THE FEASIBILITY OF INTER-CITY EXPRESS RAIL

IN THE PEARL RIVER DELTA

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Abstract of the B.A. dissertation entitled

The Feasibility of Inter-City Express Rail
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We are living in an urbanizing world under rapid development, which means more functions in the city. People have to go to different places for different activities. Transport refers to the spatial organization of people and goods. Given the complex activity pattern of individual, an efficient urban transport system is the prerequisite for an efficient city. Mass transit is regarded as the equivalent to motorized expressways, which is highly preferred in a transit-dependent society where sustainability is of high concern.

The objective of this research is to study the feasibility of inter-city rail in Pearl River Delta (PRD). Following the Open Door Policy of China, the importance of bus arouse in inter-city travel. Unlike Western Europe where inter-city rail is readily available, such system is absent in the PRD. With reference to the estimated figures from Guangdong Infrastructure Bureau, the feasibility is found from matrix generation of interactions between PRD cities based on the gravity model, using the GIS software *TransCAD*.

The results findings follow the general pattern of the figures from Guangdong Infrastructure Bureau to certain extent, supporting the distance decay concept. It shows that there are many approaches in urban transport demand modeling. It also reveals that there may be other rationales behind government's transport planning, in achieving a strategic spatial configuration and accessibility pattern of the region in balancing conflicting interests.

The main contribution of this study is to attempt in applying classical transport planning model in finding out the methodologies in transport planning in the PRD. With the pattern of inter-city travel will continue to diversify, this study confirms the essence of inter-city express rail serving the region.

Declaration

I declare that this dissertation represents my own work, except where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation, or report submitted to this University or to any other institution for a degree, diploma, or other qualification.

Signed Fung Wai Bong

Fung Wai Bong, Atlas

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Last but not least, I have to thank my parents for their patience and understanding throughout my undergraduate study. Their care to me is incredible.

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List of abbreviations

ATS	American Travel Survey
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GIS-T	Geographic Information Systems for Transport
GPS	Global Positioning System
HB	home-based
HSR	high speed rail
ICE	Inter-City Express rail service, Germany
NHB	non-home-based
O/D	Origin(s) and Destination(s)
ODP	Open Door Policy
PRC	People's Republic of China
PRD	Pearl River Delta
RMB	*Renmenbi*
UK	United Kingdom of Great Britain
USA	United States of America
UTMS	Urban Transportation Model System
WTO	World Trade Organization
YRD	Yangtze River Delta

Chapter One

Introduction

1.1 The research area

With increasing contacts in the world, the volume of inter-city travel is on increasing scale. Inter-city travel come into exist by various reasons. Having a business trip overseas and visiting relatives back to the home country are becoming more common nowadays. The rapid enhancement in the technologies for transport resulted less difficulties in inventing transport modes of faster speed, greater comfort and higher reliability. The question comes to when these transport modes are needed? To what extent they can provide convenient movement of people and goods, with minimum negative impact to our environment.

Experience from the Western Europe shows the success in using inter-city rail in solving transport issues across the borders. Through cooperation and coordination, high speed rail (HSR) are having extensive network throughout the European continent. Although Europe is made up of quite a number of countries, HSR has made crossing the borders easily by simply getting on the comfortable, state of art train. Indeed, inter-city rail network is even a competitor to air transport, which is the most advanced transport mode in terms of speed.

Regarding the Pearl River Delta (PRD) region, the majorities of the connection between the cities is still limited to inter-city buses. There is a strong need to have an inter-city rail serving the region. Recent plans of the Guangdong provincial government suggested a scenario for the future inter-city rail development. This research will focus on the feasibility of inter-city rail in the PRD, regarding the potential number of passengers traveling and to generate a model showing the possible formulation of traveling pattern.

1.2 Objective and delimitations of the study

In this study, the background relating to inter-city travel will be discussed. In urban transportation planning process, the gravity model is well known for explaining the interactions between two regions, given the distance and population of them. This study will include a collection of these data and additional variables apart from population in generating the gravity model. The model will explains the possible trip pattern supporting the idea of inter-city travel.

The study area will be based on the predictions of inter-city rail travel in PRD as suggested by the County Planning Section, Guangdong Infrastructure Bureau (2001). A total of 28 cities are included in the study. Furthermore, 5 major cities of PRD, Guangzhou, Shenzhen, Zhongshan, Zhuhai and Dongguan will be further elaborated in the analysis.

1.3 Dissertation structure and organization

This dissertation consists of seven chapters. Chapter Two after this introduction is a literature review on the diversified profile and pattern of inter-city travel. It will focus on the definition for inter-city travel and the reasons for such travel pattern. Examples of the Western world, especially Europe, will be discussed. It will then continued with the factors for the diversified travel pattern and suggest development trends of inter-city travel in future.

Chapter Three develops a conceptual framework of modeling intercity travel. The classical four stage model in transport modeling will be discussed. It will be concluded with the methodology for this study.

Chapter Four discuss the basic concept of the gravity model in the trip distribution process. It will also discuss the factors which can affect trip distribution. These factors will be taken into consideration in the analysis of this study.

Chapter Five highlights the application of Geographic Information Systems (GIS) in Transport. It covers the basic definitions and concepts of GIS and its capabilities in the field of transport planning and management. The software used in this study -- TransCAD will be introduced in this chapter.

Chapter Six is the core chapter of this dissertation. There will be an analysis on the trip distribution data of the selected 28 PRD cities. The first part of the discussion focus on the overall origin destination (O/D) pattern between all city pairs. The second part of the discussion focus on the further analysis on the five selected city pairs. Findings of this study will be drawn from this part.

Chapter Seven concludes with a summary of the research findings, together with the implications of the study and recommends possible further study to be carried out in the future.

Chapter Two

Literature Review: Diversified profile of inter-city travel

2.1 Defining inter-city travel

There are far too many definitions for inter-city travel. Although the phase "inter-city" means such travel is across the cities, there is no standard definition in the research of transport geography. "Inter-city" is described as amorphous (Pisarski 1999: 369) and only understood generally by English speakers, while Americans use "interstate" more often. While using "inter-urban" may arouse the delimitation for "urban" and "non-urban" travel activities. In the simplest sense, inter-city travel refers to travel across the city boundary, or external transport of a city.

Earlier definitions of inter-city travel use distance as a criterion. The United States Bureau of Census had distance definition of 75 or 100 miles for inter-city travel, such as the 1995 American Travel Survey (ATS) (Transportation Research Board 1995). European surveys use shorter distances like 50 or 75 km (33-50 miles). Distance is a rather crude measurement. Firstly, distance ignores that some travel is across national boundaries, which may be "short" in distance but involve longer time, such as clearing customs, and regarded by the citizens as "long" distance instead. Also, technological improvements in transport make travel for longer distance become more efficient. Distance may not be a good indicator for inter-city travel.

Time is a new indicator for inter-city travel. Technological innovations in transport make business and excursion trips of few hundred km possible to be a same-day return trip. European railways consider inter-city as the concept of "time, speed, quality of service and frequency instead of distance" (Economist Intelligence Unit 1991a). Together with rapid development in tourist travel, the World Trade Organization (WTO) also defined inter-city travel from the perspective of tourism (WTO, 1994).

Inter-city travel can be international. Inter-state vehicle traffic in United States and railway trips across the European continent are both inter-city journeys. However, the later involves trans-boundary journey. The situation is the same in Asia, air flights between Hong Kong, Singapore and Taiwan, for example, can be completed in hours. The case of the Pearl River Delta (PRD) and Yangtze River Delta (YRD) illustrate more explicit example of interactions within the region, to a greater extent.

2.2 Purposes of inter-city travel

Transport is the spatial interaction of activities. People travel since they have to do different activities at different locations. Therefore, travel is a derived demand. For inter-city travel, two major purposes exist. They are business trips and recreational trips (Pisarski 1999: 378).

2.2.1 Business trips

Concerning the time budget, business travel is usually more constrained. The tight schedule resulted a lower elasticity of demand, hence a higher price. Moreover, the trip cost is usually paid by others. Cost factors and time pressures differ and manifest themselves in ways which make sharp distinctions in travel behavior. One explicit example is the business class of air tickets.

2.2.2 Recreation travel

Early research (Christiansen 1977: 139) identified that long distance rail (National Railroad Passenger Corporation 1976) accommodates primarily vacation travel (State Department of Highways and Public Transportation 1975). Recreation and tourism are originated from time. More dispensable time outside work means more time for travel. Recreation differs from tourism as tourism involves leaving the original country. Recreation also differs with commuting. Commuting trips have the trend similar with business trips as the shortest path will be used. The distance of recreation trips, in contrast, varies for different journey.

Campbell (1967) proposed the model for recreational and vacation travel. There are three hierarchies of recreation travel. The first one refers to the "metropolitan recreational hinterland", which the recreational places scattered tangentially to the city. The second one refers to the "recreational vocational regional complex" consisting the recreational centre and non-liner grouped places. The last one refers to the "vacation service region" which the recreational centre oriented along the highways in a linear pattern. Greer and Wall's model (1979) discussed the relationship between the demand for recreation and the supply of facilities, in terms of cumulative percentage. It divides itself into three limits for recreation, namely day limit, weekend limit and vacation limit. The model confirms one major concept of geographers that time budget exists and travel time is a limited as a fraction of all time available for traveling. In other words, it is the concept of distance decay.

Added to the above is that, recreational travel is developing with eco-tourism especially in recent decades. The relationship between accessibility and the level of eco-tourism is described as controversial.

2.3 Global trends of inter-city travel

2.3.1 USA

Inter-city travel pattern differs across the world. Even within the developed world or the developing world, such pattern differs as different countries have various level of motorization. Although it is difficult to assemble a clear vision of trends of the volume of inter-city travel (WBCSD 2001a: 5-2), USA, as well known of its car dominance, is having more than 81% (Table 2.1) in using automobile in inter-city trips (Bureau of Transportation Statistics 1997).

Table 2.1
Distribution of 1995 USA domestic inter-city trips and passenger km by mode

	Distribution by mode (%)		Average trip length (km)
	Trips	Passenger km	
Automobile	81.3	54.6	894
Air	16.1	43.0	3549
Bus	2.0	1.6	1048
Rail	0.5	0.5	1404

Source: Bureau of Transportation Statistics (1997)

The air transportation system makes an unique contribution to mobility in the world. It cannot be replaced by any other mode in terms of speed. A considerable portion of inter-city travel in USA was made up by air (16.1%) (Table 2.1). The importance of air increases especially after the deregulation movement since 1978. Under the old regulatory environment, the industry was influenced heavily by protections. With regard to national security issues, national "flag" carriers once dominated the market. With deregulation, the entrance requirements lessened in terms of the capital, the number of planes and hours of aviation of the pilots. Horizontal integration are allowed, such as transport companies running air and airlines running rail to the airports. In general, deregulation have "opened the sky" for more competition.

The hub and spoke system is the distinguish feature of modern airline operation. The hubs are the centres for concentration of airport operation with highest connectivity. The spokes are minor airports providing feeder services. Larger aeroplanes can be used on services between hubs and smaller ones between spokes. As a result, the operation cost decreased. In extreme case, airlines in USA can compete with inter-state buses in terms of price and speed.

However, worries on air transport began to arouse between academics. Environmental concerns include high altitude emission of CO_2 and sulfur particles (WBCSD 2001a: 5-18), noise resulted by the landing and take-off and the resulting land transport to the airport (Pickrell 1987: 199). Congestion of air traffic is also worrying. Inadequate infrastructure capacity exists at a number of hub airports. Delayed flights showed remarkable increase relative to overall aircraft movements (Mead 2000). Some even suggest that the air transport system will be unable to cope with any more traffic one day (Pellegrin 1992: 44).

The share of bus (2%) and rail (0.5%) were insignificant (Table 2.1). Amtrak (Congress 1970: 91-158), the famous rail of USA which was launched in 1971 (Clippinger 1987: 167), was a quasi-public organization (Christiansen 1977: 1) which operated all inter-city passenger rail services (Congress 1976: 94-210). It was able to maintain a limited level of competitiveness only with generous government subsidies (Clippinger 1987: 169), although subsidies on rail is also heavy in Europe and Japan, the subsidy level in USA have been reduced. Today, the railway track of Amtrak is widely used for freight. Only two corridors, the San Francisco – Los Angeles and Boston – New York – Washington DC, are sharing the majority of inter-city rail travel. Inter-city rail can be described as being "fade out" in USA.

2.3.2 Europe

The case of inter-city rail in Europe differs much from USA. To list the railway companies in Europe is rather too far to be complete – BR of UK, SNCF of France, DB of Germany, SNCB of Belgium, CFL of Luxembourg, RENFE of Spain, FS of Italy, NS of the Netherlands, NSB of Norway, VR of Finland, OBB for Austria and CH for Greece (Gerondeau 1997: 109). With reference to the inter-city services, it is easy to hear brand names like of InterCity of UK, Train a Grand Vitesse (TGV) of France, InterCity Express (ICE) of Germany and Thalys between France, Belgium, Germany and the Netherlands.

Profile of inter-city travel varies across nations in Europe (Table 2.2). In UK, automobile trips account for 54% and air contributes 36%. Rail have the share of 7% and the remaining 3% is for buses. Using Netherlands as another example, similar patters are shown while automobile account for 58% and air contributes 29%. The rest 13% is by bus and rail.

Table 2.2
Distribution of UK and The Netherlands trips longer than 100 km in 1990 by mode

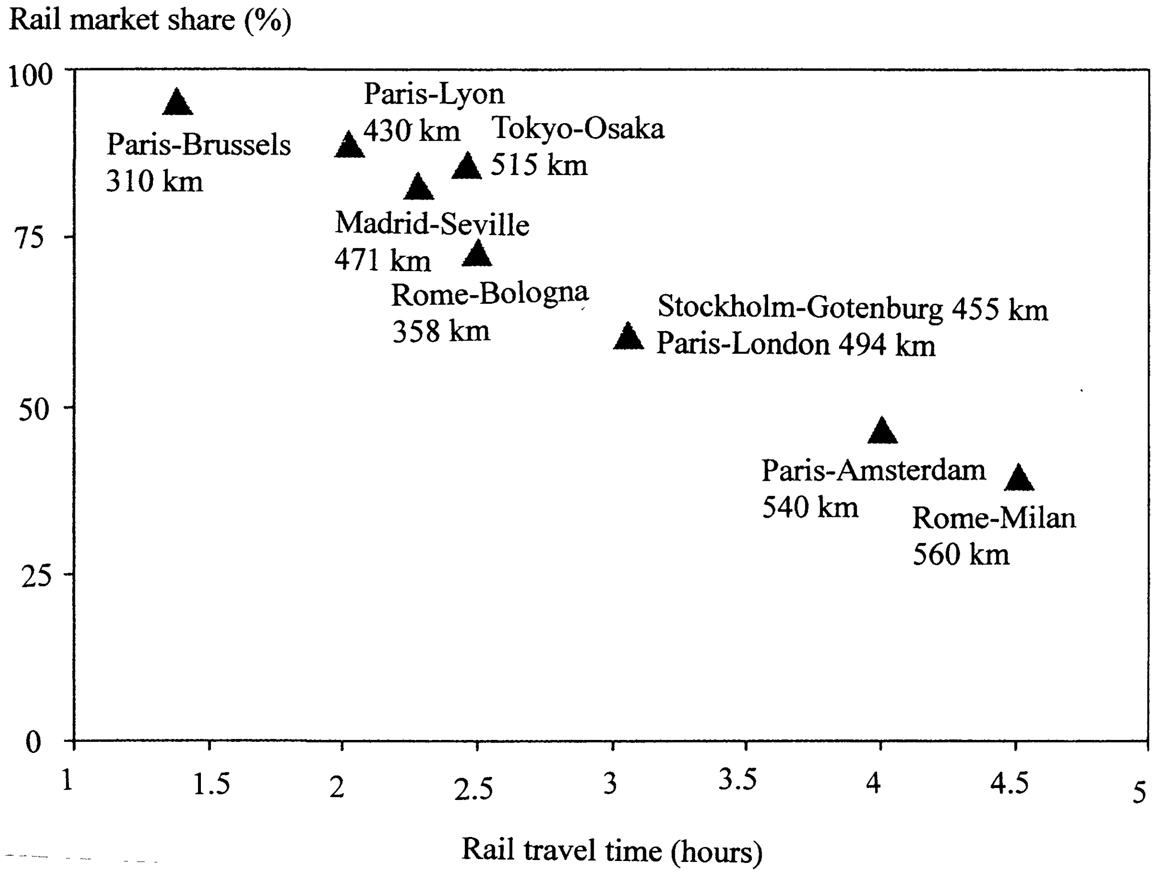
<table>
<tr><th></th><th>UK</th><th>The Netherlands</th></tr>
<tr><td>Automobile</td><td>54%</td><td>58%</td></tr>
<tr><td>Air</td><td>36%</td><td>29%</td></tr>
<tr><td>Bus</td><td>3%</td><td rowspan="2">13%</td></tr>
<tr><td>Rail</td><td>7%</td></tr>
</table>

Source: WBCSD (2001a: 5-3) and Schafer (2000)

The convenience of inter-city rail allows competition between rail and air within short to medium distances. Inter-city rail within 2 and a half hours traveling time (Gerondeau 1997: 124) are the major competitors of airlines of similar destinations. In other words, distances between 300 and 600 km in Europe were proved as inter-city rail's advantage over air. Firstly, as the airports tend to locate at the city fringe, additional time is required for traveling to the airport, together with the time for check-in. Secondly, the location of major railway stations at Europe are usually at the city centre, which gives advantage to business travel (section 2.2.1). Major rail stations in Germany, for example, are directly linked with the urban rail (U-Bahn) and suburban rail (S-Bahn), a good system of inter-change is maintained (Clippinger 1987: 193). City centre is also a concentration of hotels, place of interests and important node for local transport, which is convenient to recreational travelers (section 2.2.2).

Furthermore, some railway lines even compete "actively" with air by providing dedicated service to the airports. For instance, surface link were started between Heathrow (Fradd 1998: 81) and Paddington station in London central. Charles de Gaulle airport of Paris have been linked with TGV since 1994 (Economist Intelligence Unit 1991b: 95). In other words, rail in Europe also serves international passengers as a feeder service between the cities and the airport. Analysis shows that boredom increasingly prevails upon travelers after three hours in transit (Economist Intelligence Unit 1991c: 63). High speed rail (HSR) running at 200 to 300 km/h (Kracke 1992: 8) are competitive in this sense. A modal split of rail/air in selected destinations, especially in Europe, is shown in figure 2.1.

Figure 2.1
Rail / air modal split for distances between 300 and 600 km



Source: International Union of Railways (2000)

The Channel Tunnel is one major project known worldwide (Gueterbock 1986: 35), linking between UK and France through a tunnel. Inter-city rail services are of great variety throughout Europe. For example, EuroCityExpress (ECE) of speed between 250 and 300 km/h between important stations, EuroCity-Intercity (EC) of speed between 200 and 250 km/h between capital stations, also called skip-stop service (Blum 1992: 221) and EuroRegio (ER) of speed between 160 and 200 km/h which stops every 30 to 50 km (Braagaard 1995: 18). The flexibility of operation is achieved by having a common standard of operating tracks, like same track width, and coordinated maintenance (Viegas 1993: 79), known as inter-operability.

Cooperation and coordination of rail service can be noted by the establishment of the Community of European Railways in 1989 (Geerlings 1999: 155), consisting of 12 previous European Commission countries (Economist Intelligence Unit 1991a), formed a report (European Commission 1990) aiming for a truly international high speed rail network (Kemp 1995: 63). Earlier effort by individual countries includes InterCity service in UK since 1975, and French's TGV Sud-Est service of 200 km/h since 1981 between Paris and Lyon. In 1991, breakthrough service between Hamburg and Munich by German Federal Railway's ICE was introduced. More recent effort on franchising were done by Britain in increasing the attractiveness of rail (Preston 2001: 1) and encouraging park and ride (Whitfield 1998).

Recent keynote of development include Maglev-technology, based on the principle of magnetic levitation (Geerlings 1999: 155). The operation is non-contact so that there is no wear and tear along the tracks (Miller 1995: 101), which is more advanced than the "tilting" system (Economist Intelligence Unit 1991d: 74) of the existing HSR. The "Transrapid" project of Germany include trains of speed over 500 km/h (Gerondeau 1997: 130). Today, major inter-city services are demanded by more than 3 million passengers per year for each route (Van Witsen 2002). Scandinavia will be integrated with the European railway system by 2010 (Braagaard 1995). In short, regional cooperation is speed up by the favourable political environment (Harris Research Institute 1992).

2.3.3 Asia Pacific

Asia Pacific region is dominated by developing countries. Inter-city travel China was once dominated by rail, regarded as the political reason of channeling materials for strategic reasons, rail network were designed to fit this purpose. For the recent decades after the Open Door Policy, the importance of buses increased rapidly to the share of 75% among all inter-city travel (Wang, 2002a). The great patronage of buses can be observed clearly during Chinese New Year when thousands of workers returning to their home in different provinces from their working place in large cities. The situation is also true in the developing Southeast Asia. The relatively low affordability of commuters means a limited share of automobile, most of the inter-city trips are relying on buses, implying the room for development of inter-city rail.

Japan, as a "linear country", have been successful in using rail as the backbone of inter-city transport. The Shinkansen introduced in 1963 provides efficient linkage between Tokyo and Osaka. Today, double deck trains are running at 4 minutes interval at the speed of 275 km/h along the Tokaido route, which is at saturation level (Geerlings 1999: 156). Corridor development in Japan along the railway lines results a high modal share of rail of over 50% (Wang 2002a). In addition, local trains are important transport mode for daily commuters. Excellent catchments of rail allow commuters to walk or use bicycle after leaving the rail station to their destinations.

2.4 Factors affecting inter-city travel

2.4.1 Transport factors

Factors affecting inter-urban traffic are focused on the characteristics of the inter-urban modes. Advancement of individual mode, in terms of speed, will attract more patronage. For rail, the coverage of the tracks is important. For air, deregulation movement and the extensiveness of the flights (section 2.3.1) affect the popularity. Configuration of the station, that is the physical location of transport nodes also affects the usage of that transport (section 2.3.2), a proper integration of different transport modes at important interchange can provide convenience to the travelers.

The level of motorization in the country affects much of the usage of public transport. The high level of motorization and the configuration of state freeways in USA encourage automobile usage. Rapid motorization (Hook 1996: 69) also take place in Asia. Bangkok is one of the worst case with average automobile speed drops below 10 km/h (IIEC 1992). It is not difficult to see non-motorized transport (NMT) in Southeast Asia (Midgley 1994). A common scene is that the urban street is full of large and small buses, bicycles and taxis. Paratransit forms the majority of mixed traffic (Replogle 1996: 73).

In China, the growth of automobile also surges in recent decades. Chinese cities are relatively bicycle friendly since the majority of them are flat in terrain (Hook 1996: 77). The affordability of the citizens also made bicycles popular (Ayres 1992). However, income disparities between the east and west of China resulted that bicycles were still out of reach by the poor, while increasing affordability for motor cars become more popular among the rich. Learning from the negative drawbacks of automobile reliance in the Western world, China is undergoing the progress of transport planning, especially public transit (Replogle 1992). China is finding the pathway to promote transit in metropolis.

2.4.2 Non-transport factors

Historical and political factors influence heavily on the urban form. Historical factors not only affect the location of a city, but also the scope of operation of the transport mode. Railways developed within purely national boundaries in the early stage (Pellegrin 1992: 23). Once the boundary issue is resolved, inter-city services will be able to link the boundaries (Pisarski 1999: 369).

Cities are described as gateways to "internationalization, multinationalization and globalization" (Capello et al 1999: 215). Changing demographic and employment patterns will also affect the scale and character of inter-city travel, with more important role of tourism. Land use pattern also have a high correlation with transport connection. While this idea can be applied to the planning of cities, the Transit-city Model proposed by Newman and Kenworthy (1999) emphasis on corridor development.

Activity-pattern in the city is particular important in shaping the role of transport. Thoughts of "compact city forms" (CEC 1990) minimize the need of transit within the city. The city centre could have a diversified number of functions. In other words, the majority of travel will be out of the city itself, which is inter-city travel. To ensure the smooth pattern of movement, a high accessibility is to be maintained (Banister 1993). Transport technologies itself offer much more advantages since they means mobility, together with energy consumption and pollution. On the other hand, positive effects can be observed in economic and social development as higher accessibility generates more development, and activity-based transport.

Increasing concerns for the environment take place in recent decades. More works were done for enabling a sustainable mobility (WBCSD 2001b). As there are far more factors other than transport which can affect inter-city travel, it can be concluded that the solutions of inter-city travel, are outside the solutions of transport itself.

2.5 Future trends of inter-city travel

There are many scenarios of future inter-city travel which can be shaped. The market share between rail and cars, or between HSR and air is not easy to be forecasted. Each of the modes offer their advantages over another. Competition between modes will continue.

For example, HSR offers a great variety of advantages. Faster trips, higher reliability, better acceleration and deceleration, higher efficiency in energy consumption, lower emission and vibration, higher capacity, improved comfort and safety, lower maintenance cost, reduced interference with the landscape and more economic operation as the vehicle traveling time per cycle is lower. However, critics state that the noise, vibration and electronic fields are particularly true for Maglev-technology (Geerlings 1999: 158). One of the headaches for building HSR in the developing world is the huge capital investment required. The construction, operation and maintenance of HSR depend much on the patronage of the service, and the level of government subsidy.

The Third World is trying hard to develop various forms of rail system. Although feasibility studies on urban light rail were started in China (Yu and Shi 1987: 323) and India (Kapoor 1987: 328) in 1980s, inter-city transport planning had been absent until the recent years, despite its early emergence in the Western world (Highway Research Board 1972). Current issues are highly related to the need for appropriate sustainability policies (Capello 1999: 233) for transport development, especially the environmental quality (Hay and Trinder 1991), towards an integrated approach of inter-city transit development. One recent development in China is the introduction of the "Transrapid" HSR of Germany in Shanghai, which was officially launched in January, 2003.

Looking at the coverage of rail in several megalopolises in the world, the coverage of rail in the PRD is of the least development. Studies comparing the PRD, Tokyo, New York (New Jersey), Singapore and London shows that the percentage of rail coverage of PRD is the lowest. PRD is having a population of over 50 million, which is the highest among the compared regions, but the rail coverage is only one-eighth of New York (New Jersey). This clearly shows the need for inter-city rail development in PRD.

Freight transport is being ignored, to certain extent, especially for inter-city travel. One may note the presence of lorries in the city centre, their role of delivering goods deserves more attention. Commodity flows (Wilson 1970: 37) and intercity freight transport (Gueterbock 1986) were hardly ever mentioned by researchers.

Another difficulty is to model inter-city transport. There is no standard model for determining inter-city travel. Although aggregate (chapter 3) and disaggregate models can be used in urban travel behavior modeling, the attempts of using models in predicting inter-city travel is limited.

To conclude, the profile of inter-city travel will continue to vary in different parts of the world. Automobile dominance in the developed world will continue with the role of public transit under threat. This may have important implications on the developing world where the future modal share of inter-city transport can be influenced by transport planning. An appropriate transport planning for these regions means the plan should be comprehensive, human-oriented and sustainable.

