable amount of profit of the collectives every year. It should be noted that the collectives in villages had the rights of choice on enterprises. As the amount of profit appropriated to villagers was determined by the scale of leasing activities, the collectives preferred labour-intensive industries which must stimulate rental demand to technology-intensive ones which possibly only increased the tax income of government (*21st Century Business Herald*, 2014). As a result, Dongguan is locked on the path as a production enclave filled with industrial enterprises engaging in low-value-added activities.

⁴ Dongguan has become the largest concentration of Taiwanese investment in Mainland China after the transplantation of traditional industries from Taiwan in the early 1990s and the rapid development of Taiwanese electronic clusters around the year of millennium. The latter stage was particularly important because the manufacturing of computers and related IT peripherals brought about sectoral transformation of Taiwanese investment in the city (Yang, 2007). While Dongguan was subsumed into the flourishing global IT production network, the functions of management and research were retained in Taiwan and all the products were manufactured for exports.

⁵ Taiwan enterprises make use of the higher capital freedom and better protection offered by the relatively loose but well-monitored financial environment to avoid financial risks and escape from the restrictions of Taipei on the investments in the Mainland (Guo and Zhu, 2003).

⁶ Direct transport across the Strait was not allowed until the full restoration of Three Links in 2008.

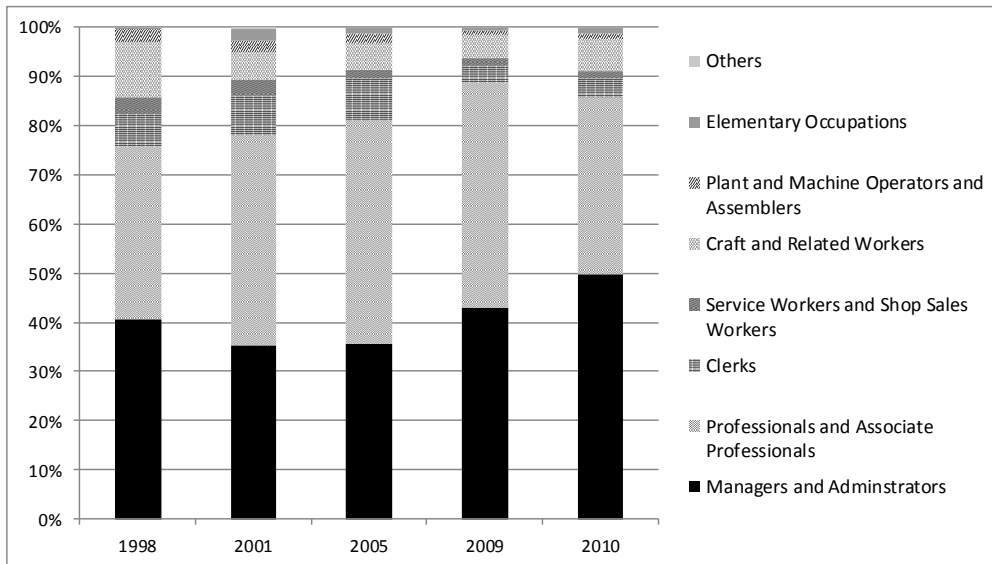
national goods has made Hong Kong a strategic foothold for manufacturing firms in Dongguan to utilize the loopholes of tax rebate policy.⁷ The firms try to capture a tax rebate equalling to a profit margin of 20% to 30% by exporting materials to the nearest separate custom territories and then re-importing them (*Xinhua Net*, 2007 b). Evidently, such activities correlate with the increasing flow of raw materials and parts between Hong Kong and Dongguan.⁸

Business travel from Hong Kong to the factories in Dongguan is very common for investors or high-ranked business staff, as face-to-face contact is still an important process in non-standardised decision making (Blum, Haynes and Karlsson, 1997). Actually, most Hong Kong residents required to work in the Mainland are managers, administrators and professionals with relatively high educational attainment (See Figure 3-2 and 3-3). The demand for hotel and leisure services explodes due to their arrival and the city has been well-known for its largest number of five-star hotels among all prefecture-level cities in China. Other people are also growing familiar with Dongguan through all kinds of economic interaction. Selected towns grasp the opportunities to involve into real estate

⁷ Since the early 1980s, Chinese government carried out the policy of tax rebate for the trading companies' exports of raw materials, parts and intermediate goods as a means to encourage exports, while the tariff and value-added has also been exempted for the imports of these materials and products in form of processing trade.

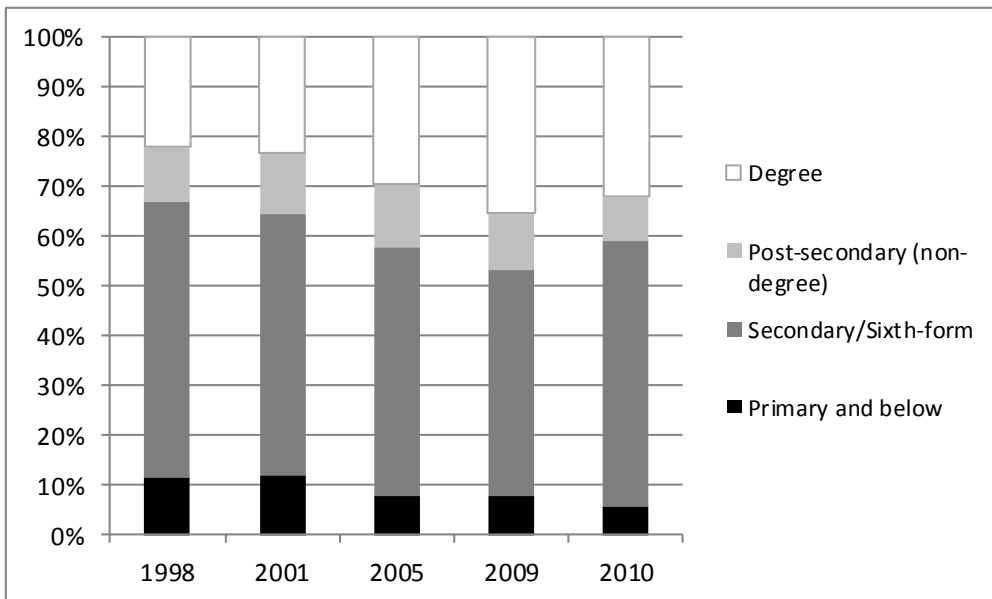
⁸ The proportion of re-imports in the total imports of the whole Dongguan kept increasing (The Study Group of Dongguan's Foreign Trade Strategy, 2008) and was at its height (about 25%) in 2008, almost more than 4 times of the year of 2001 in terms of value (*Southern.Com*, 2011). And thus the Mainland has taken the place of Taiwan as the origins of most of the imports of the city since 2006. As a result, Hong Kong has replaced the United States as Dongguan's largest trading partner in 2007 (*Southern Metropolitan Daily*, 2008).

Figure 3-2: Hong Kong residents who had worked in the mainland of China during the 12 months before enumeration by occupation while working in the Mainland of China



Source: Census and Statistics Department of Hong Kong, *Hong Kong Residents Working in the Mainland of China*, various issues.

Figure 3-3: Hong Kong residents who had worked in the mainland of China during the 12 months before enumeration by occupation while working in the Mainland of China by educational attainment



Source: Census and Statistics Department of Hong Kong, *Hong Kong Residents Working in the Mainland of China*, various issues.

development. Similarities in culture, ties of kinship and relative nearness between the two places have attracted many Hong Kong residents to establish their second home there and thus stimulated the demand for catering and other services. Tertiary sector is now as important as manufacturing in terms of value added, and decades of expansion are a result of growing flow of people along the traffic corridor between Dongguan and Hong Kong.

The communication between Dongguan and Hong Kong is basically facilitated by transport linkages of HSR and expressways.

3.2. The Expressway Network in Dongguan

The delivery of goods in and out of the factories in Dongguan is mostly facilitated by the expressway.⁹ First, it is more cost effective to handle cargoes with relatively low weight or volume by trucking, which is affordable to the low value-added manufacturing activities. Its flexibility is also important to guarantee in-time shipment to prevent the companies from suffering from any losses arisen from delay. Second, expressway network provides the most direct links from the manufacturing factories to ports in Hong Kong and Shenzhen, and hence minimize the cost arisen from the transshipment. With the introduction of more

⁹ The expressway infrastructure is gaining absolute status in delivering majority of raw materials and products in and out of the City in the period of fast industrial growth. It is interesting that waterborne transport was actually playing a more important role in transporting cargoes just after the kick-off of economic reform. In 1980, a total of 2.98 million tonnes of cargoes were sent by water freight, while the figure for road freight was 0.51 million tonnes, just a little bit more than one-sixth of the former. However, the situation has been totally reversed after Dongguan has gained the status as a city as a consequence of rapid industrialization. In 1985, delivery of 19.22 million tonnes of cargoes depended on road transport, occupying almost two-third of the transport market in the city. The volume of cargoes shipped by water grew more than three times to 9.91 million tonnes, but its market share shrunk to about 34% only. Although inland water transport was promoted in PRD region and neighbouring provinces as a component of regional cooperation in recent years, there was still a divergence over time in volume of cargoes delivered and freight traffic turnover during the decade of 2001 to 2011. The volume of cargo conveyed by vehicles has achieved a dramatic growth of about 1.3 times in these ten years, while the volume of cargo transported by waterways has decreased by about 1.7% in the same period.

convenient vehicular customs procedures (Yeung, 2001; Legislative Council Panel on Transport, HKSAR, 2002) and improvements of cross-boundary facilities (Legislative Council of HKSAR, 2010), industrial products can be handled and delivered to Hong Kong by trucking services within a day.