Chapter Three

Conceptual framework and Methodology: Modeling inter-city travel

3.1 Conceptual framework

3.1.1 Aggregate characteristics of urban travel

In the study of urban transportation, the focus is on the movement of people instead of the movement of goods. The movement of people, as suggested by academics, consists of 80% among all movements in average (Barber 1995: 81). If the urban transport capacity is able to handle people movement during peak hours, then the system will be able to handle all movements. The study of the number of trips, traffic, cars and people can also be a question. Having different size of vehicles, the number of people traveling differs with the type of cars. At the metropolitan level, travel flow can be calculated by determining the total number of travel flow patterns, known as, aggregate demand.

Characteristics of the cities have their own implications on travel flow patterns. A larger city provides more choices on transport modes. The function of a city, such as residential, commercial, industrial, educational or recreational also affects the nature of the traveling public. The natural terrain has greater implications on the transport mode, such as bicycles are not preferred in hilly cities. The state of technology of the city and the economy also matters. For example, most cities in Europe already have a long profile of transport development, such as the underground which was built long ago. If similar projects are to be taken today then huge sum of capital investment may deter the process. Linked issue is land use issues arising from transport development. A high density corridor development like

Hong Kong can stimulate transport provision on the other hand.

3.1.2 Modeling and predicting aggregate flows

The flows of people, also know as spatial interactions, refers to the human relationships, materialized by people, goods or information exchanges as the dynamics of the geographic and economic system (Durand 1999: 200). Interaction is a complex notion (Isard 1972). Spatial interaction models can fulfill the aims of explanation and prediction. Explanation refers to attributes of the locations which generate flows of people, goods or ideas among themselves. It also deals with global spatial configuration of the productive system (Durand 1999: 201). Prediction comes with estimating the number of trips which can be generated.

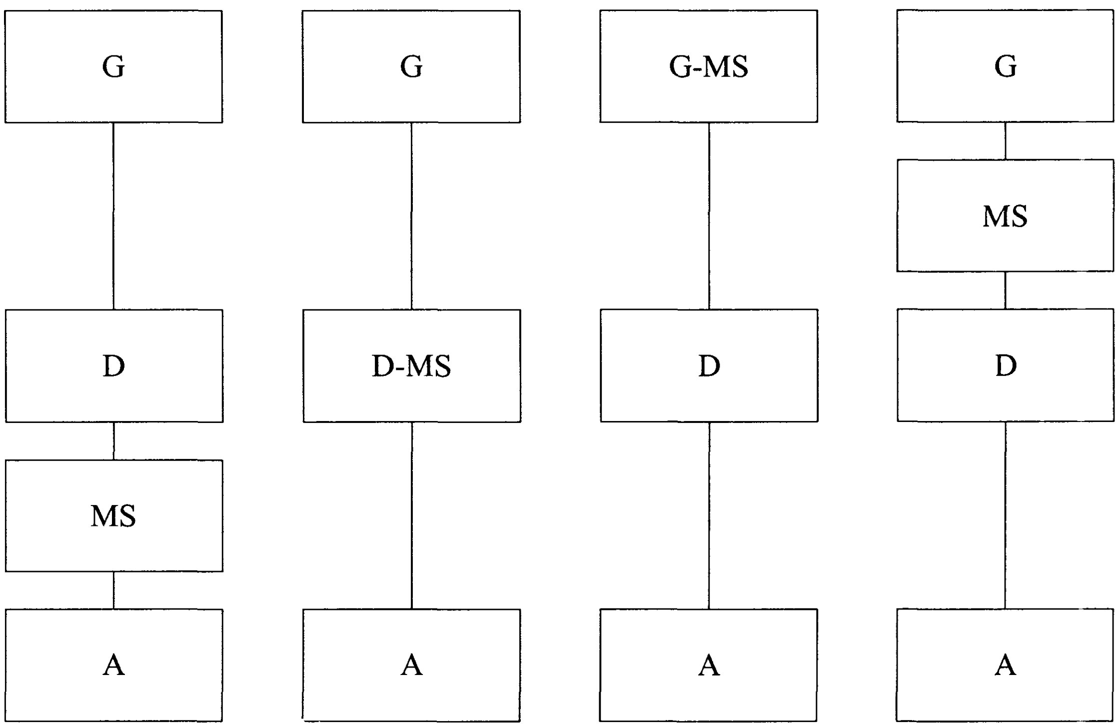
In transport planning, a model is used to estimate trips between pairs of points (Wilson 1970: 15) and to predict the flows of linkages in the transport system. The reason for establishing the models is to predict the aggregate flows. The problem comes on the kind of data to be collected and the method to collect the data. After data collection, the procedures of modeling for urban transport planning can be carried out.

3.1.3 The Urban Transportation Model System (UTMS)

As a part of the urban transport planning process, the UTMS forms as an integral part in the whole process. The process is consisted of three phases. The "Pre-Analysis Phase" includes the problem identification and the formulation of goals and objectives. The "Post-Alalysis Phase" includes the evaluation of alternatives and follow-up decision making with continuous monitoring. The most important part in between is the "Technical Analysis Phase" in which the UTMS generated from the Land use-Activity system model (Wang 2001a).

The four-stage model has been extensively used, having the components of (1) trip generation, (2) trip distribution, (3) modal split and (4) route assignment. Each of the stages will address the questions of the number of trips, origins and destinations (O/D) of the trips, mode of travel and the route taken respectively (Bates 2000: 17). Traditionally, the steps of generating the model followed the above sequence as an order. Suggestions (Sheppard 1995: 105) state that there are possible alternatives in the sequencing of the stages in the model. Figure 3.1 gives an illustration of the possible alternatives.

Figure 3.1
Alternative sequences for aggregate trip modeling



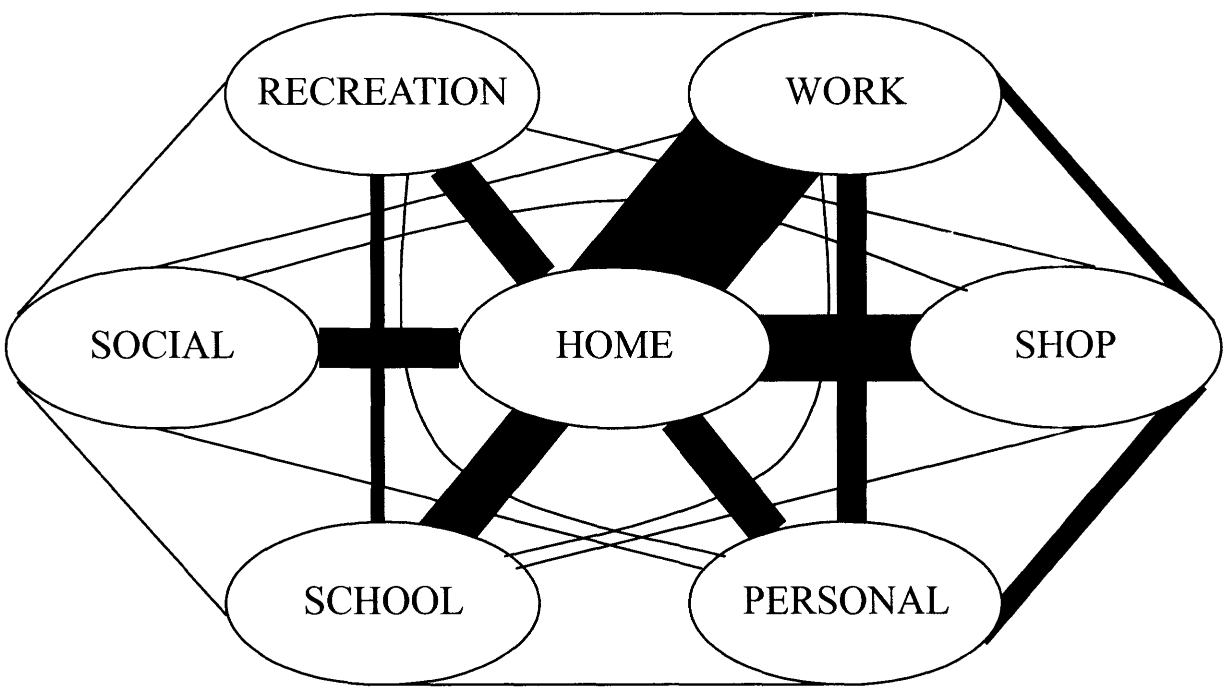
Key
G Trip generation
D Trip distributuion
MS Modal split
A Route assignment

(Source: Sheppard 1995: 105)

3.1.3.1 Trip generation

Trip generation refers to the forecast of the number of trips to and from each zone in relation to its land use pattern and related variables in the forecast year. The number of trips is to be specified within a period, for example, per hour basis (Zhang 1997: 1). Trips are divided to home-based (HB) and non-home-based (NHB). HB Trips refers to the home of the trip maker is either the origin or destination of the journey. NHB Trips refers to neither end of the trip is at the home of the trip maker. Figure 3.2 shows the trip purposes in a typical North American city, where HB trips contribute quite significantly. For less developed countries, most of the trips are between home and work, while more trips are spent on "other purposes" in the more developed countries.

Figure 3.2
Trip purposes in a typical North American city

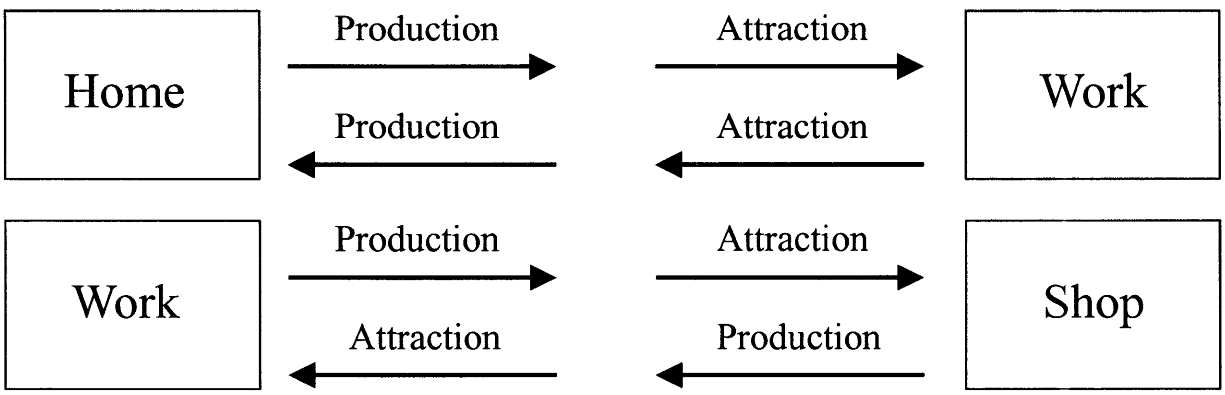


The thickness of the lines shows their relative importance.

(Source: Pas 1995: 76)

Since trip generation is the total number of trips generated by a unit (such as a household) in the zone, by their HB and NHB trips together, there should be elements responsible for the trip generations. Trip production refers to the "home end of an HB trip or as the origin of an NHB trip". Trip attraction refers to the "non-home end of an HB trip or the destination of an NHB trip" (Ortuzar 2001a: 95). A relationship between trip production and trip attraction is shown in figure 3.3.

Figure 3.3
Trip productions and attractions

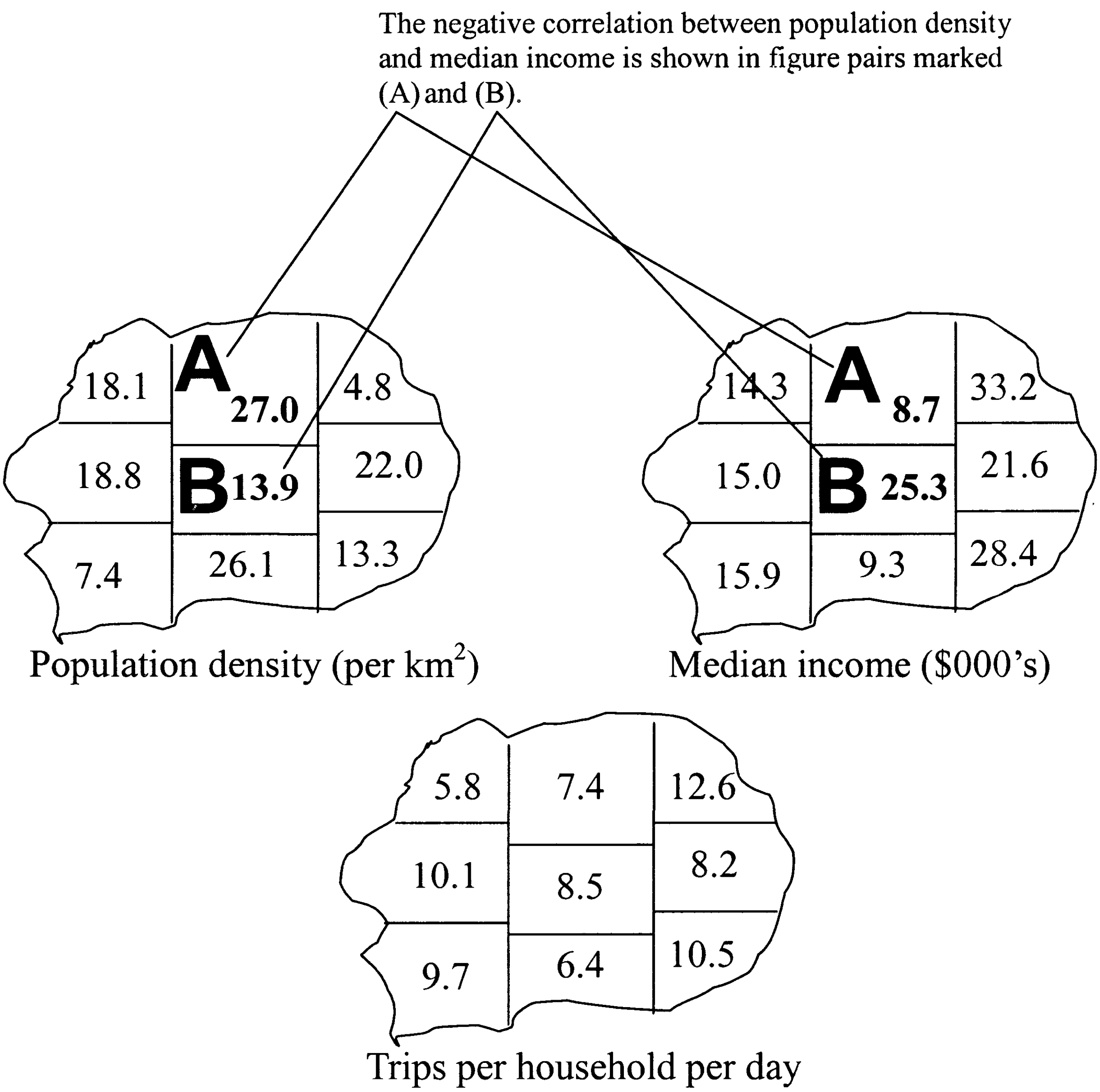


(Source: Ortuzar 2001a: 95)

Factors affecting trip generation can be quite individual. Since the unit of measurement on household basis, the income, ownership of automobile, number of family members and the structure of the household affect much. Linear regression analysis (Sheppard 1995: 106), one extension of trip generation, focus on the relationship between average income and mobility (Figure 3.4). The higher the average income, the greater the mobility and therefore more trips per household per day. Category analysis refers to a change in the land use with result a change in the trips generated (Sheppard 1995: 109).

It is important to note that, as trip generation only reflects the existing situation, the ability to estimate the future is limited, as indicated in the linear regression analysis and the category analysis.

Figure 3.4
A hypothetical example of Linear regression analysis



(Source: Sheppard 1995: 108)

3.1.3.2. Trip distribution

Trip distribution refers to the flow of trips between each O/D zone pairs, with stratification of travel purpose by using the results from trip generation (Zhang 1997: 1). The classical illustration of trip distribution is the use of the Gravity Model (section 4.1) in predicting the O/D interaction with given distance and population. The O/D pairs are treated equally. It also provides a logical basis for alternative "units" of travel such as trip chains (Bates 2000: 20). Attractiveness of each of the O/D pairs increase with population and decrease with distance.

Gravity Model works on the theoretical ground of "entropy", which refers to adding constraints in the O/D pair to make the resulting O/D matrix satisfies the constraints. In other words, it is a "Constrained Gravity Model". Further discussions on entropy can be found in section 4.1.1.

Cross-sectional data are added to express the amount of travel in terms of explanatory factors (Ortuzar 2001b: 122), to ensure temporal stability. Further calibration of the model can be supported by information from household surveys. Earlier forms of trip-end models were based on "zonal regression" using the total population of the zone. Improvements to it include "category analysis" which take the value of identifying different categories of household having different trip rates for each categories into consideration (Bates 2000: 22).

Extensions of the Gravity Model include its linear transformation and by adding constraints to it. Another extension is the Intervening Opportunities Model which suggests the emergence of intermediate location between the original O/D in attracting "away" the original interactions between the O/D. The new location becomes the intervening opportunity.

The major problem of trip distribution models deals with the delimitation of zones. For the usual case, zones are defined by the border of each region. The border definition not necessary means that all zones are having population of equal amount. Problem will arise when the zone boundary changes. The results will be further inaccurate if the division is crude. For example, one may mistake the belief that the coastal region of China is rich, while the poverty level increases towards the west. This may be true for the general observation. However, regional disparities may exist if some provinces in the west is richer than some at the coast. The model will be incorrect if the delimitation is inappropriate.

3.1.3.3 Modal split

Modal split is the allocation of the O/D flows to the available travel modes (Zhang 1997: 1). It is the combination of different transport categories. The reason for considering modal split is that there are rationale behind individual choice of different modes. The result of modal split is vital for transport planning and policy making. For instance, there are derivation in the percentage use of public transport like buses and private modes like cars. The use of cars may be related to the availability of parking space, amount of parking charges and most importantly, the time needed relative to other transport modes. Walking and cycling can also be a transport mode, which reflect the popularity of these modes and the convenience of using them. To sum up, modal split usually give a picture showing the share of private and public transport, and most importantly, the role of individual transport mode.

Elements of modal split include the diversion curve method and the choice model. The diversion curve (Sheppard 1995: 123) is constructed with a graph showing the percentage of people using public transport against the measurement of the difference in the attractiveness of the two modes. The choice models use the format of regression-type to suggest the probability that a randomly selected traveler between two zones will use which of the two modes. This is also known as a logit model (Sheppard 1995: 124).

Modal choice affects the general efficiency which people travel in urban areas, and the amount of space required for transport use (Ortuzar 2001c: 161). There are several factors which can affect the choice of mode. The trip maker's car ownership and household condition may affect the use of cars. The journey itself also differs by the trip purpose and the time of the day. Transport facilities also matter in terms of monetary costs, relative travel time and level of comfort and safety, reliability and security.

Modal split not only shows its importance when looking at the "macro" view in transport planning, but also have implications on individual modes. One study for the demand forecast for China HSR between the corridor of Beijing and Shanghai (Li et al 2000: 903) take automobiles, buses, airplanes and existing conventional railways into consideration. This concludes that the market share of one mode have inter-relations with other modes.

3.1.3.4 Route assignment

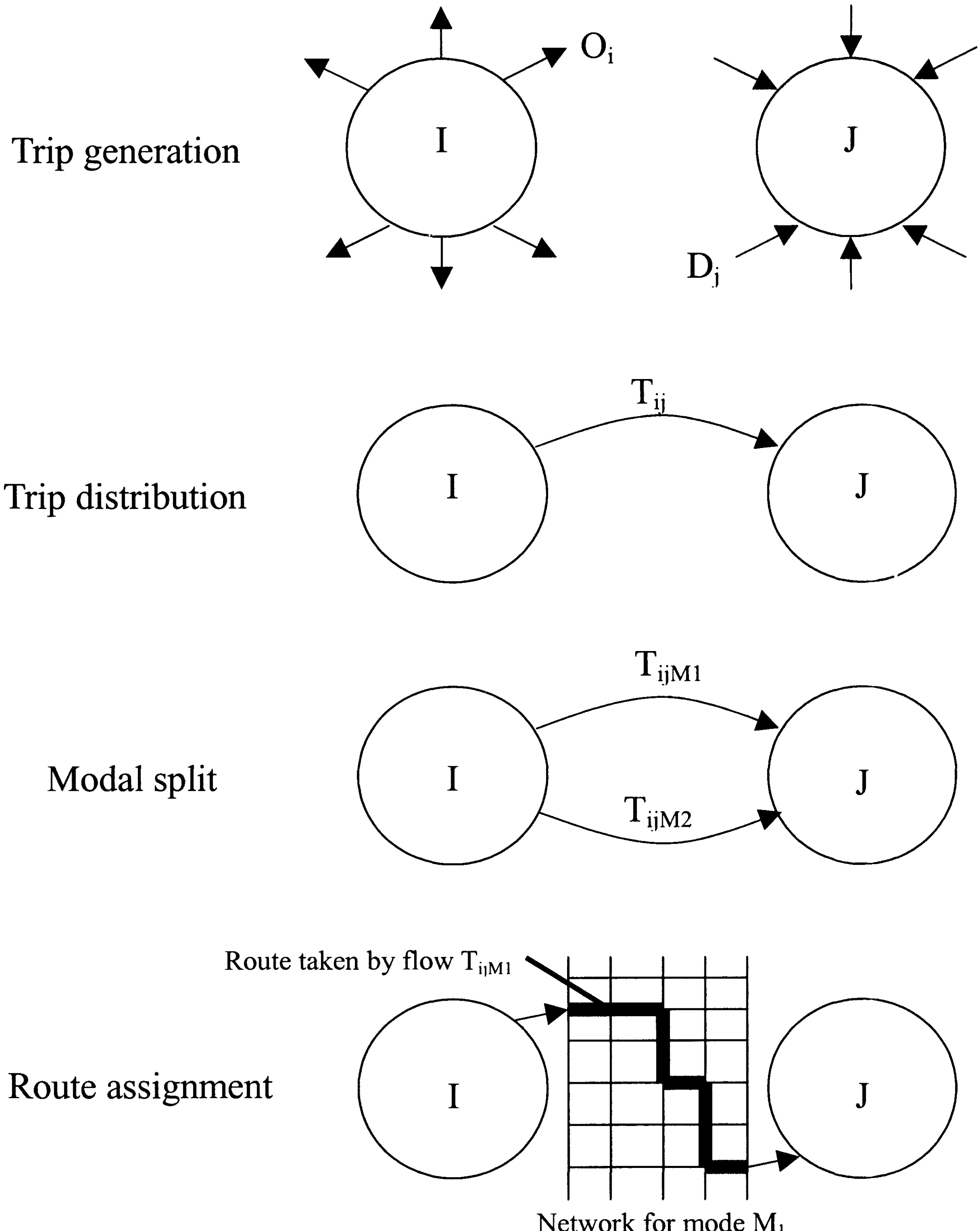
After modeling the mode between the O/D, route assignment deals with the process of selecting the specified flows on the road network (Zhang 1997:1). For example, the routing between an O/D pair of a public transport system. The route which is to be formalized will be composed of a series of links. The rationale for route assignment is to assign all required trips to the route with minimum cost (Oppenheim 1995: 16) or the shortest path. Another rationale is the incremental assignment approach which allocates a limited number of trips at a time along the cheapest available route. Therefore, route assignment works on user equilibrium and system optimization (Sheppard 1995: 125).

3.1.4 Summary and critiques of the four stage model

The four stage model is the classical approach for urban travel demand modeling, which has been progressively evolved over the last thirty years into an established methodology (Willumsen 1990). Figure 3.5 give a graphical summary of the idea of each of the components of the model.

Trip generation refers to the number of trips originating from each zones, namely I and J in the diagram and their trips are O_i and D_j respectively. Trip distribution refers to the trips T_{ij} originating from I and terminating at J. For modal split, it refers to the number of T_{ij} being divided into several modes, such as M_1 and M_2 in the diagram, the trips will become T_{ijM1} and T_{ijM2}. Lastly, route assignment refers to the route of the T_{ijM1} within the whole network of the mode M_1.

Figure 3.5
The four-stage model in modeling transport demand



Key:
I, J Zones which generate trips
O Origin
D Destination
T Number of trips
M Transport mode

There are suggestions that the four stage model still have some limitations in modeling urban transport. The values of the variables determined at one step may be different from that being used in another step. For example, the route and O/D travel times resulted in trip assignment can be different in trip distribution and modal split models (Boyce 1997: 1). As a result, inconsistencies exist. There are also other new models developed, such as the econometric models (Harker 1987: 9) for intercity freight flows.

This conventional approach is also not based on any single unifying rationale (Oppenheim 1995: 18) which can explain all different demand patterns. The presence of traffic congestion in reality is ignored. In other words, all stages in the model are given a "behavioral" interpretation. The approach proceeds from the top of the structure, which is the decision to travel, to the O/D pattern and results the model of route choice. With decades of development, additional elements were added to the original model in order to enhance the intrinsic value and the predictive power.

3.2 Objective of the study

This study is based on the theory of trip distribution (section 3.1.3.2) through applying the gravity model (section 4.1). It is intended to see whether the predicted O/D pattern for the planning of inter-city rail in the PRD region match with the concept of gravity model (chapter 6). The objective of this research is to understand the factors which may affect the trip distribution in the gravity model. Through using different factors, different scenarios of O/D pattern can be observed. These self-derived results will be compared with government's estimation of the proposed O/D for the inter-city rail in PRD. After the comparison and discussion, the feasibility of inter-city rail in PRD will be suggested as a conclusion.

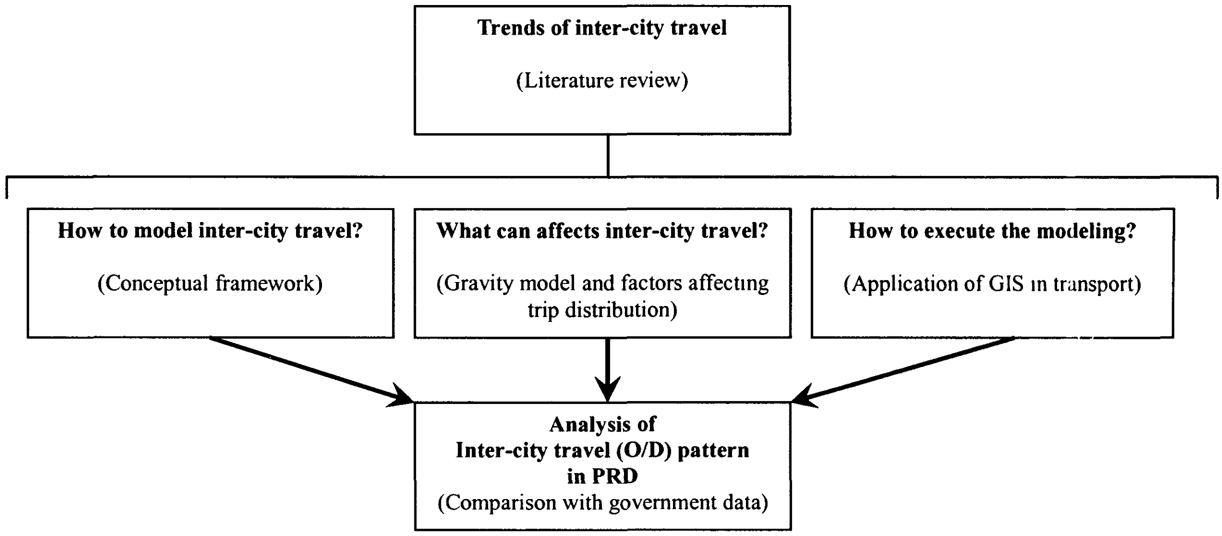
3.3 Methodology

The literature review (chapter 2) already illustrated the issues of inter-city travel nowadays. Inter-city travel has become a new trend in transportation studies. The problem comes on the method of modeling the inter-city travel flows. As the gravity model will be used for analysis in this study, the underlying principle will be discussed in chapter 4. This chapter also introduces the factors or variables which can be applied to the gravity model for different inter-city travel results.

The next question is to know the way to carry out an analysis equipping the gravity model. Geographic Information Systems (GIS) has become a trend of analyzing spatial data. Applications of GIS are wide and capabilities are shown in the area of transport planning and modeling. The ability of GIS and the software used in this study – TransCAD – will be discussed in chapter 5.

For the analysis, the raw data, which are the factors affecting the O/D pattern of inter-city travel will serve as the input. The results will be the self-derived O/D pattern generating from the raw data. As mentioned in section 3.2, the comparison between the self-derived data and government's estimation will be the findings of the research. Figure 3.6 shows the structure and linkages of the methodology.

Figure 3.6
Structure and linkages of the methodology



3.3.1 Data collection

3.3.1.1 Gravity model and factors affecting trip distribution

The basic concepts of the gravity model will be discussed through reviewing the literature concerning trip distribution pattern. The factors affecting trip distribution include distance and population are from the original formulae of gravity model for transportation analysis. New factors of Gross Domestic Product (GDP), GDP per capita, industrial output and retail sales are suggested from existing statistical publications which are attributes of individual cities.

3.3.1.2 Application of GIS in transport

The discussion on GIS and the terminologies in transport will be done by reviewing the literature. The software used in the study – TransCAD - will be introduced with the reasons for choosing this software and its capabilities. The personal use of TransCAD will form another part of this section.

3.3.1.3 Analysis of inter-city travel pattern in PRD

The data input for the analysis include distances between selected PRD cities. Distances are calculated from direct measurement on the existing highway map of PRD, which the milestones of each section of the highway are shown. Data concerning population, Gross Domestic Product (GDP), GDP per capita, industrial output and retail sales are found from the Statistical Yearbook of Guangdong (China Statistical Publishing House 2001a) and Statistical Yearbook of Guangzhou (China Statistical Publishing House 2001b). Additional data on individual towns or counties are obtained from the statistical yearbook of the region of the respective year. Furthermore, the recently established Hong Kong-Macau-PRD Development Information Net established by the Taskforce for PRD Development of The University of Hong Kong and the Hong Kong-Macau-PRD Development Research Institute of Zhongshan University of China provide useful links to latest statistical information (Hong Kong-Macau-PRD Development Information Net 2003).

The data for comparing with own research findings are from the government estimation of the O/D pattern in the PRD. The data is a planning document by the City and County Planning Section, Guangdong Infrastructure Bureau and Number 4 Design Institute, Railway Bureau (2001). The government estimation of the O/D matrix forms the backbone supporting government's plan of the inter-city rail.

Chapter Four

Gravity model and factors affecting trip distribution

4.1 Gravity model

How to put the explanation of spatial interaction into a model? Originated from Newton's universial gravitation law of physics (Durand 2000: 201), applied since 1950s, the Gravity Model is employed to explain the interaction between cities. Given their population, distance between the cities and a constant, a simple gravity model can be generated to explain the spatial interaction between two centroid (Wilson 1970: 15) of a zone. Formula (1) illustrates the gravity model in terms of a function:

$$T_{ij} = k \frac{P_i P_j}{d^{\beta}_{ij}} \qquad (1)$$

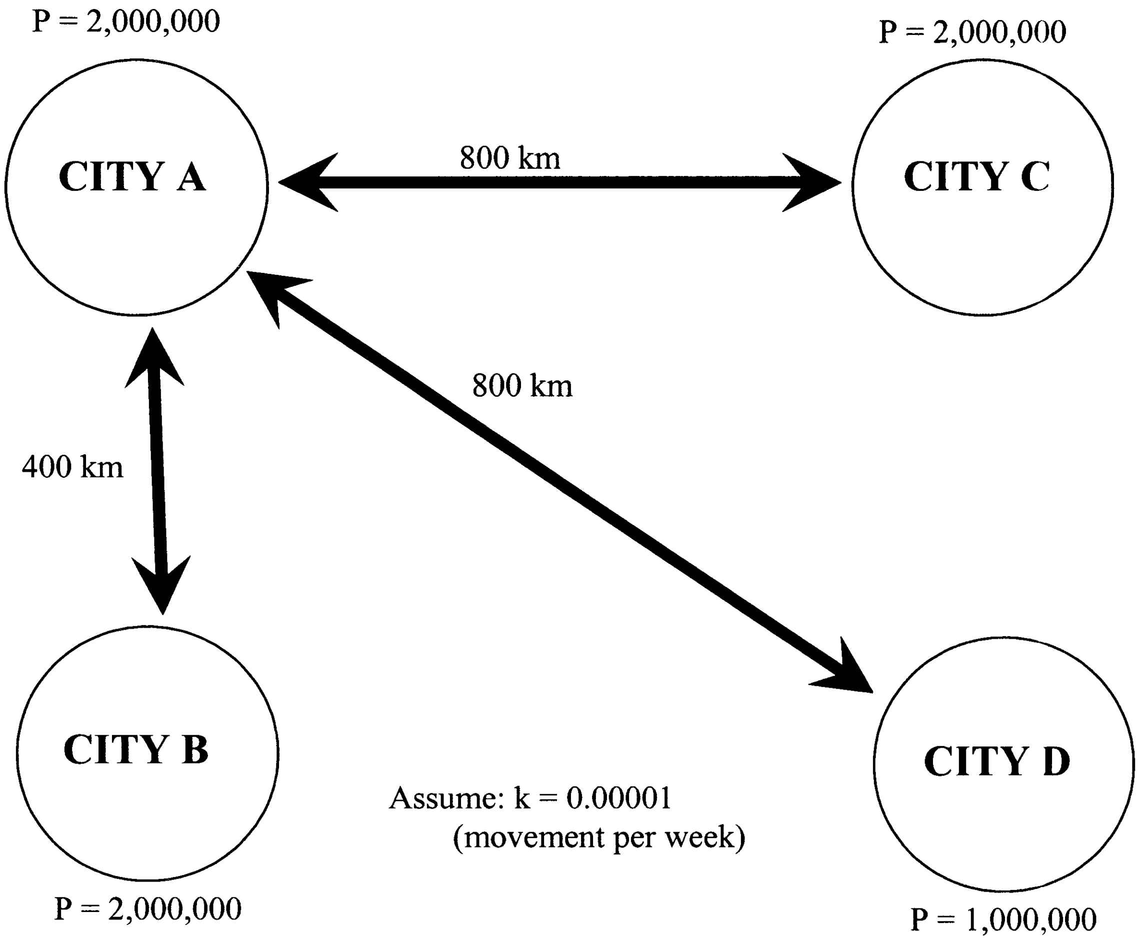
Where	T_{ij}	refers to the number of interactions (trips) (T) between two regions (i, j) in an O/D pattern
	P_i	refers to the population of i
	P_j	refers to the population of j
	d^{β}_{ij}	refers to the distance between i and j
	β	refers to the parameter attached to distance

Further illustration can be found in figure 4.1.

The presence of the parameter (β) is because of differences exists between the gravitation law and the gravity model. The formalization of the gravity model is based on the analogy of Newton's law, related to gravitational force. In spatial context, the mutual attraction between the two masses and the distance function may be different (Durand 2000: 201). The parameter allows flexibility since it is in exponential form.

Indeed, distance decay concept is the major implication from the gravity model. From (1), a greater distance between cities would led to lower level of interaction, this is the same as the concept of transferability of Ullman (1952). Putting the extra exponents (β) to distance, the effect of the distance on the number of journeys can be more clearly illustrated. It may be the case if the distance is increased by a little bit, but the level of interaction falls sharply. For example, drivers may seldom drive beyond a certain number of km from their origin, such as 50 km or 100 km, enable sufficient time for the return trip on the same day. The existence of the exponent can further increase the explanative power of the gravity model.

Figure 4.1
Illustration of gravity model (1)



In the figure, there are four cities, suppose cities A, B, and C all have a population (P) of 2,000,000, and City D has 1,000,000. The distance between AC and AD is 800 km, and the distance between AB is 400 km. Each city would have one characteristic which is the same with others and one characteristic which is different from another. From formulae (1) in the previous page, there is no parameter attached to (2). There is only one additional assumption that a constant k values 0.00001:

$$T_{ij} = k \frac{P_i P_j}{d_{ij}} \qquad (2)$$

By substitution of values into 2, different city pairs form interaction patterns as below:

City pairs	Population of 1st centroid	Population of 2nd centroid	Distance (km)	*k* value	T*ij* Trips generated/week
AB	2,000,000	2,000,000	***800***	0.00001	***50,000***
AC	2,000,000	***2,000,000***	***400***	0.00001	***100,000***
AD	2,000,000	***1,000,000***	800	0.00001	***25,000***

The equation (2) and the above table (*italic values*) confirms that the level of interaction is positively correlated with population and negatively correlated with distance.

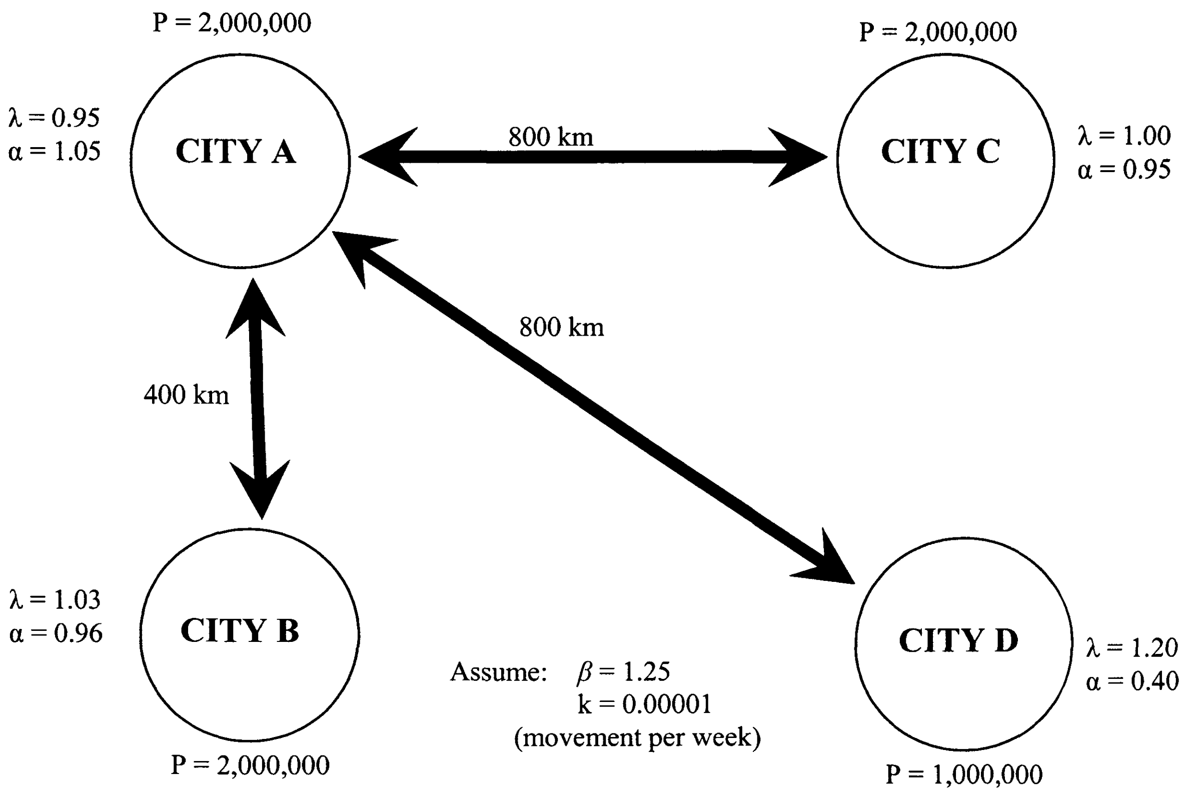
To further increase the explanative power complexity of the gravity model, it is possible to add exponents to population and distance. For example,

$$T\,ij = k \, \frac{P^{\lambda} i \, P^{\alpha} j}{d^{\beta} ij} \qquad (3)$$

Where	Tij	refers to the number of interactions (trips) (T) between two regions (i, j) in an O/D pattern
	$P^{\lambda}i$	refers to the population of i
	$P^{\alpha}j$	refers to the population of j
	$d^{\beta}ij$	refers to the distance between i and j
	β	refers to the parameter attached to distance
	λ α	refers to the parameters attached to population

Further illustration can be found in figure 4.2.

Figure 4.2
Illustration of gravity model (2)



In each of the above cities, there are different parameters attached to population (λ, α) and to distance (*β*).

$$T_{ij} = k \frac{P^{\lambda}_i P^{\alpha}_j}{d^{\beta}_{ij}} \qquad (3)$$

By substitution of values into 2, different city pairs form interaction patterns as below:

City pairs	*k* value	*λ* value	*α* value	*β* value	T*ij* Trips generated/week
AB	0.00001	0.95	0.96	1.25	6,058.88
AC	0.00001	0.95	0.95	1.25	2,203.41
AD	0.00001	0.95	0.40	1.25	5.72

(T*ij* is correct to 2 decimal places)

The above results shows that, with the same sets of population and distance, the introduction of additional parameters result a contrast with the number of trips generated when compared with figure 4.1. The parameters allow great level of flexibility in modeling.

The main advantage of using gravity model is the flexibility of introducing variables, as illustrated in figure 4.2 and the availability of "goodness-of-fit" measures (Flowerdew 1991: 100). The gravity model is easy to understand, since the interaction can be understood with direct relationship between their loads and inverse relationship of the distances (Ashish 1995: 1). On one hand, the "k factors" can improve the calibration of the model (Ortuzar 2001b: 157). On the other hand, the coefficients can be removed easily.

Since the gravity model is based upon the mechanism of trip distribution, it can cope with the changes of the trip pattern to some extent. The estimation can be good when the change in the travel pattern is small (Kawakami 1974: 328) when the "zone-to-zone" adjustment factors (parameters) are taken into consideration.

However, there are academics suggesting that the concepts of interaction, size and distance are relatively "vague" (Ashish 1995: 1) and alternative interpretations exists. The gravity model, which is simple in nature, raise more questions that it answers.

In spite of the criticisms to the gravity model, its simplicity and generality allows wide application. Early studies of the railway network already equipped the idea of gravity model (Lill 1891). Application goes to retail geography through studying the market areas (Reilly 1929, 1931), also socio-economic flows (Zipf 1946: 678). Indeed, most human spatial relationships can be explained with the basic principle of gravity model, in particular, the distance decay concept.

4.2 Factors affecting trip distribution

As discussed in section 4.1, the distance and population are the underlying factors affecting trip distribution in the gravity model. The following section will cover other factors, which can be used instead of population, in the process of modeling trip distribution. Theses factors will also be used in the main part of this research (chapter 6).

4.2.1 Distance

From the equation of the gravity model, the distance between the cities is inversely related to the level of interaction. This concept is simple to understand as every trip maker have the same time budget, the law of diminishing marginal returns set in when more time is used for traveling. Therefore, we can see that trip makers prefer trips of the shortest distance. The reason is not only because of the time for traveling itself, but also they have to sacrifice the use of time for other purposes. In economics, this is the concept of opportunity cost.

Exceptions of distance may exist especially for border issues. Given two city pairs of equal distance and population, holding all coefficients constant, if one of the pairs are of two different countries, the pair within the same country will generates more interaction. The ease of entry and exit a country is limited by the border control. With lessened border control, the level of interactions between them will be able to increase. The situation also depends on the ease of using inter-city transport modes across the border, such as the waiting time at the customs.

4.2.2 Population

Population is another important criterion for affecting the level of interactions in the gravity model. The number of attractions can be highly accurate if the exact amount of population, that is, individual, is used as the unit to calculate inter-city travel. Surveys in USA sometimes consider the household as the unit of travel. The total number of trips will be referring to the group trips made by the household (Pisarski 1999: 377). For instance, if a single individual of the household make one trip, this will be counted as one household trip. If a trip is made by both parents and two children then this will also be counted as one household trip. Therefore, the sum of total household trips is not the sum of individual trips. To make the research result more correct, and for the sake of data availability, all trips will be counted in terms of individual.

4.2.3 Gross Domestic Product (GDP)

GDP is one of the most widely used measurements to assess the state of economy of a country. Increase in GDP means an enhancement of the production level of a country. The annual GDP growth rate is an indicator for the past economic growth, and helps to predict the performance of the economy in future. Continuous growth means that the country is able to generate more wealth, and higher standard of living among the citizens.

Taking inter-city travel into consideration, the ability for the community to spend more is the major criterion for sufficient patronage if a new inter-city rail is to be launched. The demand forecast for China HSR between Beijing and Shanghai also take GDP levels into consideration (Li et al 2000: 901).

Table 4.1
GDP forecast used in the planning of China's HSR between Beijing and Shanghai

Year	GDP ($ million RMB)	Average annual growth compared with the previous calculation
1996	26,896	n/a
2000	36,851	8.2%
2010	71,721	6.9%
2020	115,081	4.8%

(Source: Li et al 2000: 901)

However, the limitation of using GDP is caused by different approaches in calculation. For instance, expenditure approach and income approach of calculating GDP will have different results. Since GDP in any of the approaches is determined by a number of factors, the influence of GDP on transport modeling is relatively less significant. Comparing with population, the effect of GDP is smaller.

4.2.4 GDP per capita

GDP itself is "aggregate", economists may suggest that GDP itself may not reveal the "true" situation of the wealth of a country. GDP per capita can be a better form of measurement, such as whether a country is at developed level or still at developing level, for instance, GDP per capita of US$5000 per annum or above in the year of 2000 are suggested as the "crude measurement" for a developed country. Although there is no unique definitions for a country as "developed" or not, GDP per capita offers a better and clearer understanding of the wealth of individual, instead of looking at the huge sum of the national GDP.

The limitations come on the income may be concentrated in the hands of people of higher income. In other words, when income distribution is not even, then GDP itself may not be sufficient to shows the complete picture of wealth of a country. Income disparity in China can shows the drawback of using GDP per capita.

4.2.5 Industrial output

Manufacturing, as a secondary industry, is of dramatic growth in most developing countries. While the tertiary industry are concentrated in the developed world, the needs of changing raw materials to semi-finished and finished product is necessary to satisfy the needs of the market worldwide. Although the rapidly developing mega-cities in China are now transforming to be tertiary industries dominated, their reliance on the hinterland of manufacturing activities still exists. With rapid development in the PRD, the manufacturing sector still share importantly, especially they are the pool of high quality labour at inexpensive wage. Industrial output not only indicates the wealth of certain region through exchanging goods, but also a potential concentration of settlements and activities, forming a source of demand for inter-city travel.

Concerning the limitations, as the industrial output of a city may not necessary sold domestically, export of goods means that they will be sold outside the city. Hence, domestic consumption will be over-estimated from looking at the figures. Furthermore, industrial location in PRD shifts quickly as entrepreneurs are always finding the least cost location. When a place no longer favours industries to set up, factories will leave and the amount of industrial output may not reveal the true picture.

4.2.6 Retail sales

The amount of retail sales reflects the affordability for consumer goods by the general public. Increasing trend of sales means an increase in the expenditure power of the citizens. Higher dispensable income means a stronger ability to increase personal expenditure. Lessons from the Western world shows that the increase of personal income is one of the factors leading to inter-city travel, especially recreational travel. Therefore, retail sales can be an indicator to see are there much "extra money" left by individuals, which may led to their consumption in recreation. The component of retail sales may not only means domestic demand, but also visitors from other places. This implies the demand of transport of moving these visitors.

However, the price for the same good or services can be different in other cities. If a good is more expensive at a place, retail sales will be higher in real terms when compared with others. This address the issue that retail sales itself is complex and the "extra money" cannot be measured accurately. "Extra money" can be channeled to investment. Lastly, the proportion of daily necessities in retail sales is important. If most of the retail sales are for daily necessities, the amount of "extra money" will be less significant.

Chapter Five

Application of Geographic Information Systems in transport

5.1 Defining Geographic Information Systems (GIS)

The late 1980s saw the first widespread use of Geographic Information Systems (GIS) especially in transport research and management (Thill 2000: 3). Although GIS is indifferent from other information systems (IS), consisted of input, process and output, GIS refers to the interactions between a map-based system and text-based system. Image data are inputted and the cartographic data are managed by the system. As an output, charts and reports are being processed. The text-based system usually refers to the attributes of the map input, to be stored in a text format.

GIS is defined as a powerful set of tools for "collecting, storing, retrieving at will, transforming and displaying spatial data from the real world" (Burrough 1986:18). While according to USGS (1997), GIS is a computer system capable of assembling, storing, manipulating and displaying geographically referenced information, which the data are identified according to their locations. GIS is based on the operation of computer and process spatial data. In the sense of transport, there are three categories of GIS models which are having relevance (Goodchild 1992: 401). Firstly, the field models which represent continuous feature of the earth surface. Secondly, discrete models represent discrete features which can be point-based, line-based or polygon-based. Thirdly, network models which represent topologically connected features like roads and railway lines. In short, the functional complexity of GIS make each system different from another.

This chapter will illustrate the basic components of GIS, where their linkages are related to transport context. The recent development in GIS for transportation (GIS-T) will be discussed. The software used in the main part of the research – TransCAD – will serves as a conclusion of this chapter.

5.2 Basic components of GIS

5.2.1 Spatial data and objects

Geographical data, to be precise, are called spatial data. With direct observation of geographic features in the real world, the input, storage and output of geographical data in a computer system does not have much difference with other data. Computer systems are able to handle spatial and non-spatial data. For spatial data, input can be carried out by scanner, digitizer and digital camera. Input of non-spatial data can be done directly by keyboard and mouse. The storage of spatial and non-spatial data can be in the form of hard disks, floppy disks and CD-Roms. Output of spatial data can be from the screen or printed by printer or plotter, while output of non-spatial data can only done by printer. Therefore, different processing tools are suitable for spatial and non-spatial data.

Data in GIS are stored in terms of records of entries. In other words, it refers to the number of observations. Since observations in a database may be large, it is not possible to have all data entry in a single file, there are usually a number of files in one database. To allow interaction between the data files, or for "cross-referencing" purposes, data files are internally linked. This structure is called "relational database systems" (Burrough & McDonnell 1998: 47). "Lookup table" provides detain explanation on specified categories in the database (figure 5.1).

Spatial objects vary in their dimension when stored in the GIS. Point features are of zero-dimension which are end points or vertices. Line features are one dimensional as they are connections of two or more points. Area features are two dimensional as they are in the area of a polygon. A more complex polygon is also known as a regional feature. By overlaying, all spatial objects overlap each other on the same surface. In other words, all features of different dimension are put on the same map.

The creation of spatial data set involves several stages of model development, as described by Peuquet (1984). For spatial data model, it refers to a formalization of the "analogue abstraction without any conventions or restrictions on implementation" (Burrough & McDonnell 1998: 18). Section 5.2.2 will give additional explanation on different types of spatial data structure.

Figure 5.1
Relational database systems and lookup table

Record number	ID	Area	Feature
Record 1	**78**	45623	Water
Record 2	**21**	84652	Trees
Record 3	**127**	91486	Grass
Record 4	**214**	60853	Flowers

First related file

Linked by common IDs

Record number	ID	Population	GDP	Class
Record 61	**21**	9465154	84354534	1
Record 62	**127**	2344248	98440735	6
Record 63	**78**	6078987	56806541	8
Record 64	**214**	5338026	10912456	1

Host file

The "host file" and the "first related file" store different record, and they have different record numbers. To link the "first related file" to the "host file", the common IDs **(bold font)** help to match the records together. For example, record 1 of first related file is linked to record 63 of the host file as they have a common ID "78". The key to relate the files is their ID.

Class	Description
1	Commercial type A
2	Commercial type B
3	Industrial
4	Educational
5	Residential
6	Recreational
7	Rural
8	Others

Lookup table

For the ease of entry when classifying the items, "class" in numbers are assigned as shown in the host file. Entry of the class may be lengthy. A simple method is to assign numbers to each of the class and set up a lookup table with description of individual class. The field "class" in the lookup table is referenced directly to the field "class" of the host file.

5.2.2. Data structure

The technique of arranging spatial data is data structure. Appropriate arrangement not only allows higher efficiency in storage, an ordered storage also allows faster speed of data retrieval. Raster and vector are the two main data structure. Raster is designed for representing a continuous phenomena, like a field-based model, based on a regular grid of cells covering the whole area (Burrough & McDonnell 1998: 304). Vector is designed to represent discrete objects, which is an object-based model based on point, line and polygon features (Burrough & McDonnell 1998: 306). Furthermore, vector is sub-divided into spaghetti and arc-node structures. Spaghetti structure refers to the use of coordinate-based method of x, y coordinates. Arc-node refers to the use of graph-theory-based method, also known as topological relationship (Dueker 2000: 255).

5.2.3 Routing and networking

Routing determines the "optimal paths for the movement of resources through a network" (Lai 2002a). To show the location of individual features on the map, address matching and geocoding help to locate the spatial locations within the spatial data. For example, the application of coordinate system can provide unique identification for the specified address. Routing also covers the "heuristic approach" in route selection.

Networking refers to the configuration of linear features to form lines for the flow. Resources flow depends on the roads itself, such as the width, speed limit and traffic control along the street. The complex configuration of roads, particular at junctions, can be handled by GIS conveniently. For instance, Caliper's TransCAD (section 5.4) is one GIS product which offers shortest path solutions.

Linked to networking are other forms of network analysis (Thill 2000: 4) from location-allocation modeling to vehicle routing, scheduling and network connectivity optimization and design. With the complex configuration of the network, models of network analysis are incorporated with some features of travel impedance on each network link. Furthermore, some of them have the capabilities of line specific traffic capacity attributes.

5.3 GIS for Transportation (GIS-T)

The strong relationship between geography and transport is one of the reasons resulting the development of GIS applications in Transportation. GIS can assist transport planning in handling traffic control, monitoring, analysis and planning (Lai 2002b). Indeed, the view of looking at transportation has changed from a group of modally segregated physical components to a means of movement (Sandia National Laboratories 2002). It is because the physical components, such as highways, bridges, tunnels, airports and sea ports can be integrated to channel the movement of people and goods.