Yet, the provision of expressway infrastructure also allows more frequent business trips and hence stimulates the demand for services in the towns of Dongguan. The expressway network as a whole has made all the towns accessible to Hong Kong, in about two hours. Such distance allows a half-day or one-day round trip from Hong Kong to the manufacturing base in Dongguan is possible (Yeung, 2001), and the managerial staff in Hong Kong can go to the factories in person to deal with any difficulties in production process whenever necessary.

To maintain the competitiveness of Dongguan, construction of expressways to Hong Kong and Shenzhen are of course regarded as effective means. The rapid development of expressway is facilitated by the ability of Dongguan Government to raise funds through cooperating with Hong Kong investors and utilizing the financial and political autonomy brought by its upgrading of administrative status from county to prefecture level (Yeung, 2001). Although the development standard of road infrastructure of the city was once similar to that of today's Cambodia (*Dongguan Daily*, 2011), the highway density of Dongguan is now the highest among all the cities in Guangdong Province and also the top of all prefecture-level cities in China. After years of development, the average time from the centres of towns to the nearest entrance of the expressways has decreased from more than half an hour to less than 15 minutes.

Table 3-1: Summary of Expressway Development in Dongguan

	2001	2011
Length of Expressways (km)	51.5	251
Expressway Density (km / 100 km ²)	2.1	10.2
Average time to the nearest entrance (min)	32.0	11.5
Maximum time to the nearest entrance (min)	88	23
<u>Minimum time to the nearest entrance (min)</u>	4	4

Source: Statistical Bureau of Guangdong Province and Survey Office of the National Bureau of Statistics in Guangdong. *Guangdong Statistical Yearbook*. Beijing: China Statistical Press. Various issues; *Google Map*.

3.3. The High-speed Passenger Service of Guangzhou-Shenzhen Railway

Instead of being a means of the local government to facilitate the production, the provision of the high-speed passenger services on the Guangzhou-Shenzhen Railway is a response of the railway sector to the fierce competition in the transportation market. This century-old railway was chosen as an experimental project in 1990 due to its favourable conditions for market and engineering testing (Cai ed., 2000). Knowledge and experiences for the nationwide “speed-up” projects and the construction of high-speed DPL in the following decades were accumulated through upgrading works. After years of modernization, the line was equipped for the speed of 200 km/h, possessing the characteristic of HSR listed in *the Council Directive 96/48/EC* of the European Union.¹⁰

¹⁰ Today the intercity trains travelling between Guangzhou East Station and Shenzhen Station may seem “too slow” in comparison with those running on the newly-built DPL with a maximum commercial speed of 300km/h. The Guangzhou-Shenzhen Railway has once attained an official recognition as HSR. It should be admitted that the features of Guangzhou-Shenzhen Railway are hardly consistent with the first clear definition of HSR given by *Code for Design of High Speed Railway* in 2009, in which the term refers to the newly-built railway infrastructure which support train operations above the speed of 250 km/h. Furthermore, the line is again excluded by the latest technical specifications as a HSR listed in the *Policy on Major Technologies of Railway* issued by the former Ministry of Railways in 2013, stating that a HSR is newly-built lines designed for the operation of electric multiple units with a maximum speed of 250km/h or above (including those

Different from expressway, the HSR service plays a relatively less important role in freight services for the firms in Dongguan. First, the high-speed infrastructure and facilities are designed to facilitate the regional flow of people rather than supporting the transportation of materials and industrial products. Second, the inflexibility of the service has limited the competitiveness of railway in freight market. Cargoes can never be directly sent to there for shipment by railway. The time-and-money-consuming transfer of transport modes and possible damage of goods during the process offset any advantage of the service. While cross-boundary freight volume between the Mainland and Hong Kong has increased almost by 30% in ten years, the volume transported by railway has decreased by more than 80%, and the railway's market share shrunk to only 0.06% in 2009 (Legislative Council of HKSAR, 2010).¹¹

However, Guangzhou-Shenzhen Railway still potentially exerts influence on the performance of manufacturing sector from the perspective of management. Face-to-face contacts are important process in non-standardised decision making (Blum, Haynes and Karlsson, 1997). The high-speed passenger service lowers the cost of managerial staff of manufacturing enterprises to travel between Hong Kong and Dongguan, possibly enhancing the management of factories. It is easy for a traveller from Hong Kong to take a high-speed train dispatched from Shenzhen Station (just next to Luohu Checkpoint on the boundary of Hong Kong),

with potential for upgrading), while equipped for speed no less than 200km/h in the initial stage of operation. However, the intercity train service between Guangzhou and Shenzhen with a maximum speed of 200 km/h was categorized by the former Ministry of Railways as the class "G", literally means "high-speed", in the late 1990s.

¹¹ Five container trains were running between the freight hub at Dongguan stations and the Yantian Port in Shenzhen in each direction per day in 2009. It was claimed that the service gained advantages in freight cost, time and punctuality in delivering bulk volume of goods over the expressway, but it is not so significant due to the short distance between the origin and the destination. Future clients' acceptance depends on availability of complementary services, including those in customs clearance assistance (*Yangcheng Evening News*, 2009).

and arrive at the intermediate stations of Dongguan (Shilong), Changping and Zhangmutou in Dongguan City. And hence 50% of the passengers are Hong Kong (and Macao) residents (Li, 2010). Passengers are characterised by high purchasing power and high level of education, which is consistent with the statistics mentioned before about the characteristics of Hong Kong residents required to work in the Mainland. Among the total, about 36% of the passengers make the trip for meetings, civil purpose, business and commuting (Li, 2010).

The impact of high-speed transport may be better reflected by the development of real estate and consumer services in Dongguan. About 21% of its passengers travel for tourism and leisure and 15% for visiting the relatives and friends (Li, 2010). As it takes about 20 minutes to reach Zhangmutou from Shenzhen by high-speed intercity trains, the town is a major beneficiary of the flow. It has long been a popular place for Hong Kong residents to purchase their second properties. Real estate sector continued to boom after the inauguration of HSR service. More than 5,400 commercial flats and 100 villas, amounting to HKD 1.5 billion, have been sold during 1998-2001. Contracts were also signed with foreign enterprises to develop not less than one million m² of land at that time (Li, 2010). The town has gradually grown into the second home for about 150 thousands Hong Kong people to spend vacations (*China Business News*, 2012), and earned the nickname “Little Hong Kong”. Another example is Changping Town. Efficient and reliable HSR increases local attractiveness for Hong Kong residents to purchase properties there in the early 2000s (*People’s Daily*, 2001). It is reported that the inter-city trains brought a lot of Hong Kong people to Changping every Friday, making the business of local taxi drivers exceptionally busy (*Southern Metropolis Daily*, 2011).

3.4. Hypotheses

Anecdotal evidence shows that both HSR and expressways facilitate growth. Therefore, the first hypothesis is that both the HSR service and expressway in Dongguan contribute to economic development. As HSR only facilitates the flow of managerial staff of manufacturing enterprises, and the expressways bear the load of delivering materials and products, the second hypothesis is that the impact of the former on manufacturing sector is not as significant as the latter. And this implies that HSR is more related to the growth of tertiary activities.

4. METHODOLOGY, CONCEPTUAL FRAMEWORK AND DATA

4.1. Estimation Approach

To estimate the impact of the transport infrastructure on the economic performance, we adopt the production function approach, with capital and labour as inputs and infrastructure as one of the determinants of the total factor productivity. This is similar to the studies conducted by Démurger (2001), Fleisher and Chan (1997) and Cantos et. al. (2005). We try to take into account the dynamic adjustment of the economy by including the lagged term of the dependent variable (i.e. economic output), thus forming a dynamic panel model. Such model has already been used to estimate the impact of rural road improvement projects financed by the World Bank (Khandker and Koolwal, 2011).

Specifically, we specify the augmented Cobb-Douglas production function as follows:

$$Y_{it} = \beta_1 Y_{it-1} + \beta_2 K_{it} + \beta_3 L_{it} + \beta_4 Rail_t + \beta_5 Xpress_{it} + \beta_6 \left(\frac{Ex}{GDP} \right)_{it} + \beta_7 Crisis_{2008} + \mu_i + v_{it} \quad (1)$$

where Y stands for output, K is the capital, L is the labour. The above regression is run for the whole economy and the manufacturing sector respectively. In the former case, output is measured by GDP. The labour and capital input are measured by the sum of permanent and migrant population and fixed capital by the stock of the whole town respectively. In the latter case, output is measured by value-added of industrial enterprises above a designated size (IVA). Labour is measured by the average labour employed in those industrial enterprises. Capital input is proxied by the stock of total assets.