As GIS can handle the complex relationships of transport infrastructure, in terms of transport management, its capabilities covers the area of infrastructure management, fleet and logistics management and transit management (ESRI 2002a). Infrastructure management refers to managing transport facilities in a spatial way. The physical location for the facilities may affect the construction and the usage level. For inter-city rail, the exact location of the stations, maintenance area, bridges and tunnels along the alignment comes to the field of infrastructure management. Fleet and logistics management refers to the decision making for allocating vehicles and vessels to collect and drop off passengers or goods. The time required to complete a whole route will affect the total fleet required, and the cost of operating the fleet. For inter-city rail, fleet refers to the train compartments required. The shorter the time to complete a journey, the smaller number the fleet and fewer employees. Additional fleet is also required for emergency use, and to substitute the original service when other trains are under maintenance. Transit management refers to the actual planning of the route, and services directly to the customers, like the operators, customer service and marketing representatives. For inter-city rail, staff on the train contributes a significant part. Customer service staff at the stations are also required to answer queries from passengers. They can handle enquiries on routing by using applications of GIS. The applications of GIS can cover a wide aspect of the operation of rail operation.

Development of GIS-T had been argued by academics that the development is more technologically motivated (Fletcher 2000). The challengers brought by GIS-T include the legacy (Thill 2000:9) of the data management system where a wide variety of types of information are to be handled by GIS. To operate different sets of data on the same "platform" requires a sound level of interoperability of the GIS applications.

Increasing demand for GIS-T is also noted at the development of real-time GIS-T, such as the Global Positioning System (GPS) for real-time identification of vehicles. Real time traffic data for traffic situation monitoring and emergency operation is becoming more popular. Research of GIS-T in China applied to the decision making support system for the railway network plan (Zhang and Wang 1999: 11). There are still ongoing concerns for data accuracy. Indeed, the reality of transport infrastructure is multi-faceted and becoming more multi-disciplinary. It is anticipated that the scope of development of GIS-T will continue to be broaden in future.

5.4 TransCAD capabilities

5.4.1 Overview

TransCAD is a GIS application developed by Caliper Corporation with first edition in 1986. The version used in this study is 3.0 for Windows operating environment. The reason for choosing TransCAD is the ability of this application especially in trip distribution modeling. Concerning other GIS software's availability, TransCAD is preferred then others in the study of transport data analysis.

TransCAD is equipped for transport data management and analysis. Its capabilities cover digital thematic mapping, geographic database management and output of graphics for further analysis. The software is a vector GIS application and stores spatial data in the topological format. Besides the "extended data model" which support the complex data structures, its core set of tools can be used in transport analysis and modeling (Caliper 1996: 2-3).

Basic operation of TransCAD is similar to other GIS applications. Thematic map creation, layering, customizing, data and data table editing are the basic features. Concerning the use for transport data analysis, it allows network setting and analysis, pin mapping and geocoding, route finding, linear referencing and matrices operation (Caliper 1996). In the field of modeling, it has extensions on all operations on the four stage model (chapter 3). Trip generation, trip distribution, model split and route assignment with their extensions like balancing and cross-classification are also included.

5.4.2 TransCAD in this study

The main analysis of this research will be discussed in chapter 6, where TransCAD will be used as the application. The feature which will be used is the trip distribution function. As illustrated in the formulae of the gravity model (section 4.1), the distance and population of two cities are the determining factors of spatial interaction. The distance and population of the selected PRD city pairs will be inputted to generate an O/D matrix. Additional matrices will be generated using GDP, GDP per capita, industrial output and retail sales, substituting the value of population in the formulae. The results offer predictions to inter-city traffic volume comparison in the final analysis.

Chapter Six

Analysis of the inter-city travel pattern in the Pearl River Delta

6.1 Introduction

The following analysis is divided into two parts. Firstly, there will be a general discussion on the overall trip distribution in the 28 selected cities of PRD. Five basic matrices, based on the relationship between their distances and population, GDP, GDP per capita, industrial output and retail sales will be the tools to generate the O/D pattern of the cities. The estimated O/D matrix by the Guangdong Infrastructure Bureau will be used for comparing with these five matrices. Secondly, there will be an in-depth focus on five selected major cities in PRD. Specific figures will show the trip distribution pattern of these five cities. The basis is the same as the factors as in the first part of the analysis.

6.2 Structure of analysis

The analysis covers 28 cities of PRD. The reason for using these 28 cities is because the data from the Guangdong Infrastructure Bureau also covers these cities. To compare the results in a more convenient way, these cities are chosen. Although the planning document also includes the data of Hong Kong and Macau, they are not included in this analysis owing to political reasons. Hong Kong and Macau are presently the Special Administrative Regions in the PRD. While different planning jurisdictions and problems for transport planning exists, the factors affecting the construction of inter-city rail in these two cities are more complex at the meantime.

Figure 6.1 illustrates the structure for the first part of the study. It covers all of the 28 cities to be studied. From the top of figure 6.1, the distances of the city pairs are found from the length of the inter-city highway between the O/D pairs (Table 6.1). As discussed in the part of gravity model (chapter 4), population will be used to form a O/D matrix with the inte-city highway distances. The function of trip distribution of TransCAD will be used. Factors other than population will then be used to generate their O/D matrices. Afterwards, these 5 matrices will be compared with the O/D matrix estimated by the Guangdong Infrastructure Bureau.

Figure 6.1
Structure of the analysis: First part of the discussion – section 6.3

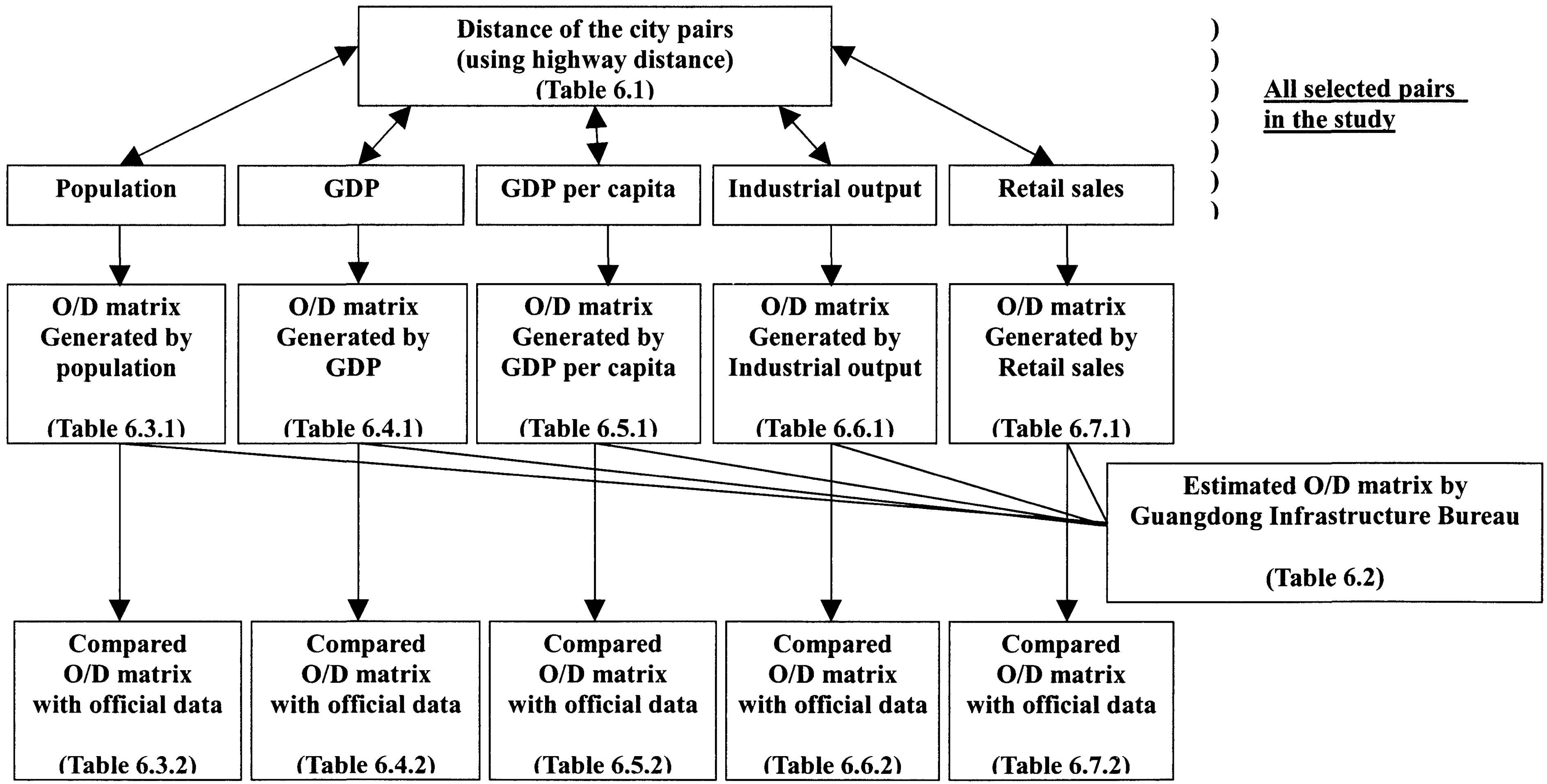
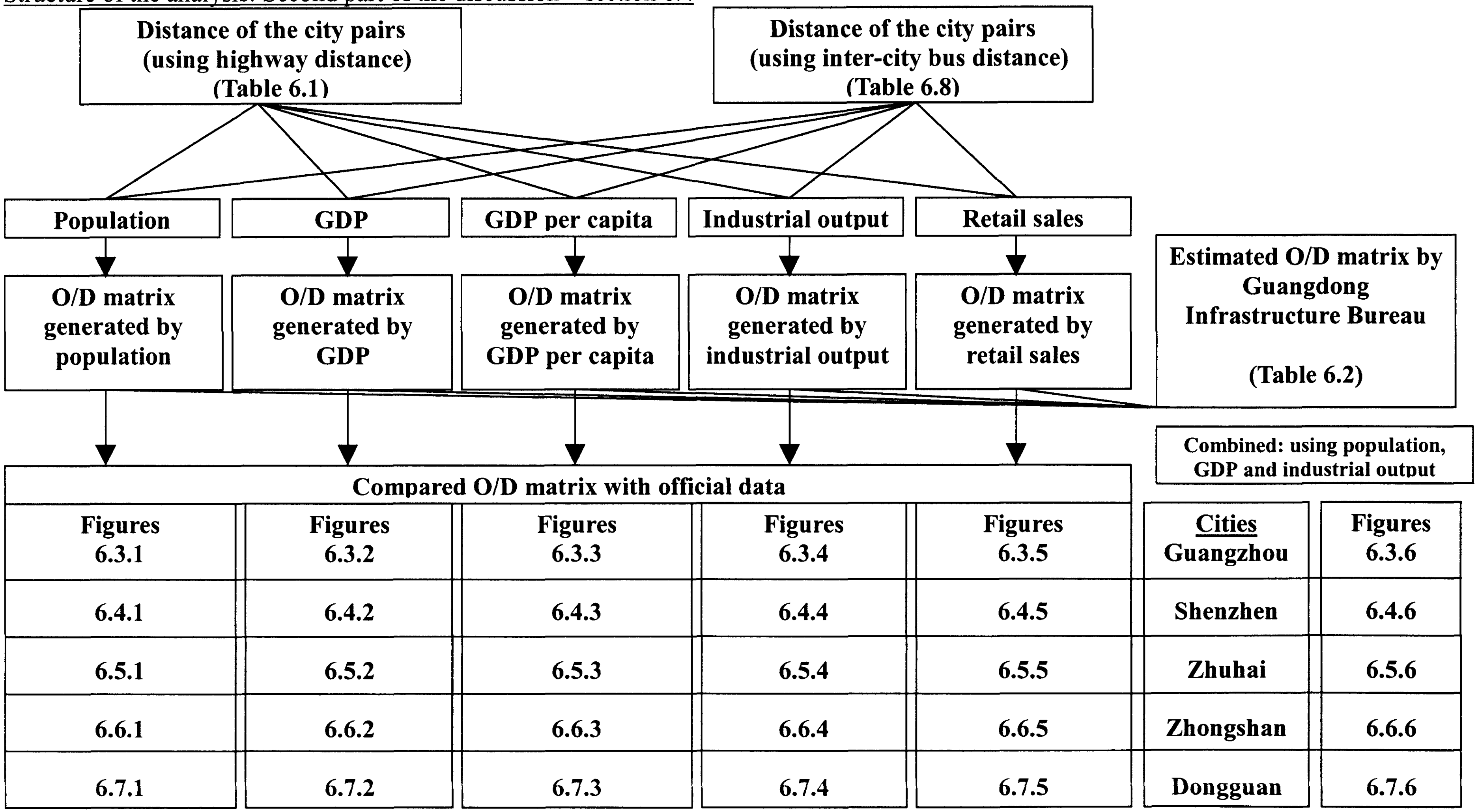


Figure 6.2 illustrates the second part of the study. Further to the inter-city highway distances matrix (Table 6.1) in the first part, inter-city bus journey distance matrix (Table 6.8) will be equipped in the analysis. The inter-city bus journey distances are obtained from their schedule of services. The focus will be on five major cities in PRD, Guangzhou, Shenzhen, Zhuhai, Zhongshan and Dongguan. The two distances data will be used to generate the O/D matrix of these five cities, using the trip distribution function in TransCAD. As the same as the first part, O/D matrices will also be generated based on population, GDP, GDP per capita, industrial output and retail sales. Each of the cities will have the first 5 graphs showing their O/D patterns based on population, GDP, GDP per capita, industrial output and retail sales separately. The 5 matrices will be compared with the O/D matrix estimated by the Guangdong Infrastructure Bureau, being classified according to each of the cities. An additional graph for each of the cities will put population, GDP and industrial output together when comparing with the O/D matrix estimated by the government.

Figure 6.2
Structure of the analysis: Second part of the discussion – section 6.4



6.3 A comparison of trip distribution in PRD cities, with O/D matrices generated using TransCAD and compared with the data of Guangdong Infrastructure Bureau

Table 6.1 shows the inter-city highway distance matrix of the PRD cities in the study, which will be the primary input for TransCAD in generating the O/D matrices to be discussed in this section. Table 6.2 illustrates the O/D matrix estimated by the Guangdong Infrastructure Bureau, which will be the comparative tool with the own findings.

6.3.1 Population

Table 6.3.1 shows the O/D matrix using the population of the PRD cities as another input, as a result of trip distribution. It is then compared with the official prediction in table 6.3.2. From table 6.3.2., the number of trips generated from own findings quite match with that of the official predictions.

Trips generated in the own findings are greater than that of the official estimation in general. Despite, the level of derivation between own findings and the official one are limited. The general level of derivation is lower for cities of Shenzhen, Zhuhai, Dongguan and Huizhou, where the derivation on average falls below 100%. However, sharp discrepancies are found for the trips between Nanhai and Foshan, where own findings values 86 times more than the official prediction. Even contrasting results is found from the pair of Shunde and Nanhai, where own findings is 506 times above the official prediction.

Findings from the population generated matrix are two fold. For larger cities, own findings have a higher correlation with the official prediction. From table 6.3.2, cities of Shenzhen, Zhuhai, Dongguan, Huizhou and Huadu do not have derivation greater than or equal to 10 times of the official estimation. Own estimation matches well with government data. However, medium sized cities like Nanhai, Shunde, Xinhui and Taishan have the greatest level of derivation, with more than five pairs of these cities generate trips more than 10 times of government data. This suggests possible under-estimation of trips in these medium sized cities.

Table 6.1

Distance matrix of PRD cities in the study (using highway distances) (km)

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng	Conghua	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen
Guangzhou	0	150.7	115.6	38.4	87.6	95.2	64.1	159	197	199	134.2	27.2	48.4	68.6	60	40.8	40.4	86.6	49.2	100.8	66.8	163.4	122	127.4	120.6	123.8	83.6	130.2
Shenzhen	150.7	0	162.2	178.9	228.1	135.4	102.8	74.4	148	102.4	101.6	113.4	189.9	150.6	191.3	171.7	126.2	227.1	190.1	241.3	196.6	251	203.8	215.4	261.5	264.7	224.5	170.4
Zhuhai	115.6	162.2	0	168.4	89.6	65.2	124	220.4	196	250.4	247.6	98.8	181.6	171.8	212.5	166	112	162.2	201.2	88.4	126.4	180.8	133.6	145.2	272.6	275.8	235.6	37.2
Foshan	38.4	178.9	168.4	0	66.8	117.2	91.9	186.6	224.6	226.6	161.8	33.6	68	96.1	85.2	4.4	30.4	66.6	45.6	88.4	46	142	94.8	106.4	117	120.2	80	155.4
Jiangmen	87.6	228.1	89.6	66.8	0	39.2	121.6	218	193.6	272.4	245.2	96.4	121.2	149.3	138.4	64.4	42.4	59.4	98.8	14	25.6	103.6	56.4	68	170.2	173.4	133.2	81
Zhongshan	95.2	135.4	65.2	117.2	39.2	0	97.2	193.6	169.2	223.6	220.8	72	154.8	145	185.7	114.8	41.2	112.6	151.6	80	76.8	131.2	84	95.6	223	226.2	186	51.2
Dongguan	64.1	102.8	124	91.9	121.6	97.2	0	150	125.6	180	177.2	74.8	104.7	65.4	106.1	89.5	88	141.9	106.7	119.6	158.4	212.8	165.6	177.2	178.1	181.3	141.1	143.6
Huizhou	159	74.4	220.4	186.6	218	193.6	150	0	38	40	26	171.2	199.4	99.6	160.8	184.2	184.4	200.4	180.8	216	254.8	309.2	262	273.6	252.2	255.4	215.2	240
Huiyang	197	148	196	224.6	193.6	169.2	125.6	38	0	54.4	64	144.8	237.4	137.6	198.8	203.5	158	247.9	212.7	189.6	228.4	282.8	235.6	247.2	284.1	287.3	247.1	213.6
Huidong	199	102.4	250.4	226.6	272.4	223.6	180	40	54.4	0	66	199.2	239.4	139.6	200.8	257.9	212.4	302.3	267.1	244	282.8	337.2	290	301.6	338.5	341.7	301.5	268
Boluo	134.2	101.6	247.6	161.8	245.2	220.8	177.2	26	64	66	0	138.1	158.9	56	124.6	143.7	185.8	196.1	160.9	217.4	256.2	310.6	263.4	275	232.3	235.5	195.3	241.4
Panyu	27.2	113.4	98.8	33.6	96.4	72	74.8	171.2	144.8	199.2	138.1	0	88.8	88.1	90.4	30.4	18	86.2	80.8	94.4	133.2	187.6	140.4	152	152.2	155.4	115.2	118.4
Huadu	48.4	189.9	181.6	68	121.2	154.8	104.7	199.4	237.4	239.4	158.9	88.8	0	109.4	59.6	65.6	98.4	121	82.4	142.8	100.4	196.4	149.2	160.8	153.8	157	116.8	231.1
Zengcheng	68.6	150.6	171.8	96.1	149.3	145	65.4	99.6	137.6	139.6	56	88.1	109.4	0	80.4	93.7	126.5	149.5	110.9	167.4	206.2	260.6	213.4	225	182.3	185.5	145.3	191.4
Conghua	60	191.3	212.5	85.2	138.4	185.7	106.1	160.8	198.8	200.8	124.6	90.4	59.6	80.4	0	90.8	117.2	141	96.2	161.6	120.4	215.2	168	179.6	167.6	170.8	130.6	238.7
Nanhai	40.8	171.7	166	4.4	64.4	114.8	89.5	184.2	203.5	257.9	143.7	30.4	65.6	93.7	90.8	0	31.2	65.4	41.2	86	43.6	139.6	92.4	104	112.6	115.8	75.6	142
Shunde	40.4	126.2	112	30.4	42.4	41.2	88	184.4	158	212.4	185.8	18	98.4	126.5	117.2	31.2	0	61.4	76.4	54	39.2	137.6	90.4	102	147.8	151	110.8	110
Gaoming	86.6	227.1	162.2	66.6	59.4	112.6	141.9	200.4	247.9	302.3	196.1	86.2	121	149.5	141	65.4	61.4	0	99	86.6	41.8	140.2	93	104.6	170.4	173.6	133.4	142.6
Sanshui	49.2	190.1	201.2	45.6	98.8	151.6	106.7	180.8	212.7	267.1	160.9	80.8	82.4	110.9	96.2	41.2	76.4	99	0	120.8	78.4	174.4	127.2	138.8	71.4	74.6	34.4	176.8
Xinhui	100.8	241.3	88.4	88.4	14	80	119.6	216	189.6	244	217.4	94.4	142.8	167.4	161.6	86	54	86.6	120.8	0	48	102.4	55.2	66.8	192.2	195.4	155.2	56
Heshan	66.8	196.6	126.4	46	25.6	76.8	158.4	254.8	228.4	282.8	256.2	133.2	100.4	206.2	120.4	43.6	39.2	41.8	78.4	48	0	101.6	54.4	66	149.8	153	112.8	104
Enping	163.4	251	180.8	142	103.6	131.2	212.8	309.2	282.8	337.2	310.6	187.6	196.4	260.6	215.2	139.6	137.6	140.2	174.4	102.4	101.6	0	52	71	245.8	249	208.8	158.4
Kaiping	122	203.8	133.6	94.8	56.4	84	165.6	262	235.6	290	263.4	140.4	149.2	213.4	168	92.4	90.4	93	127.2	55.2	54.4	52	0	19	198.6	201.8	161.6	111.2
Taishan	127.4	215.4	145.2	106.4	68	95.6	177.2	273.6	247.2	301.6	275	152	160.8	225	179.6	104	102	104.6	138.8	66.8	66	71	19	0	210.2	213.4	173.2	122.8
Zhaoqing	120.6	261.5	272.6	117	170.2	223	178.1	252.2	284.1	338.5	232.3	152.2	153.8	182.3	167.6	112.6	147.8	170.4	71.4	192.2	149.8	245.8	198.6	210.2	0	3.2	60	248.2
Gaoyao	123.8	264.7	275.8	120.2	173.4	226.2	181.3	255.4	287.3	341.7	235.5	155.4	157	185.5	170.8	115.8	151	173.6	74.6	195.4	153	249	201.8	213.4	3.2	0	63.2	251.4
Sihui	83.6	224.5	235.6	80	133.2	186	141.1	215.2	247.1	301.5	195.3	115.2	116.8	145.3	130.6	75.6	110.8	133.4	34.4	155.2	112.8	208.8	161.6	173.2	60	63.2	0	211.2
Doumen	130.2	170.4	37.2	155.4	81	51.2	143.6	240	213.6	268	241.4	118.4	231.1	191.4	238.7	142	110	142.6	176.8	56	104	158.4	111.2	122.8	248.2	251.4	211.2	0

(Source: Universal publications (2002)

Table 6.2

Estimated Origin / Destination matrix showing the number of trips per year (in 000's) by the Guangdong Infrastructure Bureau

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng	Conghua	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	Total
Guangzhou	0	10530	4680	10440	2100	4380	34820	2810	3440	1610	590	12260	47880	6360	5810	11540	6000	3020	2990	1340	2550	2300	2100	1400	3330	5190	3190	340	**193000**
Shenzhen	9330	0	1840	1670	570	3410	30180	7150	690	4130	1220	2500	790	2380	140	1000	1740	480	540	250	110	420	390	260	610	960	590	260	**73610**
Zhuhai	2440	1300	0	3900	490	20330	3630	1540	350	290	1060	1300	210	100	100	570	3650	110	480	220	100	370	340	230	530	830	510	1350	**46330**
Foshan	9910	1950	3460	0	490	9370	1430	660	660	380	140	1810	850	1490	220	9030	7570	710	700	320	600	530	490	330	780	1220	750	1840	**57690**
Jiangmen	2120	570	530	490	0	870	1620	680	150	130	100	1890	190	120	130	290	530	14960	90	3700	11380	390	360	240	120	70	50	70	**41840**
Zhongshan	4390	2370	21820	10670	880	0	6650	2810	630	530	1890	2370	370	190	160	1020	18590	200	860	380	170	650	600	400	960	1490	910	5430	**87390**
Dongguan	34800	27830	3450	1430	1600	6770	0	7340	1950	11750	3560	6460	520	17480	280	850	1050	1580	570	700	1330	1200	1100	730	1740	320	1670	520	**138580**
Huizhou	2770	6040	2160	640	660	4000	7330	0	18260	6080	1430	1800	240	780	130	390	470	2890	110	290	540	490	460	300	720	130	690	300	**60100**
Huiyang	3380	610	500	630	150	930	1760	18250	0	11410	330	610	200	190	30	380	610	130	150	70	30	110	110	70	160	260	160	80	**41300**
Huidong	1460	3410	420	340	130	770	9790	610	11350	0	280	3410	40	150	20	210	510	110	40	50	20	100	90	50	140	20	130	70	**33720**
Boluo	590	1210	1130	140	100	1860	3520	1440	330	270	0	110	50	380	20	90	100	610	20	70	120	110	10	70	150	30	140	140	**12810**
Panyu	11540	1940	1250	1920	1960	2450	10800	1720	630	530	100	0	990	120	1070	2120	23220	560	560	910	560	420	770	260	610	960	590	190	**68750**
Huadu	47700	910	230	900	190	380	520	240	190	40	50	1070	0	2550	500	1000	52	1170	4280	120	220	200	190	120	290	450	270	30	**63862**
Zengcheng	7510	2360	110	330	120	190	17440	790	170	150	380	120	2550	0	1000	1060	110	750	1220	80	140	130	120	80	190	30	190	10	**37330**
Conghua	5870	190	100	230	140	160	290	130	30	20	20	1070	500	1000	0	830	1000	410	1610	80	50	40	40	30	90	20	50	10	**14010**
Nanhai	10630	1210	680	8900	300	1110	880	410	410	230	90	1940	910	930	850	0	68	440	440	200	370	340	300	210	480	750	470	1140	**34688**
Shunde	5890	2000	3350	7770	540	17700	1080	450	640	540	90	23050	500	120	1020	630	0	530	530	240	160	400	370	250	590	910	570	2200	**72120**
Gaoming	2810	470	110	650	15120	190	1470	2780	120	110	580	510	1100	720	380	390	480	0	520	1180	11490	120	110	80	700	380	130	10	**42710**
Sanshui	2910	530	500	680	100	820	530	120	140	40	20	530	4340	1300	1630	400	500	590	0	50	110	100	100	70	150	230	140	70	**16700**
Xinhui	1360	250	230	320	3670	380	710	290	70	50	70	950	120	80	80	190	230	1180	50	0	1010	210	190	130	80	40	30	30	**12000**
Heshan	2630	110	100	610	11180	160	1370	570	30	20	120	540	230	150	50	370	160	11510	110	1060	0	110	100	70	140	80	70	10	**31660**
Enping	2320	420	390	540	400	640	1210	500	110	100	110	420	200	130	40	330	390	130	100	200	110	0	200	100	130	70	70	50	**9410**
Kaiping	2110	380	360	490	370	590	1100	460	100	90	100	790	190	120	50	290	360	120	90	170	100	210	0	5050	120	70	50	40	**13970**
Taishan	1420	260	240	330	250	390	740	300	70	50	70	260	120	80	30	200	240	80	50	120	70	100	5040	0	80	40	30	30	**10690**
Zhaoqing	4190	760	720	980	120	1170	2190	900	210	170	190	760	360	240	90	590	720	230	170	80	150	140	120	90	0	19980	6260	90	**41670**
Gaoyao	5300	970	900	1230	70	1480	370	150	260	30	30	970	460	40	30	740	900	90	220	40	80	80	70	40	20860	0	3360	110	**38880**
Sihui	2490	460	420	580	50	700	1310	530	120	100	110	460	220	140	50	350	420	130	100	40	80	70	50	40	7860	4240	0	50	**21170**
Doumen	3140	700	630	730	70	5970	530	830	190	150	150	700	270	10	110	440	1400	10	70	30	10	50	40	30	80	120	80	0	**16540**
Total	**191010**	**69740**	**50310**	**57540**	**41820**	**87170**	**143270**	**54460**	**41300**	**39000**	**12880**	**68660**	**64400**	**37350**	**14020**	**35300**	**71070**	**42730**	**16670**	**11990**	**31660**	**9390**	**13860**	**10730**	**41690**	**38890**	**21150**	**14470**	**1332530**