In both cases, $Rail_{it}$ refers to the weighted average maximum speed of the high-speed trains on the Guangzhou-Shenzhen Railway, divided by the time distance from the location of the township government to the nearest HSR stations at the t -th observation for the i -th town. The indicator combines the dimension of train speed and intensity of different levels of railway services. Higher operating speed, together with shorter headway between trains, allows higher frequency of departures and thus leads to substantial increase in capacity (Givoni, 2006), while fewer slow trains can reduce a considerable number of time slots occupied and hence free the capacity for much more intense usage of high-speed trains (Campos and Rus, 2009). Thus any increase in weighted maximum speed signifies improvement of high-speed railway services, and the coefficient of the variable is expected to be positive. However, the impact is likely to decrease with transport cost which is traditionally considered as a time distance decay function (Gutiérrez, Condeço-Melhorado and Martín, 2010). The same applies to the expressway

infrastructure, and $Xpress_{it}$ is adopted to represent the time distance from the location of the i -th township government to the nearest entrance of expressway at the t -th observation. Its coefficient is expected to be negative.

The remaining two determinants are included as control variables. Because exports are likely to favour greater capacity utilisation and trigger knowledge spillover (Wei and Liu, 2006), our model includes $\left(\frac{Ex}{GDP}\right)_{it}$ indicating the dependence on exports, measured by the ratio of exports to GDP of the i -th town in year t . The expected sign of coefficient is positive. $CRISIS_{2008}$ is the dummy variable used to capture the shock caused by the global financial crisis in 2008. The expected sign of coefficient is negative. The disturbances of both equations follow a one-way error component model, in which μ_i captures the permanent but unobservable town-specific effect and v_{it} refers to the serially-uncorrelated remainder error.

The model is estimated by the first-difference generalized method of moments (GMM) as proposed by Arellano and Bond (1991). This method is chosen because it can solve a number of econometric issues relevant to this study. The first is the endogeneity issue. Many studies have assumed the single-direction causality from infrastructure to economic growth (among others, Costa et al., 1987; Munnell, 1990). However, as argued by Rietveld (1994), supply of infrastructure is determined by the response of domestic government to changes of regional flows and local economy. Holtz-Eakin (1994) further argues the causality also goes in other direction because economic growth may enhance the government's financial ability to build more infrastructures.¹⁶ The procedures

¹⁶ In China, vigorous economic growth, together with rapid urbanization, are also regarded as a potent force driving the nationwide transport development in recent decades (Mu, 2012). If the

proposed by Arellano and Bond (1991) include the construction of instrumental variables to avoid the reverse causality problem. Second, it can handle the time-invariant heterogeneity of the individual units in a proper way. In our case, heterogeneity of towns may arise from the capability of cadres, geographical factors and policy preferences of upper level of authority.¹⁷ Third, there may be correlation between the lagged dependent variable and the error term. It is solved by this method due to the use of instrumental variables. Fourth, our data set only covers eleven years. Bias remains severe in the context of a typical panel with short time dimension.¹⁸ The GMM method will mitigate the problems arising from the short time span.¹⁹

endogeneity of infrastructure variables is not addressed, the results (such as those obtained from ordinary least square (OLS) estimators) will suffer from bias and inconsistency.

¹⁷ Nickell (1981) shows that the correlation between the lagged dependent variable and the disturbance does not disappear even after the within transformation has been performed. In a circumstance that the disturbance consists of a fixed parameter μ_i and a stochastic error v_{it} where both are independent and identically distributed (i.e., $\mu_i \sim \text{IID}(0, \sigma_u^2)$ and $v_{it} \sim \text{IID}(0, \sigma_v^2)$), he demonstrates that the fixed effects estimator suffers from an inconsistency of $O(1/T)$ which can hardly be ignored. The lagged dependent variable $y_{i,t-1}$ and the average stochastic error \bar{v}_i are correlated with each other by construction because both of them contain the lagged stochastic error $v_{i,t-1}$. For the similar principle, correlation between the stochastic error term and the average of lagged dependent variable $\bar{y}_{i,-1}$ is also aroused from the fact that the latter contains the dependent variable y_{it} which is a function of the stochastic error term v_{it} (Baltagi, 2008, pp.147). Failure of the regressors being distributed independently of the stochastic error term creates bias in the estimate of coefficient of the lagged dependent variable. The introduction of additional regressors does not help to improve the situation, and it may become even worse if certain correlation exists between the lagged dependent variable and those regressors. Yet, it is worth to address that the size of such bias tends to be zero when the number of time periods approaches infinity.

¹⁸ Judson and Owen (1999) conduct Monte Carlo simulations for panel sizes of 20 and 100 and conclude that the estimation by Within transformation can still generate a bias amounting to 20% of the true value of the coefficient of interest even when the length of the time extends to 30 years. The deviation in average will further enlarge with a decrease in the number of time periods regardless of the sample size. Kiviet (1995) argues that fixed effects estimation can actually become a superior method for analysis on balanced panel data in comparison with those belonging to instrumental variable type after removing the approximated bias from the results, but the technique is not applicable given the potential endogeneity of independent variables.

¹⁹ This approach benefits from the flexibility of GMM framework formalized by Hansen (1982) on the knowledge requirement about the model of data generating process, and obtains additional instruments from the immediate data set by making use of the existence of the orthogonality conditions between lagged dependent variables and the disturbances. The first advantage of the method is to provide a way around the trade-off between the lengths of sample and lag encountered when using the estimator developed by Anderson and Hsiao (1981). The latter is

4.2. Data

The data used in this study is a balanced panel of 32 town-level administrative jurisdictions in Dongguan City for the period of 2001 to 2011, thus including 352 observations in the regression. While the first-difference transformation of the Arellano and Bond (1990) GMM estimation procedure takes away the first year observation of all town-level administrative jurisdictions in the panel data, valid instruments for the lagged dependent variables and other endogenous attributes are not available until the third time period. Thus, the data for investigating the relationship between transport infrastructure and economic development starts from 2003. As a result, there are nine periods with a total of 288 observations in the regression analysis.

Basic town-level economic information of Dongguan is available in *Dongguan Statistical Yearbook* while some necessary city-level information is available from *Guangdong Statistical Yearbook*. Based on the raw information, we construct the data for the variables in the regression analysis.

(A) Production function variables for the whole-economy equation

(i) Real GDP. We used GDP in constant price of 2000 as a measure of output in the production function for the whole economy. It is obtained from deflating the nominal GDP of the towns by the GDP deflator of Dongguan.²⁰

proved to be inefficient. Although adopting longer lags as additional instruments is a theoretically practical way to improve efficiency, more information is introduced at the cost of reducing the sample size as observations have to be dropped the absence of the lagged ones (Roodman, 2006). The second advantage lies on the ability to give efficient estimates in case of an unknown form of heteroskedasticity. 2SLS is asymptotically inefficient due to the over identification problem of the model with time periods larger than 3, and the appearance of the first-order moving average form of serial correlation contained in the first-differenced error term (Bond, 2002).

²⁰ Ideally, town-level GDP deflators should be used. However, they are not available.

(ii) Capital stock. The data for capital stock is obtained from investment in fixed assets (deflated to prices at year 2000) using the well-known perpetual inventory method, i.e.

$$Capital = (1 - \delta) Capital_{t-1} + I_t, \quad (2)$$

where *Capital* represents the capital stock at time period *t*, *I_t* refers to the real capital formation and δ denotes the depreciation rate which is supposed to be 5%. Following Keller (2000), assuming both the steady growth rate of capital stock and average growth rate of real capital formation in all preceding time periods before the initial year are r^* , the initial capital stock in year 2001 (i.e. the first year in our data set) can be obtained by the following equation:

$$Capital_{2001} = \frac{I_{2001}}{r^* + \delta} \quad (3)$$

here r^* is substituted with the average annual growth rate of real investment over the period 2001-2011. Capital stock in the following years can be easily obtained by simple calculation.

(iii) Labour. The population figures for each town in this study are “total population” defined as the sum of the population of registered household (*hujie renkou* 戶籍人口) and the migrant population (*wailai zhanzhu renkou* 外來暫住人口) by town.²¹

(B) Production function variables for the manufacturing-sector equation

²¹ Although permanent population (*changzhu renkou* 常住人口) is generally regarded as a relatively precise measure of the size of residents in a city, it is expected to include a much larger proportion of elderly and children who are not economically active and hence should be counted as the participants of the labour force. In addition, the series for each town is not available until 2006. Given the fact that most of the migrant population in the city are peasant workers from inland provinces, “total population” can be a reasonable substitute for the measurement of working residents of which officially published data are not available.

(i) Industrial output. The industrial value-added (IVA) in constant price of 2000 of industrial enterprises above the designated size is constructed by deflating the nominal IVA figures of towns by city's IVA deflators.

(ii) Capital stock. Capital stock of the manufacturing sector of the towns is measured by the total assets of industrial enterprises above the designated size, deflated to prices at year 2000 by the GDP deflator.

(iii) Labour. Labour input of the manufacturing sector of towns is represented by the average annual labour of the industrial enterprises above the designated size. However, the accuracy of the data in year 2004 is highly dubious, as it exhibits a sharp decrease that contradicts with the city-level aggregate statistics. More reliable city-level information can be obtained from *Guangdong Economic Census Yearbook 2004*. Given the average of labour employed in all industrial enterprises above designated size in Dongguan in 2004 is provided, the figures at town level in the same year are then constructed according to their average proportion in city aggregate over the period 2001-2011 excluding 2004.

(C) Transport infrastructure.

(i) High-speed railway. The HSR service of each town is measured by the following equation:

$$\frac{\sum_n S_n \cdot \frac{Dep_n}{TDEP}}{Dist}, n = 1, 2. \quad (4)$$

where S_n is the maximum speed of trains; Dep_n is the number of departures of type- n train service per day, with $n=1$ referring to high-speed inter-city trains and $n=2$ referring to conventional trains; $TDEP$ is the daily total number of departures of intercity trains; $Dist$ is the shortest required time for the journey to the nearest railway stations along Guangzhou-Shenzhen railway served by high-speed trains

from the location of the township government. Information of high-speed train service can be obtained from various issues of *Annual Report* of Guangshen Railway Company. Data of the time to travel between the railway stations and the 32 townships in Dongguan are measured in terms of minutes and extracted with the help of *Google Map*.

(ii) Expressway. Similar to the distance to the nearest railway stations, the data on the accessibility of the Dongguan's 32 townships to the expressway infrastructure are obtained from *Google Map*. It is defined as the minimum travelling time required for a journey to the nearest entrance of expressway from the position where the township government is stationed. The variable is measured in minutes. The longer is the travelling time, the larger is the friction to enjoy the benefits of transport capacity enhancement and cuts in time cost in intra- and inter-city transportation brought the expressways, and hence the lower is the accessibility.

(D) Other control variables.

Dependence on exports is calculated by dividing the value of the exports by the scale of aggregate economy of the towns. The export figures available in various issues of *Dongguan Statistical Yearbook* are reported in US dollars, and they are converted into RMB *yuan* with the use of the annual average exchange rates of RMB *yuan* against US dollars reported in *Guangdong Statistical Yearbook 2012*. The concept of the ratio is obvious: Larger figure implies larger dependence of an economy on foreign markets.

5. EMPIRICAL RESULTS

5.1. Model Specification Tests

A series of tests are carried out to ensure that the use of the first-differenced equations for estimation is appropriate. .

First, following Arelleno and Bond (1991), Wald tests are conducted for ensuring that both production functions are appropriately specified. The test examines the joint significance of all independent variables.²² The test statistics of both general-economy equation and manufacturing-sector equation exceed their corresponding critical value. The results show that the specifications of both production functions with the determinants as in equation (1) are considered to be appropriate.

Second, the Arelleno-Bond serial correlation tests are conducted to confirm the validity of the instrumental variables adopted in both models of this study. The results of general-economy equation indicate that the model has a correct specification. The m-statistics of the first-order serial correlation test gives a significant negative figure of which the value is -3.15 and the corresponding p-value is 0.0016, and thus the null hypothesis that the first-order serial correlation of the error terms in the model is rejected. Meanwhile, the m-statistics of the second-order serial correlation test is -1.49, implying a p-value of 0.1371. The

²² The coefficients with the use of restricted and unrestricted regressions, with statistic asymptotically distributed as χ_k^2 where k represents the number of coefficients estimated. The null hypothesis enforces the restriction and assumes that the latter does not provide a significant better fit to the data than the former. Thus, the null hypothesis actually specifies that the effects of all the independent variables are not. The statistics for the test is constructed based on the idea of comparing the sizes of the weighted sum of squared residuals. If the restriction is true, it is logical to expect that the restriction will cost only a little in terms of the weighted sum of squared residuals, and thus leading to a low value of the Wald test statistics to accept the null hypothesis.

null hypothesis on the absence of the second-order serial correlation of the error terms in the model cannot be rejected. Similar results are obtained for the manufacturing-sector equation. The m-statistics of the first-order serial correlation test gives a significantly negative value of -2.99 and the corresponding p-value is 0.0028, statistically demonstrating the presence of first-order serial correlation of the error terms in the model. At the same time, the m-statistics of the second-order serial correlation test is 0.57 with a p-value of 0.5684, showing that the second-order serial correlation of the disturbances in the model is not significantly different from zero. All these evidence support that disturbances of both equations are serially uncorrelated in levels, guaranteeing the consistency of the estimators.

Table 5-1: Estimation of Production Functions and Model Specification Tests

Variable	GDP	Variable	IVA
<i>Production Function</i>		<i>Production Function</i>	
GDP(-1)	0.93*** (44.3662)	IVA(-1)	0.19*** (27.2880)
K	0.05*** (4.4572)	K	0.18*** (31.0178)
L	0.14*** (12.0473)	L	0.68*** (8.9051)
Rail	32135.63*** (6.9177)	Rail	-3192.42 (0.6813)
Xpress	-748.74*** (2.9921)	Xpress	-1250.34*** (2.4109)
(Ex/GDP)	-17058.35*** (5.4239)	(EX/GDP)	-9803.74** (2.1195)
CRISIS ₂₀₀₈	-28178.64*** (9.5371)	CRISIS ₂₀₀₈	-38561.69*** (23.6896)
<i>Specification</i>		<i>Specification</i>	
Wald	304353.7*** [0.0000]	Wald	67119.44*** [0.0000]
m_1	-3.15*** [0.0016]	m_1	-2.9930*** [0.0028]
m_2	-1.49 [0.1371]	m_2	0.5704 [0.5684]
Sargan	26.89784 [0.3610]	Sargan	28.02566 [0.3067]

Note: Absolute values of t-statistics are in (), while p-values are in [].

* Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level.

Third, Sargan tests are conducted to verify the validity of overidentifying restrictions in both models of this study. Results show that the instruments employed in both of the estimated first-differenced equations are independent from the error process as stated in the moment equations. In the general-economy equation, the Sargan test gives a statistic approximately equal to 26.89 and the computed p-value is 0.3610, and obviously the null hypothesis of the joint validity of the overidentifying moments cannot be rejected. In the manufacturing-sector equation, the Sargan test statistic obtained is approximately equal to 28.02 with a corresponding p-value of 0.3067. Again the null hypothesis cannot be rejected. All the evidence confirms that the instrument variables in both models are correctly specified and exhibit true exogeneity.

5.2. The Economic Impact of High-speed Railway and Expressway Infrastructure

The empirical result of this study favours the common view on the contribution of the provision of HSR services to general economy development. GMM coefficient estimate suggests a positive relationship between the HSR and GDP. As the estimation has already controlled for any causation flowing from local economic development to the provision of transport infrastructure, it is reasonable to conclude that replacing the conventional trains with more frequent and speeded-up ones since the late 1990s leads to better local economic performance in Dongguan. However, such effect is likely to be offset by the distance from the townships to the nearest railway stations. In the case of Shijie and Shilong towns, it takes 8 minutes and 9 minutes respectively for a traveller to go to the closest railway station in 2010. According to the estimation, such one-

minute difference can bring Shilong town a loss of real GDP amounting to about RMB 892.7 million *yuan* per year (i.e. about 17.6% of GDP of Shilong at that year), given the maximum speed of all trains on the line is 200km/h. The variation of accessibility to the railway service of the townships of Humen and Shatin, which is 47 and 52 minutes away from the nearest station respectively, will only lead to a gap of RMB 131.5 million *yuan* in real GDP level (i.e. about 2.1% of GDP of Shatin at that year).

The manufacturing-sector equation reveals a striking discovery about the unimportance of HSR infrastructure in local industrial development. The GMM analysis gives a negative coefficient for the related variable, but the corresponding t-statistics (-0.68) is obviously far less than the critical values, suggesting that the relationship between HSR and IVA is insignificant. This implies that the provision of HSR service on Guangzhou-Shenzhen Railway and its continuous enhancement in terms of speed as well as frequency has negligible effect on stimulating local industrial output. It appears that the benefits of improvement on management brought by easier movement of managerial staff were not important.²³

Recalling the basic fact that both secondary and tertiary industries constitute half of Dongguan's economy separately while agricultural activities occupy only a trivial share of the city's total value-added, a logical inference from the positive impact of the HSR services of Guangzhou-Shenzhen Railway on local general economy and its insignificant role on the manufacturing sector in Dongguan is that the improvement and HSR service is very likely to have

²³ As a matter of fact, the transport costs was reportedly almost 40% of the total operating cost of the manufacturing enterprises in Dongguan in the mid-1990s (*Dongguan Daily*, 2011). Thus it is possible that the expressway is more important to the development of the manufacturing sector in Dongguan.

significant effect on promoting the growth of tertiary activities. This is in line with the common intuition that the sustaining enhancement of service quality of Guangzhou-Shenzhen Railway continues to bring in more purchasing power to Dongguan and hence stimulates the demand for services.

Results show that township's industrial development and economy as a whole are benefited from the regional connection offered by expressway infrastructure. The coefficient estimates for the determinant of accessibility to expressway entrance give significant negative figures in the estimation of equations for both general economy and manufacturing sector. The negative implies that the existence of expressway infrastructure can boost the growth of economic activities and manufacturing output in the townships, but such effects are decaying with the increase of friction of accessing the infrastructure.