(Source: City and County Planning Section, Guangdong Infrastructure Bureau and Number 4 Design Institute, Railway Bureau (2001: 74))

Table 6.3.1

Origin / Distination matrix showing the number of trips per year (in 000's)

Generated by 2001's population, given k coefficient = 0.002781301, distance coefficient = 2

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng	Conghua
Guangzhou	0.00	9329.97	9118.18	53760.61	9170.58	23873.55	60103.57	2449.79	2611.05	2825.06	6887.19	197578.48	40743.83	28117.33	23702.19
Shenzhen	9329.97	0.00	1059.93	566.84	309.53	2700.89	5347.91	2560.54	1058.71	2441.67	2749.88	2601.39	605.70	1335.14	533.60
Zhuhai	9118.18	1059.93	0.00	367.89	1153.61	6698.33	2113.70	167.79	347.14	234.82	266.27	1970.76	380.88	589.99	248.68
Foshan	53760.61	566.84	367.89	0.00	1350.28	1348.68	2503.56	152.29	171.99	186.55	405.66	11085.94	1767.29	1226.73	1006.43
Jiangmen	9170.58	309.53	1153.61	1350.28	0.00	10702.14	1269.41	99.05	205.49	114.60	156.80	1195.57	493.85	451.18	338.59
Zhongshan	23873.55	2700.89	6698.33	1348.68	10702.14	0.00	6108.32	386.15	827.15	522.91	594.55	6589.47	930.78	1470.70	578.24
Dongguan	60103.57	5347.91	2113.70	2503.56	1269.41	6108.32	0.00	734.18	1713.29	920.98	1053.62	6968.47	2322.32	8251.44	2021.73
Huizhou	2449.79	2560.54	167.79	152.29	99.05	386.15	734.18	0.00	4694.08	4677.18	12273.57	333.61	160.57	892.22	220.74
Huiyang	2611.05	1058.71	347.14	171.99	205.49	827.15	1713.29	4694.08	0.00	4137.42	3314.22	763.02	185.35	764.86	236.29
Huidong	2825.06	2441.67	234.82	186.55	114.60	522.91	920.98	4677.18	4137.42	0.00	3440.64	445.12	201.23	820.41	255.71
Boluo	6887.19	2749.88	266.27	405.66	156.80	594.55	1053.62	12273.57	3314.22	3440.64	0.00	1026.80	506.41	5652.49	736.29
Panyu	197578.48	2601.39	1970.76	11085.94	1195.57	6589.47	6968.47	333.61	763.02	445.12	1026.80	0.00	1910.96	2691.50	1648.46
Huadu	40743.83	605.70	380.88	1767.29	493.85	930.78	2322.32	160.57	185.35	201.23	506.41	1910.96	0.00	1139.69	2476.27
Zengcheng	28117.33	1335.14	589.99	1226.73	451.18	1470.70	8251.44	892.22	764.86	820.41	5652.49	2691.50	1139.69	0.00	1886.46
Conghua	23702.19	533.60	248.68	1006.43	338.59	578.24	2021.73	220.74	236.29	255.71	736.29	1648.46	2476.27	1886.46	0.00
Nanhai	106256.43	1373.06	844.75	782246.62	3241.57	3136.39	5889.69	348.71	467.46	321.33	1147.51	30217.10	4237.09	2879.16	1977.16
Shunde	107634.91	2524.36	1843.11	16275.80	7427 38	24185.74	6050.81	345.59	770.19	470.53	681.74	85604.23	1870.36	1568.93	1178.69
Gaoming	6027.42	200.58	226.12	872.55	973.75	833.16	598.78	75.29	80.50	59.77	157.47	960.46	318.27	289.04	209.54
Sanshui	25575.80	392.06	201.27	2549.20	482.06	629.50	1450.42	126.69	149.77	104.86	320.36	1497.14	939.95	719.39	616.52
Xinhui	13788.33	550.64	2359.38	1534.98	54328.58	5115.53	2612.36	200.86	426.53	284.34	397.11	2482.06	708.23	714.48	494.41
Heshan	12675.46	334.89	465.90	2288.62	6559.77	2240.95	601.27	58.28	118.66	85.46	115.44	503.31	578.43	190.11	359.58
Enping	2812.89	272.81	302.36	318.90	531.85	1019.60	442 36	52.55	102.78	79.81	104.29	336.91	200.71	158.04	149.46
Kaiping	7307.98	599.32	802.00	1036.27	2599.02	3602.43	1057.94	105.99	214.47	156.28	210.03	871.18	503.71	341.35	355.17
Taishan	9862.71	789.58	999.25	1210.67	2631.29	4093.15	1359.79	143.05	286.70	212.64	283.57	1093.89	638.21	451.90	457.36
Zhaoqing	5210.27	253.61	134.21	473.98	198.83	356.11	637.22	79.70	102.76	79.91	188.13	516.48	330.25	325.87	248.63
Gaoyao	7650.34	382.97	202.86	694.84	296.40	535.52	951.46	120.24	155.47	121.34	283.23	766.56	490.37	486.97	370.41
Sihui	9616.85	305.19	159.35	899.16	287.93	454.00	900.44	97.08	120.47	89.34	236.07	799.59	507.88	454.97	363.16
Doumen	2815.48	376.17	4539.00	169.22	552.91	4254.74	617.35	55.43	114.49	80.29	109.72	537.52	92.12	186.19	77.20
Total	**787506.23**	**41556.93**	**37797.53**	**886471.55**	**107122.03**	**113788.66**	**124602.39**	**31611.23**	**24140.29**	**23370.21**	**43299.03**	**362995.94**	**65240.70**	**64056.57**	**42746.96**

	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	Total
Guangzhou	106256.43	107634.91	6027.42	25575.80	13788.33	12675.46	2812.89	7307.98	9862.71	5210.27	7650.34	9616.85	2815.48	**787506.23**
Shenzhen	1373 06	2524.36	200 58	392.06	550.64	334.89	272.81	599.32	789.58	253.61	382.97	305.19	376.17	**41556.93**
Zhuhai	844.75	1843.11	226.12	201.27	2359.38	465.90	302.36	802.00	999.25	134.21	202.86	159.35	4539.00	**37797.53**
Foshan	782246.62	16275.80	872.55	2549.20	1534.98	2288.62	318.90	1036 27	1210.67	473.98	694.84	899.16	169.22	**886471.55**
Jiangmen	3241.57	7427.38	973.75	482.06	54328.58	6559.77	531.85	2599.02	2631.29	198.83	296.40	287.93	552.91	**107122.03**
Zhongshan	3136.39	24185.74	833.16	629.50	5115.53	2240.95	1019.60	3602.43	4093.15	356.11	535.52	454.00	4254.74	**113788.66**
Dongguan	5889.69	6050.81	598.78	1450.42	2612.36	601.27	442.36	1057 94	1359 79	637.22	951.46	900.44	617.35	**124602.39**
Huizhou	348.71	345.59	75.29	126.69	200.86	58.28	52.55	105.99	143.05	79.70	120.24	97.08	55.43	**31611.23**
Huiyang	467.46	770.19	80.50	149.77	426.53	118.66	102.78	214.47	286.70	102.76	155.47	120.47	114.49	**24140.29**
Huidong	321.33	470.53	59.77	104.86	284.34	85.46	79.81	156.28	212.64	79.91	121.34	89.34	80.29	**23370.21**
Boluo	1147.51	681.74	157.47	320.36	397.11	115.44	104.29	210.03	283.57	188.13	283.23	236.07	109.72	**43299.03**
Panyu	30217.10	85604.23	960.46	1497.14	2482.06	503.31	336.91	871.18	1093.89	516.48	766.56	799.59	537.52	**362995.94**
Huadu	4237.09	1870.36	318.27	939.95	708.23	578 43	200.71	503.71	638.21	330.25	490.37	507.88	92.12	**65240.70**
Zengcheng	2879.16	1568.93	289.04	719.39	714.48	190.11	158.04	341.35	451.90	325.87	486.97	454.97	186.19	**64056.57**
Conghua	1977.16	1178.69	209.54	616.52	494.41	359.58	149.46	355.17	457.36	248.63	370.41	363.16	77.20	**42746.96**
Nanhai	0.00	34476.97	2018 99	6967.67	3618.75	5684.16	736.22	2433.86	2827.42	1141.83	1670.43	2246.59	452.19	**1008859.09**
Shunde	34476.97	0.00	2275.06	2012.50	9116.08	6984.05	752.63	2525.47	2919.43	658.22	975.73	1038.79	748.43	**322915.73**
Gaoming	2018.99	2275.06	0.00	308.39	912.03	1580.44	186.54	614.00	714.31	127.42	189.95	184.39	114.59	**21108.82**
Sanshui	6967.67	2012.50	308.39	0.00	641.96	615.31	165.11	449.52	555.60	993.95	1408.80	3797.83	102.10	**53773.69**
Xinhui	3618.75	9116.08	912.03	641.96	0.00	3714.61	1083.77	5401.55	5428.28	310.40	464.68	422.22	2302.92	**119415.08**
Heshan	5684.16	6984.05	1580.44	615.31	3714.61	0.00	444.46	2245.34	2244 97	206.30	305.99	322.69	269.57	**51794.01**
Enping	736.22	752.63	186.54	165.11	1083.77	444.46	0.00	3262.98	2575.86	101.74	153.40	125.05	154.30	**16627.41**
Kaiping	2433.86	2525.47	614.00	449.52	5401.55	2245.34	3262.98	0.00	52094.49	225.71	338.25	302.36	453.45	**90110.13**
Taishan	2827.42	2919.43	714.31	555.60	5428.28	2244 97	2575.86	52094.49	0.00	296.53	445.16	387.38	547.22	**95550.40**
Zhaoqing	1141.83	658.22	127.42	993.95	310.40	206.30	101.74	225.71	296.53	0.00	937181.71	1528.08	63.41	**951971.25**
Gaoyao	1670.43	975.73	189 95	1408.80	464.68	305.99	153 40	338.25	445.16	937181.71	0.00	2130.98	95.63	**958869.69**
Sihui	2246.59	1038.79	184.39	3797.83	422.22	322.69	125.05	302.36	387.38	1528.08	2130.98	0.00	77.67	**27855.54**
Doumen	452.19	748.43	114.59	102.10	2302.92	269.57	154.30	453.45	547.22	63.41	95.63	77.67	0.00	**19959.33**
Total	**1008859.09**	**322915.73**	**21108.82**	**53773.69**	**119415.08**	**51794.01**	**16627.41**	**90110.13**	**95550.40**	**951971.25**	**958869.69**	**27855.54**	**19959.33**	**6495116.40**

Table 6.3.2

Comparison of the number of trips generated (by 2001's population) between Table 6.3.1 (self prediction) and Table 6.2 (official prediction)

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng	Conghua	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	Average
Guangzhou	n/a	-11.40%	94.83%	414.95%	336.69%	445.06%	72.61%	-12.82%	-24.10%	75.47%	**1067.32%**	**1511.57%**	-14.90%	342.10%	307.96%	820.77%	**1693.92%**	99.58%	755.38%	928.98%	397.08%	22.30%	248.00%	604.48%	56.46%	47.41%	201.47%	728.08%	415.16%
Shenzhen	0.00%	n/a	-42.40%	-66.06%	-45.70%	-20.79%	-82.28%	-64.19%	**53.44%**	-40.88%	125.40%	4.06%	-23.33%	-43.90%	281.14%	37.31%	45.08%	-58.21%	-27.40%	120.26%	204.45%	-35.04%	53.67%	203.69%	-58.42%	-60.11%	-48.27%	44.68%	16.90%
Zhuhai	273.70%	-18.47%	n/a	-90.57%	135.43%	-67.05%	-41.77%	-89.10%	-0.82%	-19.03%	-74.88%	51.60%	81.37%	489.99%	148.68%	48.20%	-49.50%	105.56%	-58.07%	972.45%	365.90%	-18.28%	135.88%	334.45%	-74.68%	-75.56%	-68.75%	236.22%	97.52%
Foshan	442.49%	-70.93%	-89.37%	n/a	175.57%	-85.61%	75.07%	-76.93%	-73.94%	-50.91%	189.76%	512.48%	107.92%	-17.67%	357.47%	**8562.75%**	115.00%	22.89%	264.17%	379.68%	281.44%	-39.83%	111.48%	266.87%	-39.23%	-43.05%	19.89%	-90.80%	415.06%
Jiangmen	332.57%	-45.70%	117.66%	175.57%	n/a	**1130.13%**	-21.64%	-85.43%	36.99%	-11.85%	56.80%	-36.74%	159.92%	275.99%	160.45%	**1017.78%**	**1301.39%**	-93.49%	435.62%	**1368.34%**	-42.36%	36.37%	621.95%	996.37%	65.69%	323.43%	475.86%	689.88%	349.69%
Zhongshan	443.82%	13.96%	-69.30%	-87.36%	**1116.15%**	n/a	-8.15%	-86.26%	31.29%	-1.34%	-68.54%	178.04%	151.56%	674.05%	261.40%	207.49%	30.10%	316.58%	-26.80%	**1246.19%**	**1218.21%**	56.86%	500.41%	923.29%	-62.91%	-64.06%	-50.11%	-21.64%	252.70%
Dongguan	72.71%	-80.78%	-38.73%	75.07%	-20.66%	-9 77%	n/a	-90.00%	-12.14%	-92.16%	-70.40%	7.87%	346.60%	-52.79%	622.05%	592.91%	476.27%	-62.10%	154.46%	273.19%	-54.79%	-63.14%	-3.82%	86.27%	-63.38%	197.33%	-46.08%	18.72%	80.10%
Huizhou	-11.56%	-57.61%	-92.23%	-76.20%	-84.99%	-90.35%	-89.98%	n/a	-74.29%	-23.07%	758.29%	-81.47%	-33.09%	14.39%	69.80%	-10.59%	-26.47%	-97.39%	15.17%	-30.74%	-89.21%	-89 28%	-76.96%	-52.32%	-88.93%	-7.51%	-85.93%	-81.52%	-22.00%
Huiyang	-22.75%	73.56%	-30.57%	-72.70%	36.99%	-11.06%	-2.65%	-74.28%	n/a	-63.74%	904.31%	25.08%	-7.33%	302.56%	687 65%	23.01%	26.26%	-38.08%	-0.15%	509.33%	295.55%	-6.57%	94.97%	309.58%	-35.78%	-40.20%	-24.70%	43.11%	107.46%
Huidong	93.50%	-28.40%	-44.09%	-45.13%	-11.85%	-32.09%	-90.59%	666.75%	-63.55%	n/a	**1128.80%**	-86.95%	403.07%	446.94%	**1178.54%**	53.02%	-7.74%	-45.67%	162.14%	468.67%	327.28%	-20.19%	73.64%	325.29%	-42.92%	506.71%	-31.28%	14.71%	196.25%
Boluo	**1067.32%**	127.26%	-76.44%	189.76%	56.80%	-68.04%	-70.07%	752.33%	904.31%	**1174.31%**	n/a	833.45%	912.81%	**1387.50%**	**3581.45%**	**1175.01%**	581.74%	-74.18%	**1501.81%**	467.30%	-3.80%	-5.19%	**2000.29%**	305.10%	25.42%	844.09%	68.62%	-21.63%	653.23%
Panyu	**1612.12%**	34.09%	57.66%	477.39%	-39.00%	168.96%	-35.48%	-80.60%	21.11%	-16.01%	926.80%	n/a	93.03%	**2142.92%**	54.06%	**1325.33%**	268.67%	71.51%	167.35%	172.75%	-10.12%	-19.78%	13.14%	320.73%	-15.33%	-20.15%	35.52%	182.91%	292.95%
Huadu	-14.58%	-33.44%	65.60%	96.37%	159.92%	144.94%	346.60%	-33.09%	-2.45%	403.07%	912.81%	78.59%	n/a	-55.31%	395.25%	323.71%	**3496.85%**	-72.80%	-78.04%	490.19%	162.92%	0.36%	165.11%	431.84%	13.88%	8.97%	88.10%	207.08%	285.28%
Zengcheng	274.40%	-43.43%	436.36%	271.74%	275.99%	674.05%	-52.69%	12.94%	349.91%	446.94%	**1387.50%**	**2142.92%**	-55.31%	n/a	88.65%	171.62%	**1326.30%**	-61.46%	-41.03%	793.10%	35.79%	21.57%	184.46%	464.87%	71.51%	**1523.24%**	139.46%	**1761.92%**	466.72%
Conghua	303.79%	180.84%	148.68%	337.58%	141.85%	261.40%	597.15%	69.80%	687.65%	**1178.54%**	**3581.45%**	54.06%	395.25%	88.65%	n/a	138.21%	17.87%	-48.89%	-61.71%	518.01%	619.17%	273.64%	787.92%	**1424.54%**	176.25%	**1752.06%**	626.32%	671.98%	552.67%
Nanhai	899.59%	13.48%	24.23%	**8689.29%**	980.52%	182.56%	569.28%	-14.95%	14.01%	39.71%	**1175.01%**	**1457.58%**	365.61%	209.59%	132.61%	n/a	**50601.43%**	358.86%	**1483.56%**	**1709.37%**	**1436.26%**	116.54%	711.29%	**1246.39%**	137.88%	122.72%	378.00%	-60.33%	**2702.97%**
Shunde	**1727.42%**	26.22%	-44.98%	109.47%	**1275.44%**	36.64%	460.26%	-23.20%	20.34%	-12.86%	657.49%	271.38%	274.07%	**1207.44%**	15.56%	**5372.54%**	n/a	329.26%	279.72%	**3698.37%**	**4265.03%**	88.16%	582.56%	**1067.77%**	11.56%	7.22%	82.24%	-65.98%	804.41%
Gaoming	114.50%	-57.32%	105.56%	34.24%	-93.56%	338.51%	-59.27%	-97.29%	-32.91%	-45.67%	-72.85%	88.32%	-71.07%	-59.86%	-44.86%	417.69%	373.97%	n/a	-40.69%	-22.71%	-86.25%	55.45%	458.18%	792.89%	-81.80%	-50.01%	41.84%	**1045.91%**	109.29%
Sanshui	778.89%	-26.03%	-59.75%	274.88%	382.06%	-23.23%	173.66%	5.57%	6.98%	162.14%	**1501.81%**	182.48%	-78.34%	-44.66%	-62.18%	**1641.92%**	302.50%	-47.73%	n/a	**1183.91%**	459.37%	65.11%	349.52%	693.71%	562.63%	512.52%	**2612.73%**	45.85%	428.01%
Xinhui	913.85%	120.26%	925.82%	379.68%	**1380.34%**	**1246.19%**	267.94%	-30.74%	509.33%	468.67%	467.30%	161.27%	490.19%	793.10%	518.01%	**1804.60%**	**3863.51%**	-22.71%	**1183.91%**	n/a	267.78%	416.08%	**2742.92%**	**4075.60%**	288.01%	**1061.70%**	**1307.41%**	**7576.40%**	**1228.76%**
Heshan	381.96%	204.45%	365.90%	275.18%	-41.33%	**1300.59%**	-56.11%	-89.78%	295.55%	327.28%	-3.80%	-6.80%	151.49%	26.74%	619.17%	**1436.26%**	**4265.03%**	-86.27%	459.37%	250.44%	n/a	304.06%	**2145.34%**	**3107.10%**	47.36%	282.48%	360.99%	**2595.70%**	700.68%
Enping	21.25%	-35.04%	-22.47%	-40.94%	32.96%	59.31%	-63.44%	-89.49%	-6.57%	-20.19%	-5.19%	-19.78%	0.36%	21.57%	273.64%	123.10%	92.98%	43.49%	65.11%	441.89%	304.06%	n/a	**1531.49%**	**2475.86%**	-21.74%	119.14%	78.65%	208.60%	206.24%
Kaiping	246.35%	57.72%	122.78%	111.48%	602.44%	510.58%	-3.82%	-76.96%	114.47%	73.64%	110.03%	10.28%	165.11%	184.46%	610 34%	739.26%	601.52%	411 66%	399.47%	**3077.38%**	**2145.34%**	**1453.80%**	n/a	931.57%	88.10%	383.22%	504.72%	**1033.62%**	541.06%
Taishan	594.56%	203.69%	316.35%	266.87%	952.52%	949.52%	83.76%	-52.32%	309.58%	325.29%	305.10%	320.73%	431.84%	464.87%	**1424.54%**	**1313.71%**	**1116.43%**	792.89%	**1011.20%**	**4423.56%**	**3107.10%**	**2475.86%**	933.62%	n/a	270.67%	**1012.90%**	**1191.25%**	**1724.06%**	972.97%
Zhaoqing	24.35%	-66.63%	-81.36%	-51.64%	65 69%	-69.56%	-70.90%	-91.14%	-51.07%	-52.99%	-0.99%	-32.04%	-8.26%	35.78%	176.25%	93.53%	-8.58%	-44.60%	484.68%	288.01%	37.53%	-27.33%	88.10%	229.48%	n/a	**4590.60%**	-75.59%	-29.54%	198.21%
Gaoyao	44.35%	-60.52%	-77.46%	-43.51%	323.43%	-63.82%	157.15%	-19.84%	-40.20%	304.47%	844.09%	-20.97%	6.60%	**1117.43%**	**1134.70%**	125.73%	8.41%	111.05%	540.37%	**1061.70%**	282.48%	91.75%	383.22%	**1012.90%**	**4392.72%**	n/a	-36.58%	-13.06%	428.39%
Sihui	286.22%	-33.65%	-62.06%	55.03%	475.86%	-35.14%	-31.26%	-81.68%	0.40%	-10.66%	114.61%	73.82%	130.85%	224.98%	626.32%	541.88%	147.33%	41.84%	**3697.83%**	955.56%	303.37%	78.65%	504.72%	868.44%	-80.56%	-49.74%	n/a	55.35%	325.86%
Doumen	-10.33%	-46.26%	620.48%	-76.82%	689.88%	-28.73%	16.48%	-93.32%	-39.74%	-46.47%	-26.85%	-23.21%	-65.88%	**1761.92%**	-29.82%	2.77%	-46.54%	**1045.91%**	45.85%	**7576.40%**	**2595.70%**	208.60%	**1033.62%**	**1724.06%**	-20.73%	-20.30%	-2.91%	n/a	620.14%
Average	403.35%	12.59%	95.21%	429.02%	342.94%	253.45%	75.55%	2.00%	108.65%	165.62%	588.56%	283.62%	159.64%	442.18%	503.29%	**1040.72%**	**2615.32%**	107.32%	473.08%	**1234.13%**	697.23%	201.50%	606.47%	932.25%	204.51%	476.48%	286.77%	685.20%	n/a

Differences greater than or equal to 1000% are in **bold**

6.3.2 Gross Domestic Product (GDP)

Table 6.4.1 shows the O/D matrix using the GDP of the PRD cities as another input, as a result of trip distribution. It is then compared with the official prediction in table 6.4.2. From table 6.4.2., the number of trips generated from own findings match with that of the official predictions quite well.

In contrast to the case of population, trips generated in the own findings have values lower than that of the official prediction. The level of derivation between own findings and the official one are smaller than that of the previous section. Matchings are better for the cities of Guangzhou, Foshan, Xinhui and Heshan. However, there are two notable sharp discrepancies for the trips between Nanhai and Foshan, where own findings exceed 15 times than the official prediction. Very extreme results are found from the pair of Shunde and Nanhai, where own findings are 10 times above the official prediction.

The overall picture from the GDP generated matrix shows an over-estimation of the government data. Again, larger cities still have lower level of over-estimation. Guangzhou and Foshan only have average derivation around 10%. Small to medium sized cities like Huizhou, Huidong, Nanhai, Gaoming, Zhaoqing and Sihui have greatest derivation around 80%.