5.3. Decreasing Dependence on Exports and Economic Restructuring

Evidence found by this study demonstrates that decrease of the dependence on exports is related to higher quality of township development. In the estimated first-differenced equation for general economy, the relationship between the ratio of exports to GDP and economic development is found to be significantly negative. Similar result is obtained in the estimation of manufacturing-sector equation. The coefficient for this variable is also negative and significant. It is apparently contradictory to the general consensus about the positive economic effects of exports at the first glance. However, the negative relationship between the dependence on tangible exports and output should be interpreted as a finding specific to the period of time under study. Dongguan has

always been one of the most open cities in China in terms of participation in global production network. The exceptionally huge volume of exports is actually a product of the city's development into an enclave for international processing and assembling activities. Unfortunately, during this period of time, the gradual appreciation of Reminbi has led to a rise of production costs. Higher export share may mean a bigger problem in recent years (Feng, 2009).

Consistent with previous expectation, the results of this study proves that global financial crisis in 2008 is a strike to the development of both townships' general economy and its manufacturing sector. In the general-economy equation, the negative coefficient of the dummy variable is significant.. In the manufacturing-sector equation, the coefficient of the dummy variable is even more significant. These results are logical given the high degree of openness of Dongguan. The local economy and industrial development cannot escape from the negative impacts brought by the shock of overseas demand.

6. CONCLUDING REMARKS

This paper investigates the economic impact of the HSR services, together with those of expressway infrastructure in the case of Dongguan. Previous studies have tried hard to attribute the regional development to the presence of HSR infrastructure, or to reject its possible positive contribution on regional economy. Unfortunately, they have relied on fragmented evidence. This study adopts a rigorous quantitative method to evaluate comprehensively the economic effects of transport infrastructure. By using town-level data that generates sufficient variations and controlling potential endogeneity, this study finds that both HSR and expressway has positive impact on the development of local economy.

However, this study also finds that the impacts of different modes of transport on specific sectors may vary. Empirical result of this study shows that the availability of high-speed passenger services is not important in the development of manufacturing enterprises. It is likely due to the fact that the agglomeration of low value-added and highly outward orientated assembling and processing activities in the towns of Dongguan depends heavily on the road transport for efficient inflow of materials and international market access.

This town-level case study provides valuable hints for the formulation of regional development policies. Many local governments in China are simply competing for the direct access of all kinds of transport infrastructure network without considering their differential impacts. For those major cities which are experiencing economic transition from a manufacturing base to the hub of service and innovation, constructing HSR is probably a more appropriate choice for fostering local economic development as it facilitates efficient flow of people. Face-to-face communication is a vital element for promoting knowledge generation and service production. For those second- or third-tier cities which industrial enterprises agglomerate, more effort should be put on the planning of a comprehensive expressway network which is effective for lowering the cost of delivering raw materials and products.

The empirical results also provide important guidance for the future planning of the development of station areas in China, where a large number of stations are waiting for proper planning and development as a consequence of a large scale construction of HSRs and intercity railways. Empirical result shows that proximity to transport infrastructure is crucial for economic development. However, the benefits brought by HSR are decreasing with the increasing

transport cost for travellers to access the stations. The development of efficient and reliable transport linkage to HSR stations is important for attracting economic activities. In addition, this empirical study find that the positive influences of HSR is limited to the immediate surroundings and neighbouring places, while the divergence of welfare led by difference in access to the high-speed train service for those places very far away from railway stations is relatively not significant. This highlights the importance of transport planning adaptive to compact development around the railway stations. Taking the indirect evidence on the positive effects of HSR on tertiary development into account, the implications of the result in this study are in line with the idea of Bertolini and Spit (1998), who focus on the potential of developing station areas into an attractive place with a dense, mixed land use as means to strengthen urban competitiveness. It should be noted that industrial development should not be given priority on the land at the station neighbourhood since manufacturing firms can hardly benefit from proximity to the stations and the flow of materials and industrial products does not create additional use to support services.

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Essay Two

The Impact of High-speed Railway on Manufacturing Efficiency: a Stochastic Frontier Approach

1. INTRODUCTION

China formulated an ambitious plan of building a HSR network in 2004 as an essential part of her strategy to achieve the national goals of sustainable mobility, regional balance, and energy security. China's HSR network, the largest in the world, will be in full operation by 2020. It consists of two major elements: the nationwide construction of high-speed dedicated passenger lines (DPL) and the extensive upgrading of the conventional lines (Takagi, 2011; Okada, 2007).

The contribution of transportation infrastructure to economic growth has long been recognised in the economics literature. However, as reviewed in Essay One of this thesis, studies of the economic impact of HSR have suffered from various shortcomings. To fill the void of the literature, this essay focuses on a specific impact of transport infrastructure on the economy, namely, the productive efficiency (also called technically efficiency). Productive efficiency is measured by the ratio of the actual output to the maximum possible level for a given amount of inputs.

We adopt the stochastic frontier approach proposed by Battese and Coelli (1995) to find out the impact of a HSR line on the efficiency of manufacturing sector using a unique data set of Dongguan, a famous city in South China. Transport infrastructure can improve technical efficiency in several ways. First, as

described in detailed in Section 2, the “back factories” of Dongguan’s manufacturing factors are managed by “front shops” in Hong Kong. Better infrastructure would allow managers and staff from the latter to go to the former at a lower cost. Second, many factories have to import a huge amount of inputs and export all the finished products, better infrastructure would allow them to have better logistic management and building up a more efficient supply chain of inputs. They can thus have a reduction of inventory of inputs and avoid the associated losses. As a result, productive efficiency will improve.

Dongguan City is chosen for several reasons. First, the city is located in the middle of the Guangzhou-Shenzhen Railway, which was a pioneer of China’s experiment in upgrading conventional lines. Since 1998, the trains on this line have been operating at a maximum speed of 200 km/hour, making it qualified to be HSR by European standard. China’s DPLs have been introduced after 2008, rendering meaningful evaluation of their impact difficult. Second, as a major export processing centre with huge amount of imports and exports, development of transport infrastructure is vital to its success. The impact of transport facilities can easily be distinguished. Third, the data set covers 32 towns in Dongguan throughout the period of 2001-2011, thus providing sufficient variations across locations and over time for an econometric study to discern various effects. It also contains other variables that allow us to separate the impacts of other factors, such as the distance of a town from the entrance of expressway and the degree of outward-orientation, thus making our findings about HSR more reliable. Lastly, the advantage of using town-level data is obvious. We can identify the distance of a town from a specific infrastructure (an expressway or HSR line) and thus can measure the decaying impact of infrastructure on towns further away from the

stations. This cannot be done using more aggregate data (such as data of provinces and countries). Firm-level data can be even better in this regard, but the cost of data collection is often too high.

The remainder of the paper is organized as follows. Section 2 is a review of the literature on the relationship between transport infrastructure and productivity and technical efficiency. Section 3 delineates the conceptual and methodological framework for rigorous quantitative analysis of the impacts of HSR services and expressways on industrial efficiencies among the towns in the Dongguan, and then describes the data set. Empirical findings are reported and discussed in section 4. The last section concludes with policy recommendations.

2. LITERATURE REVIEW

Better infrastructure implies lower transport cost, and the contribution of transport infrastructure in production process has long been recognized by an abundant of economic literature. Transport infrastructure is conceptualised as an input in production (see, among others, Munnell (1990) and Aschauer (1989)) or an important factor stimulating economic growth (see, among others, Demurger (2001) and Fan and Zhang (2004)). Empirical evidence supports the view that public infrastructure appears to be complementary to private capital and plays a significant role in lowering private production costs, thus leading to productivity growth (Lynde and Richmond, 1992). Fleisher and Chen (2004) have found seemingly different evidence for the case of China. However, the reliability of their results is dubious. They use aggregate length of different modes of transportation route, resulting in a crude approximation of transport infrastructure and thus little power in explaining regional productivity gap.

As infrastructure is vital to the flow of materials and goods, its impact on industrial enterprises can be easily distinguished. Most previous studies focus on the role of infrastructure in determining the productivity of manufacturing sector. A popular approach is the estimation of the cost function of an economic sector. For instance, the study of Morrison and Schwartz (1996) indicates that infrastructure has a significant cost saving effect on aggregate manufacturing sector. Similar approach is also widely applied to more disaggregated industrial sectors. Evidence shows that most industries are directly benefited from the existence of public infrastructure (Paul, Sahni, and Biswal, 2004). Moreno, Lo ´pez-Bazo, and Art´ıs (2002) further demonstrate that infrastructure, rather than just exerting effects on variable inputs, can have long-run influence on manufacturing productivity through altering the allocation of both private and public capital. They also conduct regional analysis, but have ignored the important issue of spatial spillover, which is the major contribution of Cohen and Paul (2004). The latter find that the cost-saving effect on manufacturing firms of intra-regional infrastructure is increasing over time and can be enhanced by those in neighbouring regions. Yet, in identifying the productivity effect, all these studies only consider the existence of infrastructure, but not the distance of a regional economy from the infrastructure.