Table 6.4.1

Origin / Distination matrix showing the number of trips per year (in 000's)

Generated by 2001's GDP, given k coefficient = 0.00000044, distance coefficient = 2

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng	Conghua	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	Total
Guangzhou	0.00	9274.36	2956.04	12395.38	2197.77	4310.00	15182.87	609.44	361.64	267.95	543.85	42827.99	7172.10	3620.68	2353.78	25497.84	25893.88	912.75	3767.66	1330.10	1666.56	186.65	748.03	769.63	669.53	823.52	954.01	295.47	**167589.48**
Shenzhen	9274.36	0.00	1198.41	455.81	258.71	1700.57	4711.57	2221.57	4861.89	807.70	757.32	1966.62	371.85	599.61	184.81	1149.12	2117.98	105.93	201.43	185.26	153.56	63.13	213.95	214.89	113.66	143.78	105.59	137.68	**34276.78**
Zhuhai	2956.04	1198.41	0.00	96.48	314.46	1375.48	607.33	47.48	54.69	25.33	23.92	485.90	76.26	86.42	28.09	230.57	504.34	38.95	33.72	258.88	69.67	22.82	93.37	88.69	19.62	24.84	17.98	541.82	**9321.56**
Foshan	12395.38	455.81	96.48	0.00	261.78	196.96	511 60	30.65	19.27	14.31	25.91	1943.93	251.66	127.79	80.85	151848.98	3167.42	106.89	303.78	119.78	243.42	17.12	85.81	76.42	49.27	60.51	72.16	14.37	**172578.31**
Jiangmen	2197.77	258.71	314.46	261.78	0.00	1624.58	269.63	20.72	23.93	9.14	10.41	217.91	73.10	48.85	28.27	654.05	1502.41	123.99	59.71	4406.68	725.19	29.67	223.69	172.65	21.48	26.83	24.02	48.79	**13378.43**
Zhongshan	4310.00	1700.57	1375.48	196.96	1624.58	0.00	977.37	60.85	72.57	31.42	29.74	904.74	103.78	119.96	36.37	476.72	3685.42	79.92	58.74	1250.28	186.63	42.85	233.56	202.31	28.99	36.51	28.53	282.83	**18137.65**
Dongguan	15182.87	4711.57	607.33	511.60	269.63	977.37	0.00	161.88	210.31	77.42	73.74	1338.76	362.31	941.73	177.94	1252.62	1290.14	80.36	189.37	223.35	70.07	26.02	95.97	94.04	72.57	90.77	79.17	57.42	**29226.33**
Huizhou	609.44	2221.57	47.48	30.65	20.72	60.85	161.88	0.00	567.46	387.21	845.93	63.12	24.67	100.28	19.13	73.04	72.57	9.95	16.29	16.91	6.69	3.04	9.47	9.74	8.94	11.30	8.41	5.08	**5411.79**
Huiyang	361.64	511.40	54.69	19.27	23.93	72.57	210.31	567.46	0.00	190.70	127.18	80.37	15.85	47.86	11.40	54.51	90.04	5.92	10.72	19.99	7.58	3.31	10.67	10.87	6.42	8.13	5.81	5.84	**2534.45**
Huidong	267.95	807.70	25.33	14.31	9.14	31.42	77.42	387.21	190.70	0.00	90.41	32.11	11.79	35.16	8.45	25.66	37.67	3.01	5.14	9.13	3.74	1.76	5.32	5.52	3.42	4.35	2.95	2.80	**2099.57**
Boluo	543.85	757.32	23.92	25.91	10.41	29.74	73.74	845.93	127.18	90.41	0.00	61.66	24.70	201.66	20.26	76.29	45.44	6.61	13.08	10.61	4.21	1.92	5.96	6.13	6.70	8.45	6.49	3.19	**3031.75**
Panyu	42827.99	1966.62	485.90	1943.93	217.91	904.74	1338.76	63.12	80.37	32.11	61.66	0.00	255.83	263.59	124.50	5514.59	15662.15	110.61	167.73	182.10	50.33	17.00	67.82	64.92	50.47	62.76	60.32	42.90	**72620.73**
Huadu	7172.10	371.85	76.26	251.66	73.10	103.78	362.31	24.67	15.85	11.79	24.70	255.83	0.00	90.64	151.87	627.95	277.89	29.77	85.52	42.19	46.97	8.23	31.84	30.76	26.21	32.60	31.12	5.97	**10263.42**
Zengcheng	3620.68	599.61	86.42	127.79	48.85	119.96	941.73	100.28	47.86	35.16	201.66	263.59	90.64	0.00	84.64	312.14	170.53	19.77	47.88	31.14	11.29	4.74	15.79	15.93	18.92	23.68	20.39	8.83	**7069.89**
Conghua	2353.78	184.81	28.09	80.85	28.27	36.37	177.94	19.13	11.40	8.45	20.26	124.50	151.87	84.64	0.00	165.31	98.80	11.06	31.64	16.62	16.47	3.46	12.67	12.44	11.13	13.89	12.55	2.82	**3719.22**
Nanhai	25497.84	1149.12	230.57	151848.98	654.05	476.72	1252.62	73.04	54.51	25.66	76.29	5514.59	627.95	312.14	165.31	0.00	6983.05	257.41	864.18	293.90	629.21	41.13	209.74	185.76	123.53	151.39	187.64	39.95	**197926.28**
Shunde	25893.88	2117.98	504.34	3167.42	1502.41	3685.42	1290.14	72.57	90.04	37.67	45.44	15662.15	277.89	170.53	98.80	6983.05	0.00	290.79	250.23	742.25	775.05	42.15	218.19	192.29	71.39	88.65	86.98	66.30	**64424.00**
Gaoming	912.75	105.93	38.95	106.89	123.99	79.92	80.36	9.95	5.92	3.01	6.61	110.61	29.77	19.77	11.06	257.41	290.79	0.00	24.14	46.74	110.40	6.58	33.39	29.62	8.70	10.86	9.72	6.39	**2480.22**
Sanshui	3767.66	201.43	33.72	303.78	59.71	58.74	189.37	16.29	10.72	5.14	13.08	167.73	85.52	47.88	31.64	864.18	250.23	24.14	0.00	32.01	41.81	5.66	23.78	22.41	66.01	78.38	194.72	5.54	**6601.30**
Xinhui	1330.10	185.26	258.88	119.78	4406.68	312.57	223.35	16.91	19.99	9.13	10.61	182.10	42.19	31.14	16.62	293.90	742.25	46.74	32.01	0.00	165.30	24.34	187.13	143.37	13.50	16.93	14.18	81.80	**8926.75**
Heshan	1666.56	153.56	69.67	243.42	725.19	186.63	70.07	6.69	7.58	3.74	4.21	50.33	46.97	11.29	16.47	629.21	775.05	110.40	41.81	165.30	0.00	13.60	106.02	80 81	12.23	15.19	14.77	13.05	**5239.82**
Enping	186.65	63.13	22.82	17.12	29.67	42.85	26.02	3.04	3.31	1.76	1.92	17.00	8.23	4.74	3.46	41.13	42.15	6.58	5.66	24.34	13.60	0.00	77.76	46.80	3.04	3.84	2.89	3.77	**703.29**
Kaiping	748.03	213.95	93.37	85.81	223.69	233.56	95.97	9.47	10.67	5.32	5.96	67.82	31.84	15.79	12.67	209.74	218.19	33.39	23.78	187.13	106.02	77.76	0.00	1459.90	10.42	13.08	10.77	17.09	**4221.16**
Taishan	769.63	214.89	88.69	76.42	172.65	202.31	94.04	9.74	10.87	5.52	6.13	64.92	30.76	15.93	12.44	185.76	192.29	29.62	22.41	143.37	80.81	46.80	1459.90	0.00	10.43	13.12	10.52	15.72	**3985.69**
Zhaoqing	669.53	113.66	19.62	49.27	21.48	28.99	72.57	8.94	6.42	3.42	6.70	50.47	26.21	18.92	11.13	123.53	71.39	8.70	66.01	13.50	12.23	3.04	10.42	10.43	0.00	45483.40	68.34	3.00	**46981.33**
Gaoyao	823.52	143.78	24.84	60.51	26.83	36.51	90.77	11.30	8.13	4.35	8.45	62.76	32.60	23.68	13.89	151.39	88.65	10.86	78.38	16.93	15.19	3.84	13.08	13.12	45483.40	0.00	79.84	3.79	**47330.40**
Sihui	954.01	105.59	17.98	72.16	24.02	28.53	79.17	8.41	5.81	2.95	6.49	60.32	31.12	20.39	12.55	187.64	86.98	9.72	194 72	14.18	14.77	2.89	10.77	10.52	68.34	79.84	0.00	2.84	**2112.69**
Doumen	295.47	137.68	541.82	14.37	48.79	282.83	57.42	5.08	5.84	2.80	3.19	42.90	5.97	8.83	2.82	39.95	66.30	6.39	5.54	81.80	13.05	3.77	17.09	15.72	3.00	3.79	2.84	0.00	**1715.05**
Total	**167589.48**	**29926.29**	**9321.56**	**172578.31**	**13378.43**	**17199.94**	**29226.33**	**5411.79**	**6884.94**	**2099.57**	**3031.75**	**72620.73**	**10263.42**	**7069.89**	**3719.22**	**197926.28**	**64424.00**	**2480.22**	**6601.30**	**9864.47**	**5239.82**	**703.29**	**4221.16**	**3985.69**	**46981.33**	**47330.40**	**2112.69**	**1715.05**	**943907.35**

Table 6.4.2

Comparison of the number of trips generated (by 2001's GDP) between Table 6.4.1 (self prediction) and Table 6.2 (official prediction)

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng
Guangzhou	n/a	-11.92%	-36.84%	18.73%	4.66%	-1.60%	-56.40%	-78.31%	-89.49%	-83.36%	-7.82%	249.33%	-85.02%	-43.07%
Shenzhen	-0.60%	n/a	-34.87%	-72.71%	-54.61%	-50.13%	-84.39%	-68.93%	604.62%	-80.44%	-37.92%	-21.34%	-52.93%	-74.81%
Zhuhai	21.15%	-7.81%	n/a	-97.53%	-35.82%	-93.23%	-83.27%	-96.92%	-84.37%	-91.26%	-97.74%	-62.62%	-63.69%	-13.58%
Foshan	25.08%	-76.63%	-97.21%	n/a	-46.58%	-97.90%	-64.22%	-95.36%	-97.08%	-96.23%	-81.49%	7.40%	-70.39%	-91.42%
Jiangmen	3.67%	-54.61%	-40.67%	-46.58%	n/a	86.73%	-83.36%	-96.95%	-84.05%	-92.97%	-89.59%	-88.47%	-61.53%	-59.29%
Zhongshan	-1.82%	-28.25%	-93.70%	-98.15%	84.61%	n/a	-85.30%	-97.83%	-88.48%	-94.07%	-98.43%	-61.83%	-71.95%	-36.86%
Dongguan	-56.37%	-83.07%	-82.40%	-64.22%	-83.15%	-85.56%	n/a	-97.79%	-89.21%	-99.34%	-97.93%	-79.28%	-30.32%	-94.61%
Huizhou	-78.00%	-63.22%	-97.80%	-95.21%	-96.86%	-98.48%	-97.79%	n/a	-96.89%	-93.63%	-40.84%	-96.49%	-89.72%	-87.14%
Huiyang	-89.30%	-16.16%	-89.06%	-96.94%	-84.05%	-92.20%	-88.05%	-96.89%	n/a	-98.33%	-61.46%	-86.82%	-92.07%	-74.81%
Huidong	-81.65%	-76.31%	-93.97%	-95.79%	-92.97%	-95.92%	-99.21%	-36.52%	-98.32%	n/a	-67.71%	-99.06%	-70.53%	-76.56%
Boluo	-7.82%	-37.41%	-97.88%	-81.49%	-89.59%	-98.40%	-97.91%	-41.25%	-61.46%	-66.51%	n/a	-43.94%	-50.61%	-46.93%
Panyu	271.13%	1.37%	-61.13%	1.25%	-88.88%	-63.07%	-87.60%	-96.33%	-87.24%	-93.94%	-38.34%	n/a	-74.16%	119.66%
Huadu	-84.96%	-59.14%	-66.84%	-72.04%	-61.53%	-72.69%	-30.32%	-89.72%	-91.66%	-70.53%	-50.61%	-76.09%	n/a	-96.45%
Zengcheng	-51.79%	-74.59%	-21.44%	-61.28%	-59.29%	-36.86%	-94.60%	-87.31%	-71.85%	-76.56%	-46.93%	119.66%	-96.45%	n/a
Conghua	-59.90%	-2.73%	-71.91%	-64.85%	-79.81%	-77.27%	-38.64%	-85.28%	-61.99%	-57.75%	1.29%	-88.36%	-69.63%	-91.54%
Nanhai	139.87%	-5.03%	-66.09%	**1606.17%**	118.02%	-57.05%	42.34%	-82.19%	-86.71%	-88.84%	-15.23%	184.26%	-30.99%	-66.44%
Shunde	339.62%	5.90%	-84.95%	-59.24%	178.22%	-79.18%	19.46%	-83.87%	-85.93%	-93.02%	-49.51%	-32.05%	-44.42%	42.10%
Gaoming	-67.52%	-77.46%	-64.59%	-83.56%	-99.18%	-57.94%	-94.53%	-99.64%	-95.06%	-97.26%	-98.86%	-78.31%	-97.29%	-97.25%
Sanshui	29.47%	-61.99%	-93.26%	-55.33%	-40.29%	-92.84%	-64.27%	-86.43%	-92.34%	-87.15%	-34.62%	-68.35%	-98.03%	-96.32%
Xinhui	-2.20%	-25.90%	12.56%	-62.57%	20.07%	-17.74%	-68.54%	-94.17%	-71.44%	-81.74%	-84.84%	-80.83%	-64.84%	-61.08%
Heshan	-36.63%	39.60%	-30.33%	-60.10%	-93.51%	16.64%	-94.89%	-98.83%	-74.73%	-81.31%	-96.50%	-90.68%	-79.58%	-92.47%
Enping	-91.95%	-84.97%	-94.15%	-96.83%	-92.58%	-93.30%	-97.85%	-99.39%	-96.99%	-98.24%	-98.26%	-95.95%	-95.89%	-96.36%
Kaiping	-64.55%	-43.70%	-74.06%	-82.49%	-39.54%	-60.41%	-91.28%	-97.94%	-89.33%	-94.09%	-94.04%	-91.42%	-83.24%	-86.85%
Taishan	-45.80%	-17.35%	-63.04%	-76.84%	-30.94%	-48.12%	-87.29%	-96.75%	-84.47%	-88.96%	-91.24%	-75.03%	-74.37%	-80.09%
Zhaoqing	-84.02%	-85.04%	-97.28%	-94.97%	-82.10%	-97.52%	-96.69%	-99.01%	-96.94%	-97.99%	-96.47%	-93.36%	-92.72%	-92.12%
Gaoyao	-84.46%	-85.18%	-97.24%	-95.08%	-61.68%	-97.53%	-75.47%	-92.47%	-96.87%	-85.51%	-71.84%	-93.53%	-92.91%	-40.79%
Sihui	-61.69%	-77.05%	-95.72%	-87.56%	-51.97%	-95.92%	-93.96%	-98.41%	-95.16%	-97.05%	-94.10%	-86.89%	-85.86%	-85.43%
Doumen	-90.59%	-80.33%	-14.00%	-98.03%	-30.30%	-95.26%	-89.17%	-99.39%	-96.93%	-98.13%	-97.87%	-93.87%	-97.79%	-11.72%
Average	-11.54%	-44.04%	-68.44%	-10.12%	-40.36%	-64.92%	-73.45%	-88.66%	-61.50%	-88.30%	-68.11%	-45.33%	-74.70%	-60.45%

	Conghua	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	Average
Guangzhou	-59.49%	120.95%	331.56%	-69.78%	26.01%	-0.74%	-34.64%	-91.88%	-64.38%	-45.03%	-79.89%	-84.13%	-70.09%	-13.10%	-13.18%
Shenzhen	32.01%	14.91%	21.72%	-77.93%	-62.70%	-25.90%	39.60%	-84.97%	-45.14%	-17.35%	-81.37%	-85.02%	-82.10%	-47.04%	-19.64%
Zhuhai	-71.91%	-59.55%	-86.18%	-64.59%	-92.97%	17.67%	-30.33%	-93.83%	-72.54%	-61.44%	-96.30%	-97.01%	-96.47%	-59.87%	-65.63%
Foshan	-63.25%	**1581.61%**	-58.16%	-84.95%	-56.60%	-62.57%	-59.43%	-96.77%	-82.49%	-76.84%	-93.68%	-95.04%	-90.38%	-99.22%	-11.84%
Jiangmen	-78.25%	125.54%	183.47%	-99.17%	-33.66%	19.10%	-93.63%	-92.39%	-37.86%	-28.06%	-82.10%	-61.68%	-51.97%	-30.30%	-39.58%
Zhongshan	-77.27%	-53.26%	-80.18%	-60.04%	-93.17%	229.02%	9.78%	-93.41%	-61.07%	-49.42%	-96.98%	-97.55%	-96.87%	-94.79%	-55.08%
Dongguan	-36.45%	47.37%	22.87%	-94.91%	-66.78%	-68.09%	-94.73%	-97.83%	-91.28%	-87.12%	-95.83%	-71.63%	-95.26%	-88.96%	-72.66%
Huizhou	-85.28%	-81.27%	-84.56%	-99.66%	-85.19%	-94.17%	-98.76%	-99.38%	-97.94%	-96.75%	-98.76%	-91.31%	-98.78%	-98.31%	-90.45%
Huiyang	-61.99%	-85.66%	-85.24%	-95.44%	-92.85%	-71.44%	-74.73%	-96.99%	-90.30%	-84.47%	-95.99%	-96.87%	-96.37%	-92.70%	-84.71%
Huidong	-57.75%	-87.78%	-92.61%	-97.26%	-87.15%	-81.74%	-81.31%	-98.24%	-94.09%	-88.96%	-97.56%	-78.27%	-97.73%	-95.99%	-85.96%
Boluo	1.29%	-15.23%	-54.56%	-98.92%	-34.62%	-84.84%	-96.50%	-98.26%	-40.44%	-91.24%	-95.53%	-71.84%	-95.37%	-97.72%	-66.48%
Panyu	-88.36%	160.12%	-32.55%	-80.25%	-70.05%	-79.99%	-91.01%	-95.95%	-91.19%	-75.03%	-91.73%	-93.46%	-89.78%	-77.42%	-44.22%
Huadu	-69.63%	-37.21%	434.41%	-97.46%	-98.00%	-64.84%	-78.65%	-95.89%	-83.24%	-74.37%	-90.96%	-92.76%	-88.48%	-80.10%	-57.03%
Zengcheng	-91.54%	-70.55%	55.02%	-97.36%	-96.08%	-61.08%	-91.93%	-96.36%	-86.85%	-80.09%	-90.04%	-21.06%	-89.27%	-11.72%	-58.82%
Conghua	n/a	-80.08%	-90.12%	-97.30%	-98.03%	-79.23%	-67.06%	-91.36%	-68.33%	-58.55%	-87.63%	-30.54%	-74.90%	-71.77%	-68.27%
Nanhai	-80.55%	n/a	**10169.20%**	-41.50%	96.40%	46.95%	70.06%	-87.90%	-30.09%	-11.54%	-74.26%	-79.81%	-60.08%	-96.50%	422.68%
Shunde	-90.31%	**1008.42%**	n/a	-45.13%	-52.79%	209.27%	384.41%	-89.46%	-41.03%	-23.08%	-87.90%	-90.26%	-84.74%	-96.99%	32.35%
Gaoming	-97.09%	-34.00%	-39.42%	n/a	-95.36%	-96.04%	-99.04%	-94.52%	-69.64%	-62.98%	-98.76%	-97.14%	-92.52%	-36.11%	-82.26%
Sanshui	-98.06%	116.04%	-49.95%	-95.91%	n/a	-35.99%	-61.99%	-94.34%	-76.22%	-67.99%	-55.99%	-65.92%	39.09%	-92.09%	-58.56%
Xinhui	-79.23%	54.69%	222.72%	-96.04%	-35.99%	n/a	-83.63%	-88.41%	-1.51%	10.28%	-83.12%	-57.68%	-52.75%	172.66%	-29.68%
Heshan	-67.06%	70.06%	384.41%	-99.04%	-61.99%	-84.41%	n/a	-87.63%	6.02%	15.45%	-91.27%	-81.01%	-78.90%	30.50%	-37.71%
Enping	-91.36%	-87.54%	-89.19%	-94.94%	-94.34%	-87.83%	-87.63%	n/a	-61.12%	-53.20%	-97.66%	-94.51%	-95.87%	-92.46%	-91.12%
Kaiping	-74.67%	-27.67%	-39.39%	-72.17%	-73.58%	10.07%	6.02%	-62.97%	n/a	-71.09%	-91.32%	-81.32%	-78.46%	-57.28%	-66.92%
Taishan	-58.55%	-7.12%	-19.88%	-62.98%	-55.18%	19.47%	15.45%	-53.20%	-71.03%	n/a	-86.96%	-67.20%	-64.93%	-47.59%	-56.30%
Zhaoqing	-87.63%	-79.06%	-90.08%	-96.22%	-61.17%	-83.12%	-91.85%	-97.83%	-91.32%	-88.41%	n/a	127.64%	-98.91%	-96.67%	-82.99%
Gaoyao	-53.69%	-79.54%	-90.15%	-87.93%	-64.37%	-57.68%	-81.01%	-95.19%	-81.32%	-67.20%	118.04%	n/a	-97.62%	-96.55%	-74.25%
Sihui	-74.90%	-46.39%	-79.29%	-92.52%	94.72%	-64.56%	-81.54%	-95.87%	-78.46%	-73.70%	-99.13%	-98.12%	n/a	-94.33%	-77.44%
Doumen	-97.43%	-90.92%	-95.26%	-36.11%	-92.09%	172.66%	30.50%	-92.46%	-57.28%	-47.59%	-96.25%	-96.84%	-96.45%	n/a	-66.26%
Average	-68.83%	84.33%	391.43%	-82.80%	-56.95%	-20.74%	-37.91%	-91.23%	-65.19%	-57.62%	-82.18%	-72.23%	-80.59%	-61.57%	n/a

Differences greater than or equal to 1000% are in **bold**.

6.3.3 GDP per capita

Table 6.5.1 shows the O/D matrix using the GDP per capita of the PRD cities as another input, as a result of trip distribution. It is then compared with the official prediction in table 6.5.2.

Although the previous section suggested that the findings of using GDP shows a moderate pattern. The use of GDP per capita, shows a completely different scenario. Most of the own findings, from table 6.5.2, are having great differentiation with official estimation. Own findings can be as high as 200 times above official estimation for the city pair of Foshan and Nanhai, while it can be also drops down to -83.91% for the pair of Huidong and Dongguan. Overall speaking, the relationship between the own findings and the official figures is not strong. Nearly all cities have more than one pair having a deviation of more than 10 times of the official figures.

The most important finding is the query of using GDP per capita to generate a trip distribution matrix which can be comparable with official data. Income disparity across the PRD comparing with the more "uniform" results of using GDP means variation in income distribution affects GDP per capita. Hence, the surprising results in table 6.5.2. Another finding similar to the above sections is the correlation between own estimation and government data is higher in cities like Guangzhou, Shenzhen and Enping. The correlation is lower in cities of Sanshui and Heshan. Again, this illustrates the level of discrapency is lower in larger cities than smaller ones.

Table 6.5.1

Origin / Distination matrix showing the number of trips per year (in 000's)

Generated by 2001's GDP per capita, given k coefficient = 11.4117251, distance coefficient = 2

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng
Guangzhou	0.00	9330.00	10717.90	116574.50	22810.02	14556.68	44934.55	7270.15	2609.69	1753.71	3192.14	211428.02	49622.81	20085.25
Shenzhen	9330.00	0.00	5511.19	5437.09	3405.69	7284.85	17686.09	33613.47	44500.06	6704.78	5637.95	12313.90	3263.20	4218.88
Zhuhai	10717.90	5511.19	0.00	4147.83	14919.59	21236.35	8216.60	2589.13	1804.05	757.94	641.69	10965.42	2412.01	2191.38
Foshan	116574.50	5437.09	4147.83	0.00	32215.17	7887.88	17953.32	4335.05	1648.85	1110.77	1803.47	113789.24	20645.89	8405.39
Jiangmen	22810.02	3405.69	14919.59	32215.17	0.00	71797.84	10441.83	3234.24	2259.74	782.70	799.64	14076.46	6617.81	3546.12
Zhongshan	14556.68	7284.85	21236.35	7887.88	71797.84	0.00	12317.24	3090.84	2229.82	875.53	743.26	19018.88	3057.59	2833.60
Dongguan	44934.55	17686.09	8216.60	17953.32	10441.83	12317.24	0.00	7205.51	5663.07	1890.72	1614.99	24660.79	9353.81	19493.05
Huizhou	7270.15	33613.47	2589.13	4335.05	3234.24	3090.84	7205.51	0.00	61589.32	38114.84	74677.78	4686.45	2567.28	8366.77
Huiyang	2609.69	4680.80	1804.05	1648.85	2259.74	2229.82	5663.07	61589.32	0.00	11355.34	6791.44	3609.93	998.03	2415.59
Huidong	1753.71	6704.78	757.94	1110.77	782.70	875.53	1890.72	38114.84	11355.34	0.00	4379.01	1307.97	672.98	1609.28
Boluo	3192.14	5637.95	641.69	1803.47	799.64	743.26	1614.99	74677.78	6791.44	4379.01	0.00	2252.75	1264.52	8278.46
Panyu	211428.02	12313.90	10965.42	113789.24	14076.46	19018.88	24660.79	4686.45	3609.93	1307.97	2252.75	0.00	11016.91	9100.96
Huadu	49622.81	3263.20	2412.01	20645.89	6617.81	3057.59	9353.81	2567.28	998.03	672.98	1264.52	11016.91	0.00	4386.08
Zengcheng	20085.25	4218.88	2191.38	8405.39	3546.12	2833.60	19493.05	8366.77	2415.59	1609.28	8278.46	9100.96	4386.08	0.00
Conghua	20119.38	2003.59	1097.59	8194.40	3162.22	1323.86	5675.40	2459.78	886.79	596.03	1281.39	6623.60	11324.27	5059.92
Nanhai	105265.54	6017.10	4351.40	7433282.30	35333.13	8380.55	19296.13	4535.01	2047.45	874.14	2330.74	141701.08	22614.36	9012.93
Shunde	107923.27	11196.46	9609.06	156534.50	81939.52	65408.32	20064.22	4548.91	3414.28	1295.52	1401.48	406299.77	10103.53	4970.91
Gaoming	14737.70	2169.47	2874.77	20464.28	26196.30	5494.63	4841.84	2416.69	870.26	401.30	789.42	11116.42	4192.57	2233.17
Sanshui	43636.89	2958.98	1785.53	41718.99	9049.35	2896.91	8183.99	2837.52	1129.75	491.26	1120.66	12091.36	8640.03	3878.46
Xinhui	6912.50	1221.13	6150.22	7381.27	299672.70	6917.12	4331.15	1321.90	945.40	391.43	408.17	5890.14	1912.87	1131.84
Heshan	21461.56	2508.24	4101.65	37168.75	122202.92	10233.90	3366.77	1295.29	888.29	397.31	400.73	4033.85	5276.33	1017.13
Enping	1811.99	777.38	1012.75	1970.44	3769.54	1771.50	942.38	444.36	292.71	141.18	137.74	1027.33	696.57	321.70
Kaiping	5000.26	1813.95	2853.24	6801.03	19565.95	6648.18	2393.87	952.05	648.78	293.62	294.63	2821.57	1856.78	738.01
Taishan	3489.30	1235.68	1838.16	4108.41	10242.52	3905.81	1590.96	664.35	448.45	206.58	205.69	1831.91	1216.44	505.19
Zhaoqing	6217.17	1338.65	832.67	5424.94	2610.45	1146.11	2514.60	1248.38	542.10	261.85	460.25	2917.24	2123.05	1228.72
Gaoyao	5115.16	1132.70	705.26	4456.26	2180.47	965.75	2103.85	1055.38	459.58	222.79	388.26	2426.12	1766.39	1028.85
Sihui	10924.29	1533.54	941.23	9797.27	3598.69	1391.01	3382.68	1447.68	605.06	278.68	549.80	4299.46	3108.17	1633.10
Doumen	3835.56	2266.91	32151.72	2211.20	8287.59	15633.67	2781.33	991.24	689.58	300.37	306.46	3466.26	676.14	801.50
Total	**871336.01**	**157261.65**	**156416.31**	**8075468.51**	**814718.19**	**299047.69**	**262900.75**	**277559.36**	**161343.42**	**77467.61**	**122152.51**	**1044773.80**	**191386.43**	**128492.25**

	Conghua	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	Total
Guangzhou	20119.38	105265.54	107923.27	14737.70	43636.89	6912.50	21461.56	1811.99	5000.26	3489.30	6217.17	5115.16	10924.29	3835.56	**871336.01**
Shenzhen	2003.59	6017.10	11196.46	2073.34	2958.98	1221.13	2508.24	777.38	1813.95	1235.68	1338.65	1132.70	1533.54	2266.91	**196984.79**
Zhuhai	1097.59	4351.40	9609.06	1826.81	1785.53	6150.22	4101.65	1012.75	2853.24	1838.16	832.67	705.26	941.23	32151.72	**155368.35**
Foshan	8194.40	7433282.30	156534.50	17731.49	41718.99	7381.27	37168.75	1970.44	6801.03	4108.41	5424.94	4456.26	9797.27	2211.20	**8072735.72**
Jiangmen	3162.22	35333.13	81939.52	11466.60	9049.35	299672.70	122202.92	3769.54	19565.95	10242.52	2610.45	2180.47	3598.69	8287.59	**799988.49**
Zhongshan	1323.86	8380.55	65408.32	3699.85	2896.91	27668.50	10233.90	1771.50	6648.18	3905.81	1146.11	965.75	1391.01	15633.67	**318004.29**
Dongguan	5675.40	19296.13	20064.22	2480.98	8183.99	4331.15	3366.77	942.38	2393.87	1590.96	2514.60	2103.85	3382.68	2781.33	**260539.88**
Huizhou	2459.78	4535.01	4548.91	1977.17	2837.52	1321.90	1295.29	444.36	952.05	664.35	1248.38	1055.38	1447.68	991.24	**277119.83**
Huiyang	886.79	2047.45	3414.28	617.28	1129.75	945.40	888.29	292.71	648.78	448.45	542.10	459.58	605.06	689.58	**121271.17**
Huidong	596.03	874.14	1295.52	277.21	491.26	391.43	397.31	141.18	293.62	206.58	261.85	222.79	278.68	300.37	**77343.52**
Boluo	1281.39	2330.74	1401.48	464.40	1120.66	408.17	400.73	137.74	294.63	205.69	460.25	388.26	549.80	306.46	**121827.49**
Panyu	6623.60	141701.08	406299.77	11116.42	12091.36	5890.14	4033.85	1027.33	2821.57	1831.91	2917.24	2426.12	4299.46	3466.26	**1044773.80**
Huadu	11324.27	22614.36	10103.53	4192.57	8640.03	1912.87	5276.33	696.57	1856.78	1216.44	2123.05	1766.39	3108.17	676.14	**191386.43**
Zengcheng	5059.92	9012.93	4970.91	2233.17	3878.46	1131.84	1017.13	321.70	738.01	505.19	1228.72	1028.85	1633.10	801.50	**128492.25**
Conghua	0.00	7354.71	4437.65	1923.79	3949.70	930.69	2286.08	361.50	912.48	607.57	1113.96	929.94	1548.99	394.89	**96560.17**
Nanhai	7354.71	0.00	151491.62	21633.66	52096.62	7950.22	42175.59	2078.31	7297.73	4383.60	5970.78	4894.44	11183.61	2699.57	**8116252.33**
Shunde	4437.65	151491.62	0.00	24672.89	15229.60	20270.28	52448.53	2150.38	7664.19	4581.08	3483.61	2893.59	5233.80	4522.28	**1183789.25**
Gaoming	1923.79	21633.66	24672.89	0.00	5691.05	4945.37	28942.80	1299.70	4543.86	2733.34	1644.48	1373.66	2265.55	1688.46	**202157.42**
Sanshui	3949.70	52096.62	15229.60	5691.05	0.00	2428.96	7862.84	802.72	2321.32	1483.53	8951.35	7109.19	32560.13	1049.75	**281956.42**
Xinhui	930.69	7950.22	20270.28	4945.37	2428.96	0.00	13947.65	1548.21	8196.02	4258.86	821.39	689.00	1063.63	6957.36	**418595.46**
Heshan	2286.08	42175.59	52448.53	28942.80	7862.84	13947.65	0.00	2144.37	11506.46	5948.63	1843.71	1532.30	2745.46	2750.50	**390487.68**
Enping	361.50	2078.31	2150.38	1299.70	802.72	1548.21	2144.37	0.00	6361.78	2596.78	345.94	292.26	404.78	598.98	**36103.27**
Kaiping	912.48	7297.73	7664.19	4543.86	2321.32	8196.02	11506.46	6361.78	0.00	55782.18	815.18	684.52	1039.56	1869.68	**161676.86**
Taishan	607.57	4383.60	4581.08	2733.34	1483.53	4258.86	5948.63	2596.78	55782.18	0.00	553.75	465.80	688.65	1166.66	**116739.89**
Zhaoqing	1113.96	5970.78	3483.61	1644.48	8951.35	821.39	1843.71	345.94	815.18	553.75	0.00	3307512.24	9162.29	455.98	**3371540.86**
Gaoyao	929.94	4894.44	2893.59	1373.66	7109.19	689.00	1532.30	292.26	684.52	465.80	3307512.24	0.00	7159.54	385.33	**3359928.65**
Sihui	1548.99	11183.61	5233.80	2265.55	32560.13	1063.63	2745.46	404.78	1039.56	688.65	9162.29	7159.54	0.00	531.72	**119078.36**
Doumen	394.89	2699.57	4522.28	1688.46	1049.75	6957.36	2750.50	598.98	1869.68	1166.66	455.98	385.33	531.72	0.00	**99470.71**
Total	**96560.17**	**8116252.33**	**1183789.25**	**178253.60**	**281956.42**	**439346.83**	**390487.68**	**36103.27**	**161676.86**	**116739.89**	**3371540.86**	**3359928.65**	**119078.36**	**99470.71**	**30591509.36**

Table 6.5.2

Comparison of the number of trips generated (by GDP per capita) between Table 6.5.1 (self prediction) and Table 6.2 (official prediction)

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng
Guangzhou	n/a	-11.40%	129.02%	**1016.61%**	986.19%	232.34%	29.05%	158.72%	-24.14%	8.93%	441.04%	**1624.54%**	3.64%	215.81%
Shenzhen	0.00%	n/a	199.52%	225.57%	497.49%	113.63%	-41.40%	370.12%	**6349.28%**	62.34%	362.13%	392.56%	313.06%	77.26%
Zhuhai	339.26%	323.94%	n/a	6.35%	**2944.81%**	4.46%	126.35%	68.13%	415.44%	161.36%	-39.46%	743.49%	**1048.58%**	**2091.38%**
Foshan	**1076.33%**	178.83%	19.88%	n/a	**6474.52%**	-15.82%	**1155.48%**	556.83%	149.83%	192.31%	**1188.19%**	**6186.70%**	**2328.93%**	464.12%
Jiangmen	975.94%	497.49%	**2715.02%**	**6474.52%**	n/a	**8152.63%**	544.56%	375.62%	**1406.49%**	502.08%	699.64%	644.79%	**3383.06%**	**2855.10%**
Zhongshan	231.59%	207.38%	-2.67%	-26.07%	**8058.85%**	n/a	85.22%	9.99%	253.94%	65.19%	-60.67%	702.48%	726.38%	**1391.37%**
Dongguan	29.12%	-36.45%	138.16%	**1155.48%**	552.61%	81.94%	n/a	-1.83%	190.41%	-83.91%	-54.64%	281.75%	**1698.81%**	11.52%
Huizhou	162.46%	456.51%	19.87%	577.35%	390.04%	-22.73%	-1.70%	n/a	237.29%	526.89%	**5122.22%**	160.36%	969.70%	972.66%
Huiyang	-22.79%	667.34%	260.81%	161.72%	**1406.49%**	139 77%	221.77%	237.48%	n/a	-0.48%	**1958.01%**	491.79%	399.02%	**1171.36%**
Huidong	20.12%	96.62%	80.46%	226.70%	502.08%	13.70%	-80.69%	**6148.33%**	0.05%	n/a	**1463.93%**	-61.64%	**1582.44%**	972.85%
Boluo	441.04%	365.95%	-43.21%	**1188.19%**	699.64%	-60.04%	-54.12%	**5085.96%**	**1958.01%**	**1521.85%**	n/a	**1947.96%**	**2429.03%**	**2078.54%**
Panyu	**1732.13%**	534.74%	777.23%	**5826.52%**	618.19%	676.28%	128.34%	172.47%	473.00%	146.79%	**2152.75%**	n/a	**1012.82%**	**7484.14%**
Huadu	4.03%	258.59%	948.70%	**2193.99%**	**3383.06%**	704.63%	**1698.81%**	969.70%	425.28%	**1582.44%**	**2429.03%**	929.62%	n/a	72.00%
Zengcheng	167.45%	78.77%	**1892.17%**	**2447.09%**	**2855.10%**	**1391.37%**	11.77%	959.08%	**1320.94%**	972.85%	**2078.54%**	**7484.14%**	72.00%	n/a
Conghua	242.75%	954.52%	997.59%	**3462.78%**	**2158.73%**	727.41%	**1857.03%**	**1792.14%**	**2855.96%**	**2880.14%**	**6306.95%**	519.03%	**2164.85%**	405.99%
Nanhai	890.27%	397.28%	539.91%	**83420.03%**	**11677.71%**	655.00%	**2092.74%**	**1006.10%**	399.38%	280.06%	**2489.71%**	**7204.18%**	**2385.10%**	869.13%
Shunde	**1732.31%**	459.82%	186.84%	**1914.60%**	**15073.99%**	269.54%	**1757.80%**	910.87%	433.48%	139.91%	**1457.20%**	**1662.69%**	**1920.71%**	**4042.42%**
Gaoming	424.47%	361.59%	**2513.43%**	**3048.35%**	73.26%	**2791.91%**	229.38%	-13.07%	625.21%	264.82%	36.11%	**2079.69%**	281.14%	210.16%
Sanshui	**1399.55%**	458.30%	257.11%	**6035.14%**	**8949.35%**	253.28%	**1444.15%**	**2264.60%**	706.97%	**1128.15%**	**5503.28%**	**2181.39%**	99.08%	198.34%
Xinhui	408.27%	388.45%	**2574.01%**	**2206.65%**	**8065.47%**	**1720.30%**	510.02%	355.83%	**1250.57%**	682.86%	483.09%	520.01%	**1494.06%**	**1314.80%**
Heshan	716.03%	**2180.22%**	**4001.65%**	**5993.24%**	993.05%	**6296.19%**	145.75%	127.24%	**2860.98%**	**1886.56%**	233.95%	647.01%	**2194.06%**	578.09%
Enping	-21.90%	85.09%	159.68%	264.90%	842.38%	176.80%	-22.12%	-11.13%	166.10%	41.18%	25.22%	144.60%	248.28%	147.46%
Kaiping	136.98%	377.35%	692.57%	**1287.96%**	**5188.09%**	**1026.81%**	117.62%	106.97%	548.78%	226.25%	194.63%	257.16%	877.25%	515.01%
Taishan	145.73%	375.26%	665.90%	**1144.97%**	**3997.01%**	901.49%	114.99%	121.45%	540.65%	313.16%	193.84%	604.58%	913.70%	531.48%
Zhaoqing	48.38%	76.14%	15.65%	453.57%	**2075.38%**	-2.04%	14.82%	38.71%	158.14%	54.03%	142.23%	283.85%	489.74%	411.97%
Gaoyao	-3.49%	16.77%	-21.64%	262.30%	**3014.95%**	-34.75%	468.61%	603.59%	76.76%	642.62%	**1194.19%**	150.12%	284.00%	**2472.12%**
Sihui	338.73%	233.38%	124.10%	**1589.18%**	**7097.38%**	98.72%	158.22%	173.15%	404.21%	178.68%	399.81%	834.67%	**1312.81%**	**1066.50%**
Doumen	22.15%	223.84%	**5003.45%**	202.90%	**11739.42%**	161.87%	424.78%	19.43%	262.94%	100.25%	104.31%	395.18%	150.42%	**7915.05%**
Average	431.00%	378.01%	920.19%	**4917.06%**	**4085.75%**	979.80%	486.56%	837.28%	905.41%	536.20%	**1352.05%**	**1444.91%**	**1140.10%**	**1501.36%**

	Conghua	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	Average
Guangzhou	246.29%	812.18%	**1698.72%**	388.00%	**1359.43%**	415.86%	741.63%	-21.22%	138.11%	149.24%	86.70%	-1.44%	242.45%	**1028.11%**	447.94%
Shenzhen	**1331.14%**	501.71%	543.47%	331.95%	447.96%	388.45%	**2180.22%**	85.09%	365.12%	375.26%	119.45%	17.99%	159.92%	771.89%	612.64%
Zhuhai	997.59%	663.40%	163.26%	**1560.74%**	271.99%	**2695.55%**	**4001.65%**	173.72%	739.19%	699.20%	57.11%	-15.03%	84.55%	**2281.61%**	837.36%
Foshan	**3624.73%**	**82217.63%**	**1967.83%**	**2397.39%**	**5859.86%**	**2206.65%**	**6094.79%**	271.78%	**1287.96%**	**1144.97%**	595.51%	265.27%	**1206.30%**	20.17%	**4782.11%**
Jiangmen	**2332.48%**	**12083.84%**	**15360.29%**	-23.35%	**9954.83%**	**7999.26%**	973.84%	866.55%	**5334.99%**	**4167.72%**	**2075.38%**	**3014.95%**	**7097.38%**	**11739.42%**	**4155.72%**
Zhongshan	727.41%	721.62%	251.85%	**1749.93%**	236.85%	**7181.18%**	**5919.94%**	172.54%	**1008.03%**	876.45%	19.39%	-35.18%	52.86%	187.91%	**1137.55%**
Dongguan	**1926.93%**	**2170.13%**	**1810.88%**	57.02%	**1335.79%**	518.74%	153.14%	-21.47%	117.62%	117.94%	44.52%	557.45%	102.56%	434.87%	492.19%
Huizhou	**1792.14%**	**1062.82%**	867.85%	-31.59%	**2479.56%**	355.83%	139.87%	-9.31%	106.97%	121.45%	73.39%	711.83%	109.81%	230.41%	651.18%
Huiyang	**2855.96%**	438.80%	459.72%	374.83%	653.17%	**1250.57%**	**2860.98%**	166.10%	489.80%	540.65%	238.81%	76.76%	278.16%	761.97%	686.61%
Huidong	**2880.14%**	316.26%	154.02%	152.01%	**1128.15%**	682.86%	**1886.56%**	41.18%	226.25%	313.16%	87.03%	**1013.93%**	114.37%	329.10%	751.48%
Boluo	**6306.95%**	**2489.71%**	**1301.48%**	-23.87%	**5503.28%**	483.09%	233.95%	25.22%	**2846.33%**	193.84%	206.83%	**1194.19%**	292.71%	118.90%	**1434.50%**
Panyu	519.03%	**6584.01%**	**1649.78%**	**1885.07%**	**2059.17%**	547.27%	620.33%	144.60%	266.44%	604.58%	378.24%	152.72%	628.72%	**1724.35%**	**1462.95%**
Huadu	**2164.85%**	**2161.44%**	**19329.87%**	258.34%	101.87%	**1494.06%**	**2298.33%**	248.28%	877.25%	913.70%	632.09%	292.53%	**1051.18%**	**2153.80%**	**1836.20%**
Zengcheng	405.99%	750.28%	**4419.01%**	197.76%	217.91%	**1314.80%**	626.52%	147.46%	515.01%	531.48%	546.70%	**3329.49%**	759.53%	**7915.05%**	**1607.71%**
Conghua	n/a	786.11%	343.77%	369.22%	145.32%	**1063.36%**	**4472.16%**	803.75%	**2181.20%**	**1925.23%**	**1137.73%**	**4549.70%**	**2997.99%**	**3848.91%**	**1924.09%**
Nanhai	765.26%	n/a	**222681.79%**	**4816.74%**	**11740.14%**	**3875.11%**	**11298.81%**	511.27%	**2332.58%**	**1987.43%**	**1143.91%**	552.59%	**2279.49%**	136.80%	**14015.87%**
Shunde	335.06%	**23946.29%**	n/a	**4555.26%**	**2773.51%**	**8345.95%**	**32680.33%**	437.59%	**1971.40%**	**1732.43%**	490.44%	217.98%	818.21%	105.56%	**4087.86%**
Gaoming	406.26%	**5447.09%**	**5040.19%**	n/a	994.43%	319.10%	151.90%	983.08%	**4030.78%**	**3316.67%**	134.93%	261.49%	**1642.73%**	**16784.61%**	**1942.21%**
Sanshui	142.31%	**12924.15%**	**2945.92%**	864.59%	n/a	**4757.91%**	**7048.04%**	702.72%	**2221.32%**	**2019.33%**	**5867.57%**	**2990.95%**	**23157.23%**	**1399.64%**	**3626.68%**
Xinhui	**1063.36%**	**4084.32%**	**8713.16%**	319.10%	**4757.91%**	n/a	**1280.96%**	637.24%	**4213.69%**	**3176.05%**	926.74%	**1622.51%**	**3445.44%**	**23091.20%**	**2937.26%**
Heshan	**4472.16%**	**11298.81%**	**32680.33%**	151.46%	**7048.04%**	**1215.82%**	n/a	**1849.43%**	**11406.46%**	**8398.05%**	**1216.93%**	**1815.38%**	**3822.08%**	**27405.03%**	**5245.70%**
Enping	803.75%	529.79%	451.38%	899.77%	702.72%	674.10%	**1849.43%**	n/a	**3080.89%**	**2496.78%**	166.11%	317.52%	478.26%	**1097.97%**	585.00%
Kaiping	**1724.96%**	**2416.46%**	**2028.94%**	**3686.55%**	**2479.24%**	**4721.19%**	**11406.46%**	**2929.42%**	n/a	**1004.60%**	579.32%	877.88%	**1979.11%**	**4574.20%**	**1924.51%**
Taishan	**1925.23%**	**2091.80%**	**1808.79%**	**3316.67%**	**2867.06%**	**3449.05%**	**8398.05%**	**2496.78%**	**1006.79%**	n/a	592.19%	**1064.51%**	**2195.51%**	**3788.88%**	**1687.61%**
Zhaoqing	**1137.73%**	912.00%	383.84%	614.99%	**5165.50%**	926.74%	**1129.14%**	147.10%	579.32%	515.28%	n/a	**16454.12%**	46.36%	406.65%	**1210.34%**
Gaoyao	**2999.80%**	561.41%	221.51%	**1426.29%**	**3131.45%**	**1622.51%**	**1815.38%**	265.33%	877.88%	**1064.51%**	**15755.76%**	n/a	113.08%	250.30%	**1453.01%**
Sihui	**2997.99%**	**3095.32%**	**1146.14%**	**1642.73%**	**32460.13%**	**2559.08%**	**3331.82%**	478.26%	**1979.11%**	**1621.63%**	16.57%	68.86%	n/a	963.44%	**2458.17%**
Doumen	258.99%	513.54%	223.02%	**16784.61%**	**1399.64%**	**23091.20%**	**27405.03%**	**1097.97%**	**4574.20%**	**3788.88%**	469.98%	221.11%	564.65%	n/a	**3967.36%**
Average	**1746.09%**	**6725.22%**	**12172.10%**	**1804.53%**	**3973.14%**	**3116.86%**	**5222.19%**	578.91%	**2028.69%**	**1622.09%**	**1246.64%**	**1540.37%**	**2063.73%**	**4205.58%**	n/a

Differences greater than or equal to 1000% are in **bold**.

6.3.4 Industrial output

Table 6.6.1 shows the O/D matrix using the industrial output of the PRD cities as another input, as a result of trip distribution. It is then compared with the official prediction in table 6.6.2. From table 6.6.2., the number of trips generated from own findings match with that of the official predictions quite well.

The overall scenario looks like that of using GDP in the analysis. The derivation between the own findings and the official figures is less extreme. Cities like Guangzhou, Shenzhen, Zhuhai, Zhongshan, Panyu, Zengcheng, Conghua, Sanshui and Kaiping have relatively lower discrepancies. A small number of great differences still exists. For example, the city pairs of Foshan and Nanhai (40 times greater than government estimation), Nanhai and Shunde (27 times greater than government estimation), Shunde and Huadu (12 times greater than government estimation), Shunde and Heshan (13 times greater than government estimation), Xinhui and Zhongshan (12 times greater than government estimation), Xinhui and Doumen (13 times greater than government estimation). Very extreme results are found from the pair of Shunde and Nanhai, where own findings are 200 times above government estimation.

The overall picture of industrial output generated matrix shows an over-estimation of the government data. Despite, lower level of over-estimation take place in large cities like Guangzhou, Shenzhen, Zhuhai, Zhongshan and Panyu. Small to medium sized cities like Huidong, Heshan and Enping having derivation of around 80%. A minor of them like Nanhai, Shunde and Xinhui, in contrast, shows an under-estimation of government data.

Table 6.6.1

Origin / Distination matrix showing the number of trips per year (in 000's)

Generated by 2001's industrial output, given k coefficient = 0.000000228, distance coefficient = 2

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng	Conghua
Guangzhou	0.00	9349.94	4301.60	16759.55	2798.26	6991.68	16076.52	1801.13	314.46	183.82	523.35	53218.69	8325.41	3928.16	3053.51
Shenzhen	9349.94	0.00	2886.33	1020.01	545.19	4565.82	8257.01	10866.65	6997.08	917.06	1206.17	4044.61	714.41	1076.69	396.80
Zhuhai	4301.60	2886.33	0.00	311.64	956.52	5330.55	1536.30	335.22	113.60	41.52	54.98	1442.45	211.48	223.98	87.06
Foshan	16759.55	1020.01	311.64	0.00	739.83	709.24	1202.45	201.05	37.19	21.80	55.35	5361.84	648.44	307.74	232.82
Jiangmen	2798.26	545.19	956.52	739.83	0.00	5508.65	596.76	127.99	43.50	13.11	20.94	565.99	177.36	110.78	76.66
Zhongshan	6991.68	4565.82	5330.55	709.24	5508.65	0.00	2756.11	478.91	168.04	57.40	76.21	2994.04	320.83	346.60	125.66
Dongguan	16076.52	8257.01	1536.30	1202.45	596.76	2756.11	0.00	831.63	317.90	92.33	123.35	2891.83	731.10	1776.05	401.28
Huizhou	1801.13	10866.65	335.22	201.05	127.99	478.91	831.63	0.00	2394.07	1288.80	3949.63	380.54	138.95	527.87	120.43
Huiyang	314.46	736.00	113.60	37.19	43.50	168.04	317.90	2394.07	0.00	186.75	174.70	142.57	26.27	74.12	21.12
Huidong	183.82	917.06	41.52	21.80	13.11	57.40	92.33	1288.80	186.75	0.00	97.99	44.94	15.41	42.96	12.35
Boluo	523.35	1206.17	54.98	55.35	20.94	76.21	123.35	3949.63	174.70	97.99	0.00	121.05	45.29	345.64	41.52
Panyu	53218.69	4044.61	1442.45	5361.84	565.99	2994.04	2891.83	380.54	142.57	44.94	121.05	0.00	605.81	583.38	329.48
Huadu	8325.41	714.41	211.48	648.44	177.36	320.83	731.10	138.95	26.27	15.41	45.29	605.81	0.00	187.40	375.47
Zengcheng	3928.16	1076.69	223.98	307.74	110.78	346.60	1776.05	527.87	74.12	42.96	345.64	583.38	187.40	0.00	195.57
Conghua	3053.51	396.80	87.06	232.82	76 66	125.66	401.28	120.43	21.12	12.35	41.52	329.48	375.47	195.57	0.00
Nanhai	30063.05	2242.41	649.45	397409.89	1611.92	1496.89	2567.33	417.81	91.75	34.07	142.10	13263.99	1410.94	655.51	415.10
Shunde	34733.54	4702.13	1616.17	9430.95	4212.53	13165.53	3008.29	472.28	172.41	56.91	96.29	42858.27	710.37	407.41	282.24
Gaoming	1099.91	211.28	112.13	285.91	312.31	256.47	168.35	58.18	10.19	4.09	12.58	271.92	68.36	42.44	28.37
Sanshui	4797.87	424.54	102.60	858.70	158.94	199.21	419.20	100.64	19.49	7.37	26.30	435.74	207.53	108.60	85.82
Xinhui	2018.96	465.41	938.76	403.58	13981.51	1263.54	589.33	124.55	43.32	15.60	25.45	563.86	122.05	84.19	53.72
Heshan	2217.93	338.25	221.52	719.08	2017.36	661.45	162.09	43.18	14.40	5.60	8.84	136.63	119.12	26.77	46.69
Enping	147.38	82.51	43.05	30.00	48.98	90.12	35.71	11.66	3.74	1.57	2.39	27.39	12.38	6.66	5.81
Kaiping	1050.71	497.39	313.33	267.53	656.76	873.70	234.34	64.54	21.39	8.42	13.22	194.33	85.24	39.49	37.89
Taishan	1143.06	528.22	314.69	251.95	535.98	800.23	242.80	70.21	23.05	9.24	14.38	196.69	87.06	42.15	39.33
Zhaoqing	828.57	232.80	57.99	135.34	55.57	95.53	156.12	53.67	11.34	4.76	13.09	127.43	61.81	41.70	29.34
Gaoyao	631.81	182.57	45.52	103.04	43.02	74.60	121.06	42.05	8.91	3.76	10.24	98.22	47.66	32.36	22.70
Sihui	834.73	152.91	37.59	140.14	43.93	66.47	120.41	35.68	7.25	2.91	8.97	107.68	51.88	31.78	23.39
Doumen	639.05	492.85	2799.49	68.97	220.57	1629.05	215.88	53.28	18.03	6.83	10.90	189.29	24.61	34.01	13.00
Total	**207832.65**	**57135.95**	**25085.51**	**437714.03**	**36180.93**	**51102.53**	**45631.57**	**24990.61**	**11456.65**	**3177.34**	**7220.94**	**131198.67**	**15532.65**	**11280.00**	**6553.12**