Conceptually, productivity growth can be a result of an advancement of production technology (technical change) and/or an improvement of technical efficiency (efficiency change). The major contribution of transport infrastructure should fall in the former as it is likely to facilitate more efficient utilization of resources in the production process rather than triggering technology innovation. Different from the studies mentioned above, Sharma and Sehgal (2010) adopt

production frontier approach for assessment and prove that the infrastructure endowment has significant effect on technical efficiency level of industries.

Munnell (1992) points out that a well-constructed highway reduces both the time required to deliver goods to the market and the wear and the tear of trucks, and hence manufacturers can pay less on producing a particular amount of outputs. The argument is consistent to the estimation of Keeler and Ying (1988) which show that the cost savings of trucking brought by the federal-aid highway system in the United States is at least one-third of total construction cost. Thanks to faster and more reliable transportation as a consequence of highway spending as well as deregulation, while the uncertainty of order being received and lost sales associated to the risk of stock-out is reduced, firms can further substitute transportation for inventory holdings by placing smaller and more frequent orders to minimize expenditure. Lower inventory level implies that the huge capital cost of storing inventory and any loss due to perishing will then decrease (Shirley and Winston, 2004). According to our best knowledge, however, similar impact of HSR on the technical efficiency of manufacturing firms has never been examined.

Although Munnell (1992) asserts that the story of other transport infrastructure is closely akin to that of highways, the unique technical characteristics of HSR infrastructure make a separate assessment on its impact on manufacturing efficiency necessary. The high-speed train sets running on HSR are designed for facilitating efficient flow of passengers and have relatively little relationship on transporting materials and products. Even if HSR has any favourable effect on reducing inputs for manufacturing enterprise produce a particular level of outputs, most possibly it comes from the increase the effectiveness of decision-making by facilitating on more frequent face-to-face

communications (Blum, Haynes and Karlsson, 1997). With the presence of frequent and efficient HSR service, the managerial staff in Hong Kong can now make a day-return trip conveniently to the factories at Dongguan to streamline the production process in person whenever necessary, even though expressway has long been known to play a substantial role in this aspect.

Based on the fact that transport costs was reportedly almost 40% of the total operating cost of the manufacturing enterprises in Dongguan in the mid-1990s (*Dongguan Daily*, 2011), we formulate the hypothesis that the expressway plays a more significant role than HSR on improving efficiency of low-value-added, export-oriented manufacturing industry in Dongguan. In the following section, we will employ a unique town-level data set to test whether the proximity to HSR and expressways in Dongguan contributes to improvement in efficiency of the manufacturing industry in the city or not.

3. INFRASTRUCTURE AND INDUSTRIAL EFFICIENCY: METHODOLOGY

3.1. Methodology

The focus of this essay is how transport infrastructure affects the productivity efficiency of Dongguan's industry. In order to distinguish the efficiency impacts of HSR on local industry in Dongguan City from the other transport infrastructure, this study includes two different variables of transport infrastructure, the high-speed Guangzhou-Shenzhen Railway and the expressways in Dongguan, in the function of productive efficiency (or inefficiency). Given the relatively small geographical scale of the 32 towns scattering in the city, it is interesting and meaningful to find out the spatial dimension of the impacts. Different from the previous studies, this paper adopts the shortest time from the

towns (represented by the location of township government) to the nearest HSR stations and to the nearest entrances of the expressways, instead of absolute length of infrastructure and transport route density, as the determinants of the industrial efficiency. If a transport infrastructure generates significant positive impacts, it is expected that such impacts will be offset by the rise in generalized transport cost as the time distance between the firms and the infrastructure increases.

The investigation is conducted through estimating the production frontier of the industry sector in the 32 town-level administrative divisions in the city. The technical efficiency of the industry sector of a town can be measured by the distance between the actual production level and the corresponding reference point on the production frontier. Shorter distance implies more effective utilization of inputs and hence higher efficiency. The determinants of the predicted technical efficiency can then be explored.

This study adopts the stochastic frontier approach proposed by Battese and Coelli (1995). One major advantage of this method is that it simultaneously estimates the parameters of the stochastic frontier and the inefficiency model. Secondly, being an extension of the inefficiency model for cross-sectional data, this method can deal with the (unbalanced) panel data. Last but not least, the change of technical efficiency over time for each town can be obtained from this approach and test can be conducted explicitly to find out whether the trend is increasing or declining. Cost function approach is theoretically feasible, as conducted by those studies mentioned in the section of literature review. Yet, it is not suitable for this study due to the lack of relevant data.

The model of Battese and Coelli (1995) takes the form

$$\ln(Y_{it}) = f(x_{it}, t, \beta) + (V_{it} - U_{it}) \quad i=1, \dots, N, t=1, \dots, T, \quad (1)$$

where Y_{it} represents the output, x_{it} are the logarithms of the input quantities, t is the time trend and β are the unknown coefficients to be estimated. V_{it} and U_{it} together form the error component of the model. V_{it} are random error terms that are assumed to be i.i.d. $N(0, \sigma_v^2)$ and their distribution are independent from U_{it} . U_{it} are non-negative random variables with the assumed function of accounting the technical inefficiency. They are assumed to be independently distributed as truncations at zero of the $N(m_{it}, \sigma_u^2)$ distribution. The mean, m_{it} , is equal to $z_{it} \delta$, where z_{it} is a $k \times 1$ vector of explanatory variables influencing the technical inefficiency of the industry in a town, and δ is a $k \times 1$ vector of corresponding parameters to be estimated. Here, the z_{it} includes $DXPRESS_{it}$, $DRAIL_{it}$, $SIZE_{it}$, $DENSITY_{it}$ and FDI_{it} . $DXPRESS$ is the time distance from the location of the i -th township government to the nearest entrance of expressway at the t -th observation; $DRAIL_{it}$ is the time distance from the location of the township government to the nearest HSR stations on the Guangzhou-Shenzhen Railway at the t -th observation for the i -th town; $SIZE_{it}$ is the real average gross industrial output value of the firms in the i -th town at the t -th time period; $DENSITY_{it}$ is the real average industrial density measured by industrial value-added per km^2 of land area in the i -th town at the t -th time period and FDI_{it} is the ratio of actually utilized foreign direct investment (FDI) to the industrial total assets of the i -th town in year t .

The method of maximum likelihood is adopted for simultaneous estimation of the frontier and the inefficiency model and the related likelihood function is presented in Battese and Coelli (1993). The function is expressed in terms of variance parameters, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$, to replace the σ_v^2 and σ_u^2 through utilization of the parameterisation of Battese and Corra

(1977). The estimation is implemented with the use of the computer programme Frontier 4.1 (See Coelli, 1996).

Under the above estimation framework, the technical efficiency TE_{it} of the i -th town at time t is defined as the ratio of the observed output level to the maximum output indicated by the corresponding estimated production frontier, that is:

$$TE_{it} = Y_{it} / \exp(x_{it} \beta) = \exp(-U_{it}) \quad (2)$$

3.2. Data

The data from the year of 1999 to 2009 of the 32 town-level administrative divisions are used in this study. Unfortunately, the data of 2004 have to be discarded because the quantity of labour in all towns in that year shown in the statistical yearbook is not reliable. Specifically, the sharp decrease in the scale of employees in all towns contradicts to the increase in labour shown in the city-level aggregate statistics. As a result, only 10 years of data are employed in the following empirical analysis.

The output of the production function is measured by the industrial value-added in constant price of 2000. To obtain the real value, the nominal values available in the published source have to be deflated, using a deflator obtained from nominal industrial value added and the corresponding real indices for Dongguan City.

The labour input is measured in the average number of employees during the year in the towns. The real value of total assets is used as a measure of the capital input. The nominal values available in the published source are deflated by the city-level GDP deflators.

The data for output, inputs and the GDP indices for deflating the assets for all the towns are available in various issues of *Dongguan Statistical Yearbook*, while the provincial indices for gross industrial output value and the city indices of industrial value-added for deflating the output can be found in various issues of *Guangdong Statistical Yearbook*. The distances to the transport infrastructure are obtained from Google Map, and the values of the remaining determinants are all acquired from various issues of *Dongguan Statistical Yearbook*. As mentioned above, the data in 2004 are excluded in this analysis due to data quality problem. Consequently, there is a total of 320 observation points in the data set.

4. EMPIRICAL RESULTS

4.1. Estimation of Production Frontier and Model Specification Tests

A specific production function is needed for implementing the estimation of the production frontier. This study starts with a translog production function with a general form of technical progress. Specifically,

$$\begin{aligned} \ln Y_{it} = & \beta_0 + \beta_T t + \beta_K \ln K + \beta_L \ln L + \beta_{LK} (\ln K) (\ln L) + \beta_{KT} t \ln K \\ & + \beta_{LT} t \ln L + (1/2) \beta_{TT} t^2 + (1/2) \beta_{KK} (\ln K)^2 + (1/2) \beta_{LL} (\ln L)^2 \\ & + V_{it} - U_{it} \end{aligned}$$

$$\begin{aligned} \text{where } U_{it} = & \delta_0 + \delta_1 t + \delta_2 (\text{DRAIL}_{it}) + \delta_3 (\text{DRAIL}_{it})^2 + \delta_4 (\text{DXPRESS}_{it}) \\ & + \delta_5 (\text{DXPRESS}_{it})^2 + \delta_6 (\text{SIZE}_{it}) + \delta_7 (\text{DENSITY}_{it}) + \delta_8 (\text{FDI}_{it}) \quad (3) \end{aligned}$$

In this inefficiency model of U_{it} , the time trend t is included to capture the systematic change of inefficiency level over time, which might be caused by the evolution of operation and management of the industrial firms for instance. Not only the distances between the towns and the two types of infrastructures are

Table 4-1: Estimation of the Stochastic Production Frontier

Variable		Model (1)	Model (2)	Model (3)
<i>Stochastic frontier</i>				
Constant	β_0	14.735 (1.483)	5.064*** (4.753)	4.306*** (6.858)
t	β_T	-0.169 (-0.629)	-0.251* (-1.785)	-0.137*** (-4.910)
ln(K)	β_K	-0.785 (-0.672)	0.614*** (9.386)	0.664*** (20.811)
ln(L)	β_L	1.418* (1.872)	0.358*** (5.866)	0.327*** (12.366)
(ln K)*(ln L)	β_{KL}	0.044 (0.859)		
ln(K)*t	β_{KT}	-0.006 (-0.425)	0.007 (0.867)	
ln(L)*t	β_{LT}	0.016 (1.318)	-0.005 (-0.616)	
t ²	β_{TT}	0.001 (0.237)		
ln(K) ²	β_{KK}	0.047 (0.691)		
ln(L) ²	β_{LL}	-0.210*** (-2.583)		
<i>Inefficiency Model</i>				
Constant	δ_0	1.87362*** (5.715)	1.88405*** (6.115)	1.89269*** (6.058)
t	δ_1	-0.14906*** (4.365)	-0.15193 (5.278)	-0.14884*** (5.143)
(DRAIL _{it})	δ_2	0.00281 (0.689)	0.00374 (0.911)	0.00312 (0.776)
(DRAIL _{it}) ²	δ_3	-0.00006 (0.933)	-0.00006 (0.915)	-0.00005 (0.783)
(DXPRESS _{it})	δ_4	0.01008*** (3.449)	0.00947*** (3.269)	0.00922*** (3.009)
(DXPRESS _{it}) ²	δ_5	-0.00009** (2.099)	-0.00008* (1.938)	-0.00008* (1.820)
(SIZE _{it})	δ_6	-0.00003*** (5.419)	-0.00003*** (5.594)	-0.00003*** (5.773)
(DENSITY _{it})	δ_7	-0.00003*** (2.497)	-0.00003*** (2.350)	-0.00003*** (2.620)
(FDI _{it})	δ_8	-0.00110 (0.708)	-0.00135 (0.941)	-0.00136 (0.979)
<i>Variance parameters</i>				
σ^2		0.042*** (10.744)	0.042*** (10.777)	0.042*** (10.776)
γ		0.691*** (4.565)	0.651*** (3.533)	0.675*** (4.008)
<i>Log-likelihood Function</i>		83.492	78.964	78.557

Note: Absolute values of t-statistics are in parentheses.

* Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level.

adopted to show the relative importance of the proximity to the infrastructure, square terms are also included to capture any non-linear relationship between the industrial efficiency and the proximity of infrastructure, since the benefits for industrial firms brought by the infrastructure are likely to be marginal outside the catchment area.

As shown in the table, the t-statistics show that a considerable number of the terms in Model (1) are not significant. So the log-likelihood (LR) tests are adopted to examine whether a parsimonious specification is more appropriate. Cobb-Douglas production function as represented by Model (2) is tested against Model (1). The result of the LR test indicates that the null hypothesis $\beta_{LK} = \beta_{KK} = \beta_{LL} = \beta_{TT} = 0$ is not rejected at the level of significance at 5%, suggesting that Model (2) is a better specification than Model (1). Further tests are conducted to check the validity of more reduced form. Model (1) is then reduced into Model (3), in which a unique time trend to reflect the technical changes. The result shows that the hypothesis $\beta_{LK} = \beta_{KK} = \beta_{LL} = \beta_{TT} = \beta_{LT} = \beta_{KT} = 0$ holds. A further test of Model (3) against Model (2) confirms that Model (3) is the most appropriate specification.

Hypothesis testing is also conducted for ensuring that both the stochastic production frontier and the inefficiency determinants are appropriately specified, by applying the procedures clearly explained in Coelli, Rao and Battese (1998). The first null hypothesis ($\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = 0$) specifies that inefficiency effects are totally absent from the model. The second one is that the inefficiency effects are not stochastic (i.e. $\gamma = 0$). The third one is that all the determinants of inefficiency effect are not significant (i.e. $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = 0$). The results show that all the three hypotheses are

Table 4-2: Summary of Hypothesis Testing

	Test Statistics	Critical Values (5%)	Decision
<i>Testing the form of production function</i>			
(a) Model (2) against Model (1) ($H_0: \beta_{LK} = \beta_{KK} = \beta_{LL} = \beta_{TT} = 0$)	9.06	9.49	Cannot reject H_0
(b) Model (3) against Model (1) ($H_0: \beta_{LK} = \beta_{KK} = \beta_{LL} = \beta_{TT} = \beta_{LT} = \beta_{KT} = 0$)	9.87	12.59	Cannot reject H_0
(c) Model (3) against Model (2) ($H_0: \beta_{LT} = \beta_{KT} = 0$)	0.81	5.59	Cannot reject H_0
<i>Testing the form of production function</i>			
(d) No inefficiency ($H_0: \gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = 0$)	140.97	14.85	Reject H_0
(e) Non-stochastic inefficiency ($H_0: \gamma = 0$)	54.19	2.71	Reject H_0
(f) No inefficiency effects ($H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = 0$)	89.27	15.50	Reject H_0

Note:

- (1) Critical values are χ^2 statistics or, when $\gamma = 0$ is involved, the mixed χ^2 statistics that are available from Kodde and Palm (1986).
- (2) In the test of (d), δ_0 and δ_1 are not identified and thus the degree of freedom is 2.

rejected, at 5% level of significance. In short, the specification of stochastic production function with the determinants of the inefficiency as in Model (3) is considered to be appropriate.

Regarding the variables of the production function, t has a negative sign and indicates a general technical regress for the industrial sectors in Dongguan City. In other words, with the amount of inputs unchanged, the value-added created by the industrial firms are decreasing over time. Technical regress is not

uncommon in the existing literature.²⁵ The result here is not really surprising when considering the difficult condition faced by the low-value added, export-oriented industrial activities in the city, especially after the mid of the first decade in the new millennium. Without any effective technological upgrading and amelioration of production process, it is widely known that most of the low-value-added manufacturing firms in Dongguan do not have enough capabilities to adapt to the changing demand in the international market. Their ability to create value is also seriously weakened by the rapid rise of wages in the Mainland and the gradual appreciation of Renminbi.

4.2. Technical Efficiency and the Impact of Infrastructure

The performance of the industry scattered among the towns in Dongguan in terms of productive efficiency is, however, inspiring. The average productive efficiency score is very low, only 0.164 in 1999, but it gradually increases and reaches the peak of 0.876 in 2009. The index for the change in overall productive efficiency keeps higher than one during the period under study, meaning that the efficiency improvement over the previous year is not a contingency but a quite

²⁵ Technical regress exists in an abundance of literature. By adopting non-parametric linear programming methods, Kumar (2006) observes technical regress of manufacturing sectors in some states in India in both pre-reform and post-reform periods. It is followed by Bhandan et. al. (2010), which studies the effects of economic reforms on manufacturing sector in India by categories of industries. They demonstrate that some industry groups have experienced technical regress. The analysis of Haouas, Yagoubi and Heshmati (2003) based on labour requirement approach shows that there is technical regress in particular industry in Tunisia. Among the studies using stochastic frontier model, Bos et. al. (2010) give explanation on technical regress including economic mismanagement, migration from less developed countries and disasters. Limam and Miller (2004) find that technical regress exists in selected countries of Africa, Latin America and the West. Piesse and Thirtle (2000) also show that the manufacturing sector has experienced technical regress in the late 1980s and early 1990s, outweighing any efficiency gains. Technical regress does not necessarily mean that the firms are becoming more “foolish” over time. They argue that this can be a result of increasing difficulties of the communist system and the disruption caused by the beginning of the transition. Following similar rationales, we argue that the knowledge and skills adopted by the manufacturing firms in Dongguan have not been sufficient to adapt to the changes of international demand and changing input structure since the mid-2000s.

Table 4-3: Productive Efficiency Scores of Towns in Dongguan City

Township	1999	2000	2001	2002	2003	2005	2006	2007	2008	2009	Rank of 2009
1 Guancheng	0.176	0.204	0.266	0.255	0.304	0.486	0.512	0.899	0.788	0.953	6
2 Shilong	0.240	0.313	0.357	0.426	0.835	0.969	0.957	0.722	0.880	0.956	4
3 Humen	0.173	0.249	0.274	0.268	0.361	0.506	0.695	0.872	0.890	0.956	5
4 Dongcheng	0.195	0.238	0.268	0.288	0.355	0.614	0.759	0.885	0.860	0.920	11
5 Wanjiang	0.147	0.187	0.216	0.234	0.365	0.445	0.621	0.652	0.835	0.830	25
6 Nancheng	0.167	0.189	0.248	0.260	0.369	0.700	0.811	0.960	0.942	0.974	2
7 Zhongtang	0.159	0.168	0.230	0.232	0.346	0.607	0.740	0.895	0.906	0.878	18
8 Wangniudun	0.176	0.203	0.259	0.217	0.221	0.407	0.589	0.610	0.781	0.907	15
9 Machong	0.226	0.288	0.405	0.417	0.585	0.892	0.949	0.969	0.980	0.981	1
10 Shijie	0.143	0.205	0.316	0.329	0.443	0.805	0.949	0.921	0.934	0.956	3
11 Gaobu	0.175	0.161	0.190	0.254	0.332	0.569	0.445	0.915	0.836	0.943	8
12 Daogao	0.147	0.194	0.297	0.298	0.330	0.463	0.639	0.747	0.789	0.897	17
13 Hungmei	0.154	0.119	0.264	0.296	0.353	0.450	0.483	0.596	0.776	0.902	16
14 Shatian	0.179	0.224	0.299	0.302	0.318	0.673	0.736	0.753	0.829	0.939	9
15 Houjie	0.173	0.229	0.295	0.281	0.383	0.554	0.686	0.774	0.873	0.925	10
16 Changan	0.218	0.223	0.299	0.339	0.514	0.694	0.772	0.895	0.781	0.916	13
17 Liaobu	0.207	0.231	0.550	0.580	0.711	0.674	0.797	0.804	0.924	0.947	7
18 Dalingshan	0.145	0.206	0.281	0.316	0.371	0.385	0.627	0.760	0.693	0.815	27
19 Dalang	0.150	0.181	0.229	0.237	0.419	0.526	0.672	0.832	0.815	0.871	21
20 Huangjiang	0.167	0.197	0.193	0.279	0.330	0.486	0.607	0.792	0.710	0.910	14
21 Zhangmutou	0.148	0.206	0.242	0.264	0.290	0.415	0.509	0.810	0.723	0.844	22
22 Qingxi	0.170	0.206	0.295	0.331	0.527	0.639	0.748	0.740	0.810	0.917	12
23 Tangxia	0.156	0.197	0.255	0.260	0.384	0.623	0.740	0.820	0.783	0.875	20
24 Fenggang	0.140	0.140	0.181	0.235	0.258	0.391	0.497	0.678	0.604	0.739	30
25 Xiegang	0.147	0.181	0.267	0.244	0.305	0.443	0.408	0.607	0.578	0.740	29
26 Changping	0.153	0.208	0.249	0.273	0.301	0.453	0.605	0.689	0.657	0.877	19
27 Qiaotou	0.134	0.150	0.192	0.197	0.220	0.374	0.481	0.570	0.563	0.703	31
28 Hengli	0.170	0.186	0.253	0.232	0.302	0.387	0.470	0.698	0.653	0.838	24
29 Dongkang	0.139	0.201	0.295	0.229	0.312	0.471	0.559	0.680	0.625	0.822	26
30 Qishi	0.141	0.192	0.220	0.244	0.278	0.458	0.585	0.519	0.623	0.687	32
31 Shipai	0.126	0.233	0.221	0.255	0.300	0.404	0.526	0.658	0.669	0.773	28
32 Chashan	0.117	0.229	0.257	0.281	0.314	0.415	0.633	0.716	0.785	0.838	23
Mean	0.164	0.204	0.271	0.286	0.376	0.543	0.650	0.764	0.778	0.876	
Geometric Mean	0.162	0.201	0.264	0.279	0.359	0.525	0.634	0.754	0.770	0.872	
Maximum	0.240	0.313	0.550	0.580	0.835	0.969	0.957	0.969	0.980	0.981	
Minimum	0.117	0.119	0.181	0.197	0.220	0.374	0.408	0.519	0.563	0.687	
Coefficient of Variations	0.173	0.187	0.258	0.258	0.351	0.279	0.227	0.157	0.146	0.091	

stable trend. Here the time variable in the inefficiency model plays a role in explaining such trend. Its significantly negative coefficient reflects that many firms have struck hard to find ways of better utilization of input resources to lower the unit production costs.

As expected, the HSR does not have statistically significant efficiency effect on the industrial sector in Dongguan, although the positive sign of the corresponding distance implies that locating nearer from the railway stations is favourable for efficiency improvement. The high-speed train services have little connection with the logistic demand of the manufacturing firms, and so the proximity to the railway stations does not really matter from the perspective of management and operation in the manufacturing process. In contrast, proximity of the towns to the nearest entrance of expressways is found to have significant positive relationship to the inefficient effect, i.e. efficiency increases with shorter travel time to the entrance. The scale of the coefficient is also relatively larger, compared with those related to HSR. Such result confirms the aforementioned hypothesis that the proximity of expressway infrastructure is a guarantee of efficient access to source of materials and international market and so crucial for determining the efficiency of the industrial firms. However, such relationship is probably not linear as the square of the shortest time distance to the expressway entrance is significantly negative at 10% level of significance. This indicates that the inefficiency effect of the increasing distance from the town to the entrance increases at a decelerating rate.

One can easily notice that those without expressway entrances and located far away tend to have low scores after years of development. For instance, among the bottom 5 towns in productive efficiency in 2009, Qishi, Qiaotou, Fenggang

and Shipai lie at the eastern outskirts of Dongguan City where the expressway network does not stretch over. A journey of around 20-25 minutes (about two times of the average) is necessary to reach the nearest expressway entrance from three of them. Xiegang Town seems like an exception just because an expressway is extended to the town in the 3rd quarter of that year. Obviously, time period is not sufficiently long for any efficiency effect of the newly open expressway to be completely reflected. Relatively low scores are recorded in towns with HSR stations either. Changping and Zhangmutou ranks at 19 and 22 respectively. Shilong has a much higher ranking thanks to its location advantage as well as strong industrial tradition.

Regarding the remaining determinants of productive inefficiency, the signs of average firm output and industrial output density are both significantly negative, implying that productive efficiency is higher in towns with larger firms and higher concentration of manufacturing activities. Efforts on achieving scale of economies and agglomeration contribute to reduce inefficiency. The result shows that the impact of FDI is negative but not significant. One possible explanation is that Dongguan is integrated to the global production network basically as a manufacturing enclave in the study period. Experience in enterprise management or advanced technology and know-how on producing the core components are hardly leaked to the firms in Dongguan along with the flow of capital and products.

5. CONCLUDING REMARKS

This paper investigates the impact of the HSR services, together with those of expressway infrastructure. It specifically analyses systematically how transport

infrastructure affects the productive efficiency of the manufacturing sector. In contrast to the previous studies that have tried hard to attribute the regional development to the HSR, or to reject its possible positive contribution, this study cautions that it is important to take the features of local development into account when evaluating the economic effects of transport infrastructure. The concentration on low value-added and highly outward orientated assembling and processing activities in Dongguan has resulted in the dependence on road transport for efficient inflow of materials and shipment of final products to the international market. Thus, the expressway instead of the high-speed passenger railway plays a critical role in the development of the manufacturing sector. Empirical results have shown that HSR is not significant in determining industrial efficiency in Dongguan. Instead, the proximity to the nearest expressway entrance from various towns has exerted considerable efficiency effect on the sector, which has been struggling for survival in difficult market environment in recent years.²⁶

It should be noted that this paper is not an attempt to deny the favourable spatial-economic impact of HSR, or simply to encourage further large-scale construction of expressway in the Mainland. As HSR facilitates the flow of people, this may lead to concentration of purchasing power and information to the stations around. Chan and Hall (2011) has made initial research attempt to show that cities connected to HSRs can seize the opportunities for accelerating the growth of service sectors, especially those that are knowledge intensive. Future research may focus on its impact on the growth of service sector.

²⁶ In a sense, the finding of this study supports the argument of Chung (2009) that Hong Kong's HSR station should not be considered as a means to support the fading "front shop, back factory" model.

This town-level case study provides the justification on the construction of expressway for those cities depending heavily on the development of manufacturing sector. As industrial enterprises can enjoy the efficiency gain brought by the proximity to the expressway entrance, local governments may give higher priority on improving the quantity and quality of expressway infrastructure in the regional policy packages. This can increase local industrial competitiveness or as an attraction to manufacturing activities. Allocating resources on constructing the expensive HSR infrastructure to link up industrial centres may not be a wise choice unless these places have a future plan of industrial upgrading or economic restructuring.

This study also provides important guidance for the future planning of the development of station areas in China, especially for the PRD region. There are already four HSR lines operating in the region, namely, Wuhan-Guangzhou DPL, Guangzhou-Shenzhen section of Guangzhou-Shenzhen-Hong Kong DPL, the Guangzhou-Zhuhai Intercity Railway and Xiamen-Shenzhen Railway. A series of HSR lines, including the Nanning-Guangzhou Railway, and Guiyang-Guangzhou DPL will be gradually open for service in the next few years. A number of stations are waiting for proper planning and development. According to the empirical evidence of this study, industrial development should not be given priority on the land at the station neighbourhood since manufacturing firms can hardly benefit from the proximity to the stations and the flow of materials and industrial products does not create additional use to support the services.

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