	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	Total
Guangzhou	30063.05	34733.54	1099.91	4797.87	2018.96	2217.93	147.38	1050.71	1143.06	828.57	631.81	834.73	639.05	**207832.65**
Shenzhen	2242 41	4702.13	211.28	749.87	465.41	338.25	82.51	497.39	528.22	232.80	182.57	152.91	492.85	**63722.37**
Zhuhai	649.45	1616.17	112.13	87.43	938.76	221.52	43.05	313.33	314.69	57.99	45.52	37.59	2799.49	**25070.34**
Foshan	397409.89	9430.95	285.91	290.95	403.58	719.08	30.00	267.53	251.95	135.34	103.04	140.14	68.97	**437146.28**
Jiangmen	1611.92	4212.53	312.31	214.02	13981.51	2017.36	48.98	656.76	535.98	55.57	43.02	43.93	220.57	**36236.01**
Zhongshan	1496.89	13165.53	256.47	318.22	5054.16	661.45	90.12	873.70	800.23	95.53	74.60	66.47	1629.05	**55012.17**
Dongguan	2567.33	3008.29	168.35	434.98	589.33	162.09	35.71	234.34	242.80	156.12	121.06	120.41	215.88	**45647.35**
Huizhou	417.81	472.28	58.18	83.91	124.55	43.18	11.66	64.54	70.21	53.67	42.05	35.68	53.28	**24973.88**
Huiyang	91.75	172.41	10.19	9.79	43.32	14.40	3.74	21.39	23.05	11.34	8.91	7.25	18.03	**5185.87**
Huidong	34.07	56.91	4.09	6.88	15.60	5.60	1.57	8.42	9.24	4.76	3.76	2.91	6.83	**3176.84**
Boluo	142.10	96.29	12.58	26.30	25.45	8.84	2.39	13.22	14.38	13.09	10.24	8.97	10.90	**7220.94**
Panyu	13263.99	42858.27	271.92	435.74	563.86	136.63	27.39	194.33	196.69	127.43	98.22	107.68	189.29	**131198.67**
Huadu	1410.94	710.37	68.36	207.53	122.05	119.12	12.38	85.24	87.06	61.81	47.66	51.88	24.61	**15532.65**
Zengcheng	655.51	407.41	42.44	108.60	84.19	26.77	6.66	39.49	42.15	41.70	32.36	31.78	34.01	**11280.00**
Conghua	415.10	282.24	28.37	85.82	53.72	46.69	5.81	37.89	39.33	29.34	22.70	23.39	13.00	**6553.12**
Nanhai	0.00	18131.01	600.42	2130.12	863.52	1620.86	62.86	570.27	534.02	295.91	224.82	317.79	167.26	**477991.07**
Shunde	18131.01	0.00	771.68	701 73	2481.06	2271.46	73.30	674.90	628.90	194.56	149.78	167.59	315.75	**142487.05**
Gaoming	600.42	771.68	0.00	60.81	140.37	290.68	10.27	92.79	87.02	21.30	16.49	16.82	27.34	**5078.48**
Sanshui	2130.12	701.73	60.81	0.00	101.57	116.34	9.35	69.83	69.58	170.79	125.72	356.19	25.04	**11889.60**
Xinhui	863.52	2481.06	140.37	101.57	0.00	548.19	47.89	654.99	530.60	41.63	32.37	30.91	440.85	**26607.79**
Heshan	1620.86	2271.46	290.68	116.34	548.19	0.00	23.47	325.36	262.23	33.06	25.47	28.23	61.67	**12345.95**
Enping	62.86	73.30	10.27	9.35	47.89	23.47	0.00	141.58	90.10	4.88	3.82	3.28	10.57	**1030.73**
Kaiping	570.27	674.90	92.79	69.83	654.99	325.36	141.58	0.00	4999.98	29.73	23.13	21.73	85.23	**12047.82**
Taishan	534.02	628.90	87.02	69.58	530.60	262.23	90.10	4999.98	0.00	31.48	24.54	22.45	82.91	**11662.86**
Zhaoqing	295.91	194.56	21.30	170.79	41.63	33.06	4.88	29.73	31.48	0.00	70894.91	121.49	13.18	**73758.01**
Gaoyao	224.82	149.78	16.49	125.72	32.37	25.47	3.82	23.13	24.54	70894.91	0.00	87.99	10.33	**73086.88**
Sihui	317.79	167.59	16.82	356.19	30.91	28.23	3.28	21.73	22.45	121.49	87.99	0.00	8.81	**2849.01**
Doumen	167.26	315.75	27.34	25.04	440.85	61.67	10.57	85.23	82.91	13.18	10.33	8.81	0.00	**7664.75**
Total	**477991.07**	**142487.05**	**5078.48**	**11794.97**	**30398.41**	**12345.95**	**1030.73**	**12047.82**	**11662.86**	**73758.01**	**73086.88**	**2849.01**	**7664.75**	**1934289.15**

Table 6.6.2

Comparison of the number of trips generated (by 2001's industrial output) between Table 6.6.1 (self prediction) and Table 6.2 (official prediction)

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng	Conghua
Guangzhou	n/a	-11.21%	-8.09%	60.53%	33.25%	59.63%	-53.83%	-35.90%	-90.86%	-88.58%	-11.30%	334.08%	-82.61%	-38.24%	-47.44%
Shenzhen	0.21%	n/a	56.87%	-38.92%	-4.35%	33.90%	-72.64%	51.98%	914.07%	-77.80%	-1.13%	61.78%	-9.57%	-54.76%	183.43%
Zhuhai	76.30%	122.03%	n/a	-92.01%	95.21%	-73.78%	-57.68%	-78.23%	-67.54%	-85.68%	-94.81%	10.96%	0.71%	123.98%	-12.94%
Foshan	69.12%	-47.69%	-90.99%	n/a	50.99%	-92.43%	-15.91%	-69.54%	-94.36%	-94.26%	-60.46%	196.23%	-23.71%	-79.35%	5.83%
Jiangmen	31.99%	-4.35%	80.47%	50.99%	n/a	533.18%	-63.16%	-81.18%	-71.00%	-89.92%	-79.06%	-70.05%	-6.65%	-7.68%	-41.03%
Zhongshan	59.26%	92.65%	-75.57%	-93.35%	525.98%	n/a	-58.55%	-82.96%	-73.33%	-89.17%	-95.97%	26.33%	-13.29%	82.42%	-21.46%
Dongguan	-53.80%	-70 33%	-55.47%	-15.91%	-62.70%	-59.29%	n/a	-88.67%	-83.70%	-99.21%	-96.54%	-55.23%	40.60%	-89.84%	43.31%
Huizhou	-34.98%	79.91%	-84.48%	-68.59%	-80.61%	-88.03%	-88.65%	n/a	-86.89%	-78.80%	176.20%	-78.86%	-42.10%	-32.32%	-7.36%
Huiyang	-90.70%	20.66%	-77.28%	-94.10%	-71.00%	-81.93%	-81.94%	-86.88%	n/a	-98.36%	-47.06%	-76.63%	-86.86%	-60.99%	-29.61%
Huidong	-87.41%	-73.11%	-90.11%	-93.59%	-89.92%	-92.55%	-99.06%	111.28%	-98.35%	n/a	-65.00%	-98.68%	-61.47%	-71.36%	-38.27%
Boluo	-11.30%	-0.32%	-95.13%	-60.46%	-79.06%	-95.90%	-96.50%	174.28%	-47.06%	-63.71%	n/a	10.05%	-9.42%	-9.04%	107.59%
Panyu	361.17%	108.49%	15.40%	179.26%	-71.12%	22.21%	-73.22%	-77.88%	-77.37%	-91.52%	21.05%	n/a	-38.81%	386.15%	-69.21%
Huadu	-82.55%	-21.49%	-8.05%	-27.95%	-6.65%	-15.57%	40.60%	-42.10%	-86.17%	-61.47%	-9.42%	-43.38%	n/a	-92.65%	-24.91%
Zengcheng	-47.69%	-54.38%	103.62%	-6.75%	-7.68%	82.42%	-89.82%	-33.18%	-56.40%	-71.36%	-9.04%	386.15%	-92.65%	n/a	-80.44%
Conghua	-47.98%	108.84%	-12.94%	1.22%	-45.24%	-21.46%	38.37%	-7.36%	-29.61%	-38.27%	107.59%	-69.21%	-24.91%	-80.44%	n/a
Nanhai	182.81%	85.32%	-4.49%	**4365.28%**	437.31%	34.86%	191.74%	1.91%	-77.62%	-85.19%	57.89%	583.71%	55.05%	-29.52%	-51.17%
Shunde	489.70%	135.11%	-51.76%	21.38%	680.10%	-25.62%	178.55%	4.95%	-73.06%	-89.46%	6.99%	85.94%	42.07%	239.51%	-72.33%
Gaoming	-60.86%	-55.05%	1.93%	-56.01%	-97.93%	34.98%	-88.55%	-97.91%	-91.51%	-96.28%	-97.83%	-46.68%	-93.79%	-94.11%	-92.53%
Sanshui	64.88%	-19.90%	-79.48%	26.28%	58.94%	-75.71%	-20.91%	-16.13%	-86.08%	-81.57%	31.52%	-17.79%	-95.22%	-91.65%	-94.73%
Xinhui	48.45%	86.16%	308.16%	26.12%	280 97%	232.51%	-17.00%	-57.05%	-38.11%	-68.79%	-63.64%	-40.65%	1.71%	5.23%	-32.85%
Heshan	-15.67%	207.50%	121.52%	17.88%	-81.96%	313.41%	-88.17%	-92.42%	-51.99%	-71.98%	-92.63%	-74.70%	-48.21%	-82.15%	-6.62%
Enping	-93.65%	-80.35%	-88.96%	-94.44%	-87.76%	-85.92%	-97.05%	-97.67%	-96.60%	-98.43%	-97.83%	-93.48%	-93.81%	-94.87%	-85.47%
Kaiping	-50.20%	30.89%	-12.96%	-45.40%	77.50%	48.09%	-78.70%	-85.97%	-78.61%	-90.64%	-86.78%	-75.40%	-55.14%	-67.09%	-24.22%
Taishan	-19.50%	103.16%	31.12%	-23.65%	114.39%	105.19%	-67.19%	-76.60%	-67.07%	-81.53%	-79.45%	-24.35%	-27.45%	-47.32%	31.11%
Zhaoqing	-80.23%	-69.37%	-91.95%	-86.19%	-53.69%	-91.84%	-92.87%	-94.04%	-94.60%	-97.20%	-93.11%	-83.23%	-82.83%	-82.62%	-67.40%
Gaoyao	-88.08%	-81.18%	-94.94%	-91.62%	-38.54%	-94.96%	-67.28%	-71.97%	-96.57%	-87.48%	-65.87%	-89.87%	-89.64%	-19.09%	-24.33%
Sihui	-66.48%	-66.76%	-91.05%	-75.84%	-12.15%	-90 50%	-90.81%	-93.27%	-93.96%	-97.09%	-91.85%	-76.59%	-76.42%	-77.30%	-53.22%
Doumen	-79.65%	-29.59%	344.36%	-90.55%	215.10%	-72.71%	-59.27%	-93.58%	-90.51%	-95.45%	-92.73%	-72.96%	-90.89%	240.07%	-88.18%
Average	13.82%	18.36%	-1.86%	133.10%	62.20%	12.67%	-43.31%	-45.04%	-40.18%	-84.05%	-38.16%	18.80%	-40.94%	-8.33%	-25.72%

	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	**Average**
Guangzhou	160.51%	478.89%	-63.58%	60.46%	50 67%	-13.02%	-93.59%	-49.97%	-18.35%	-75.12%	-87.83%	-73.83%	87.95%	14.17%
Shenzhen	124.24%	170.24%	-55.98%	38.86%	86.16%	207.50%	-80.35%	27.54%	103.16%	-61.84%	-80.98%	-74.08%	89.56%	56.93%
Zhuhai	13.94%	-55.72%	1 93%	-81 79%	326.71%	121.52%	-88.36%	-7.84%	36.82%	-89.06%	-94.52%	-92.63%	107.37%	-1.30%
Foshan	**4301.00%**	24.58%	-59.73%	-58.44%	26.12%	19.85%	-94.34%	-45.40%	-23.65%	-82.65%	-91.55%	-81.31%	-96.25%	125.62%
Jiangmen	455.84%	694.82%	-97.91%	137.80%	277.88%	-82.27%	-87.44%	82.43%	123.33%	-53.69%	-38.54%	-12.15%	215.10%	66.58%
Zhongshan	46.75%	-29.18%	28.24%	-63.00%	**1230.04%**	289.09%	-86.14%	45.62%	100.06%	-90.05%	-94.99%	-92.70%	-70.00%	51.73%
Dongguan	202.04%	186.50%	-89.35%	-23.69%	-15.81%	-87.81%	-97.02%	-78.70%	-66.74%	-91.03%	-62.17%	-92.79%	-58.48%	-41.55%
Huizhou	7.13%	0.48%	-97.99%	-23.71%	-57.05%	-92.00%	-97.62%	-85.97%	-76.60%	-92.55%	-67.65%	-94.83%	-82.24%	-50.97%
Huiyang	-75.86%	-71.74%	-92.16%	-93.47%	-38.11%	-51.99%	-96.60%	-80.55%	-67.07%	-92.92%	-96.57%	-95.47%	-77.47%	-73.80%
Huidong	-83.77%	-88.84%	-96.28%	-82.81%	-68.79%	-71.98%	-98.43%	-90.64%	-81.53%	-96.60%	-81.22%	-97.76%	-90.24%	-76.91%
Boluo	57.89%	-3.71%	-97.94%	31.52%	-63.64%	-92.63%	-97.83%	32.17%	-79.45%	-91.27%	-65.87%	-93.59%	-92.21%	-34.54%
Panyu	525.66%	84.57%	-51.44%	-22.19%	-38.04%	-75.60%	-93.48%	-74.76%	-24.35%	-79.11%	-89.77%	-81.75%	-0.38%	21.26%
Huadu	41.09%	**1266.09%**	-94.16%	-95.15%	1.71%	-45.85%	-93.81%	-55.14%	-27.45%	-78.69%	-89.41%	-80.78%	-17.97%	5.51%
Zengcheng	-38.16%	270.38%	-94.34%	-91.10%	5.23%	-80.88%	-94.87%	-67.09%	-47.32%	-78.05%	7.87%	-83.27%	240.07%	-4.77%
Conghua	-49.99%	-71.78%	-93.08%	-94.67%	-32.85%	-6.62%	-85.47%	-5.27%	31.11%	-67.40%	13.50%	-53.22%	30.02%	-22.49%
Nanhai	n/a	**26563.24%**	36.46%	384.12%	331.76%	338.07%	-81.51%	90.09%	154.30%	-38.35%	-70.02%	-32.39%	-85.33%	**1234.75%**
Shunde	**2777.94%**	n/a	45.60%	32.40%	933.78%	**1319.67%**	-81.68%	82.41%	151.56%	-67.02%	-83.54%	-70.60%	-85.65%	241.74%
Gaoming	53.95%	60.77%	n/a	-88.31%	-88.10%	-97.47%	-91.44%	-15.65%	8.77%	-96.96%	-95.66%	-87.06%	173.39%	-51.70%
Sanshui	432.53%	40.35%	-89.69%	n/a	103.14%	5.76%	-90.65%	-30.17%	-0.60%	13.86%	-45.34%	154.42%	-64.23%	-2.52%
Xinhui	354.48%	978.72%	-88.10%	103.14%	n/a	-45.72%	-77.19%	244.73%	308.15%	-47.96%	-19.08%	3.03%	**1369.50%**	139.07%
Heshan	338.07%	**1319.67%**	-97.47%	5.76%	-48.28%	n/a	-78.66%	225.36%	274.62%	-76.38%	-68.16%	-59.67%	516.67%	81.68%
Enping	-80.95%	-81.21%	-92.10%	-90.65%	-76.05%	-78.66%	n/a	-29.21%	-9.90%	-96.24%	-94.54%	-95.32%	-78.86%	-84.81%
Kaiping	96.64%	87.47%	-22.68%	-22.41%	285.29%	225.36%	-32.58%	n/a	-0.99%	-75.23%	-66.95%	-56.53%	113.08%	-2.38%
Taishan	167.01%	162.04%	8.77%	39.16%	342.17%	274.62%	-9.90%	-0.79%	n/a	-60.65%	-38.64%	-25.18%	176.38%	33.55%
Zhaoqing	-49.85%	-72.98%	-90.74%	0.47%	-47.96%	-77.96%	-96.51%	-75.23%	-65.02%	n/a	254.83%	-98.06%	-85.35%	-65.39%
Gaoyao	-69.62%	-83.36%	-81.68%	-42.86%	-19.08%	-68.16%	-95.22%	-66.95%	-38.64%	239.86%	n/a	-97.38%	-90.61%	-59.82%
Sihui	-9.20%	-60.10%	-87.06%	256.19%	-22.73%	-64.71%	-95.32%	-56.53%	-43.89%	-98.45%	-97.92%	n/a	-82.37%	-59.83%
Doumen	-61.99%	-77.45%	173.39%	-64.23%	**1369.50%**	516.67%	-78.86%	113.08%	176.38%	-83.52%	-91.40%	-88.98%	n/a	60.97%
Average	356.94%	**1173.81%**	-53.30%	1.90%	176.06%	80.92%	-85.00%	1.02%	29.51%	-63.22%	-56.89%	-64.96%	72.65%	n/a

Differences greater than or equal to 1000% are in **bold**.

6.3.5 Retail sales

Table 6.7.1 shows the O/D matrix using the retail sales of the PRD cities as another input, as a result of trip distribution. It is then compared with the official prediction in table 6.7.2.

The cities of Guangzhou and Foshan have the lowest level of discrepancies of 7% to 8% from the official prediction. The majority of the remaining cities shows greater derivation, in particular, Huizhou, Huidong, Gaoming, Enping, Zhaoqing, Gaoyao and Sihui are 80% lower than government estimation. Extreme cases take place in the city pairs of Foshan and Nanhai (16 times greater than government estimation) and Shunde and Nanhai (69 times greater than government estimation).

The overall picture of retail sales shows an over-estimation of the government data. Again, larger cities like Guangzhou, Foshan still have lower level of derivation and higher level of it take place at small to medium sized cities where Huidong, Enping and Gaoyao have the most significant derivation of 80% below government's estimation. The extreme figure of Shunde (2 times above government prediction) is mainly due to the effect of the city pair of Shunde and Nanhai, making the average greater.

Table 6.7.1

Origin / Destination matrix showing the number of trips per year (in 000's)

Generated by 2001's retail sales, given k coefficient = 0.000002994, distance coefficient = 2

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu	Zengcheng	Conghua	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	Total
Guangzhou	0.00	9331.06	3343.09	16863.93	1476.32	4587.35	16601.93	578.84	296.13	369.65	420.08	38593.98	7961.38	3611.22	3219.33	29570.69	23516.01	744.51	5091.31	1520.62	1981.49	344.82	839.05	1243.48	1015.71	485.91	1110.23	403.91	**175122.02**
Shenzhen	9331.06	0.00	890.57	407.48	114.19	1189.33	3385.26	1386.47	2616.01	732.14	384.37	1164.49	271.23	392.97	166.09	875.68	1263.90	125.32	178.85	139.17	119.97	76.64	157.69	228.13	113.30	55.74	80.74	123.67	**25970.46**
Zhuhai	3343.09	890.57	0.00	96.95	156.02	1081.31	490.50	33.31	33.08	25.81	13.64	323.41	62.53	63.66	28.38	197.50	338.30	64.93	33.66	218.60	61.19	31.14	77.36	105.84	21.98	10.82	15.46	547.05	**8366.08**
Foshan	16863.93	407.48	96.95	0.00	156.24	186.27	497.06	25 86	14.02	17.54	17.78	1556.49	248.22	113.25	98.26	156474.54	2555.92	122.68	364.75	121.68	257.16	28.10	85.52	109.71	66.41	31.72	74.61	17.45	**180609.60**
Jiangmen	1476.32	114.19	156.02	156.24	0.00	758.58	129.34	8.63	8.60	5.53	3.53	86.15	35.60	21.38	16.96	332.77	598.59	73.16	35 40	2210.14	378 27	24.05	110.07	122.38	14.30	6.94	12.26	29.26	**6924.66**
Zhongshan	4587.35	1189.33	1081.31	186.27	758.58	0.00	742.89	40.17	41.30	30.13	15.97	566.73	80.08	83.17	34.58	384.31	2326.56	101.35	55.18	993.58	154.24	55.03	182.11	227.22	30.57	14.98	23.08	268.75	**14254.79**
Dongguan	16601.93	3385.26	490.50	497.06	129.34	742.89	0 00	109.80	122.99	76.27	40.67	861.54	287.21	670.76	173.80	1037.42	836.72	169.21	182.75	182.35	59.49	34.32	76.88	108.51	78.62	38.25	65.79	56.06	**27116.42**
Huizhou	578.84	1386.47	33.31	25.86	8.63	40.17	109.80	0.00	288.24	331.34	405.31	35.28	16.99	62.04	16.23	52.54	40.88	13.32	13.65	11.99	4.93	3.49	6.59	9.76	8.41	4.13	6.07	4.31	**3518.59**
Huiyang	296.13	275.17	33.08	14.02	8.60	41.30	122.99	288.24	0.00	140.69	52.53	38.73	9.41	25.53	8.34	33.81	43.73	3.45	7.75	12.22	4.82	3.27	6.40	9.39	5.21	2.57	3.61	4.27	**1495.26**
Huidong	369.65	732.14	25.81	17.54	5.53	30.13	76.27	331.34	140.69	0.00	62.92	26.07	11.79	31.59	10.41	26.81	30.82	3.08	6.26	9.40	4.01	2.93	5.38	8.04	4.67	2.31	3.09	3.45	**1982.14**
Boluo	420.08	384.37	13.64	17.78	3.53	15.97	40.67	405.31	52.53	62.92	0.00	28.03	13.83	101.46	13.98	44.63	20.82	3.33	8.91	6.12	2.52	1.79	3.37	5.00	5.13	2.51	3.81	2.20	**1684.24**
Panyu	38593.98	1164.49	323.41	1556.49	86.15	566.73	861.54	35.28	38.73	26.07	28.03	0.00	167.13	154.72	100.22	3763.90	8371.14	53.10	133.40	122.52	35.22	18.49	44.77	61.73	45.06	21.79	41.32	34.51	**56449.91**
Huadu	7961.38	271.23	62.53	248.22	35.60	80.08	287.21	16.99	9.41	11.79	13.83	167.13	0.00	65.54	150.59	527.96	182.96	17.60	83.78	34.97	40.49	11.02	25.89	36.03	28.83	13.95	26.25	5.92	**10417.15**
Zengcheng	3611.22	392.97	63.66	113.25	21.38	83.17	670.76	62.04	25.53	31.59	101.46	154.72	65.54	0.00	75.41	235.80	100.88	10.51	42.14	23.19	8.75	5.70	11.53	16.77	18.70	9.10	15.46	7.86	**5979.07**
Conghua	3219.33	166.09	28.38	98.26	16.96	34.58	173.80	16.23	8.34	10.41	13.98	100.22	150.59	75.41	0.00	171.25	80.15	8.06	38.20	16.97	17.49	5.70	12.69	17.95	15.08	7.32	13.05	3.45	**4519.93**
Nanhai	29570.69	875.68	197.50	156474.54	332.77	384.31	1037.42	52.54	33.81	26.81	44.63	3763.90	527.96	235.80	171.25	0.00	4803.36	159.03	884.49	254.49	566.63	57.55	178.19	227.32	141.94	67.66	165.39	41.37	**201277.04**
Shunde	23516.01	1263.90	338.30	2555.92	598.59	2326.56	836.72	40.88	43.73	30.82	20.82	8371.14	182.96	100.88	80.15	4803.36	0.00	140.68	200.56	503.30	546.57	46.19	145.16	184.27	64.24	31.03	60.04	53.75	**47086.51**
Gaoming	744.51	56.78	23.46	77.47	44.37	45.31	46.81	5.04	2.58	2.21	2.72	53.10	17.60	10.51	8.06	159.03	140.68	0.00	17.38	28.47	69.93	6.47	19.95	25.49	7.03	3.41	6.03	4.65	**1629.05**
Sanshui	5091.31	178.85	33.66	364.75	35.40	55.18	182.75	13.65	7.75	6.26	8.91	133.40	83.78	42.14	38.20	884.49	200.56	17.38	0.00	32.29	43.88	9.23	23.54	31.95	88.38	40.82	199.99	6.68	**7855.18**
Xinhui	1520.62	139.17	218.60	121.68	2210.14	248.40	182.35	11.99	12.22	9.40	6.12	122.52	34.97	23.19	16.97	254.49	503.30	28.47	32.29	0.00	146.74	33.57	156.72	172.95	15.29	7.46	12.32	83.49	**6325.41**
Heshan	1981.49	119.97	61.19	257.16	378.27	154.24	59.49	4.93	4.82	4.01	2.52	35.22	40.49	8.75	17.49	566.63	546.57	69.93	43.88	146.74	0.00	19.52	92.34	101.39	14.41	6.96	13.34	13.85	**4765.57**
Enping	344.82	76.64	31.14	28.10	24.05	55.03	34.32	3.49	3.27	2.93	1.79	18.49	11.02	5.70	5.70	57.55	46.19	6.47	9.23	33.57	19.52	0.00	105.23	91.22	5.57	2.74	4.06	6.22	**1034.05**
Kaiping	839.05	157.69	77.36	85.52	110.07	182.11	76.88	6.59	6.40	5.38	3.37	44.77	25.89	11.53	12.69	178.19	145.16	19.95	23.54	156.72	92.34	105.23	0.00	1727.93	11.58	5.65	9.18	17.11	**4137.91**
Taishan	1243.48	228.13	105.84	109.71	122.38	227.22	108.51	9.76	9.39	8.04	5.00	61.73	36.03	16.77	17.95	227.32	184.27	25.49	31.95	172.95	101.39	91.22	1727.93	0.00	16.70	8.17	12.92	22.68	**4932.94**
Zhaoqing	1015.71	113.30	21.98	66.41	14.30	30.57	78.62	8.41	5.21	4.67	5.13	45.06	28.83	18.70	15.08	141.94	64.24	7.03	88.38	15.29	14.41	5.57	11.58	16.70	0.00	26589.48	78.80	4.06	**28509.46**
Gaoyao	485.91	55.74	10.82	31.72	6.94	14.98	38.25	4.13	2.57	2.31	2.51	21.79	13.95	9.10	7.32	67.66	31.03	3.41	40.82	7.46	6.96	2.74	5.65	8.17	26589.48	0.00	35.80	2.00	**27509.23**
Sihui	1110.23	80.74	15.46	74.61	12.26	23.08	65.79	6.07	3.61	3.09	3.81	41.32	26.25	15.46	13.05	165.39	60.04	6.03	199.99	12.32	13.34	4.06	9.18	12.92	78.80	35.80	0.00	2.95	**2095.65**
Doumen	403.91	123.67	547.05	17.45	29.26	268.75	56.06	4.31	4.27	3.45	2.20	34.51	5.92	7.86	3.45	41.37	53.75	4.65	6.68	83.49	13.85	6.22	17.11	22.68	4.06	2.00	2.95	0.00	**1770.92**
Total	**175122.02**	**23561.07**	**8324.62**	**180564.39**	**6895.88**	**13453.57**	**26994.02**	**3510.30**	**3835.24**	**1981.27**	**1683.63**	**56449.91**	**10417.15**	**5979.07**	**4519.93**	**201277.04**	**47086.51**	**2002.12**	**7855.18**	**7070.60**	**4765.57**	**1034.05**	**4137.91**	**4932.94**	**28509.46**	**27509.23**	**2095.65**	**1770.92**	**863339.22**

Table 6.7.2

Comparison of the number of trips generated (by 2001's retail sales) between Table 6.7.1 (self prediction) and Table 6.2 (official prediction)

	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen	Zhongshan	Dongguan	Huizhou	Huiyang	Huidong	Boluo	Panyu	Huadu
Guangzhou	n/a	-11.39%	-28.57%	61.53%	-29.70%	4.73%	-52.32%	-79.40%	-91.39%	-77.04%	-28.80%	214.80%	-83.37%
Shenzhen	0.01%	n/a	-51.60%	-75.60%	-79.97%	-65.12%	-88.78%	-80.61%	279.13%	-82.27%	-68.49%	-53.42%	-65.67%
Zhuhai	37.01%	-31.49%	n/a	-97.51%	-68.16%	-94.68%	-86.49%	-97.84%	-90.55%	-91.10%	-98.71%	-75.12%	-70.23%
Foshan	70.17%	-79.10%	-97.20%	n/a	-68.11%	-98.01%	-65.24%	-96.08%	-97.88%	-95.38%	-87.30%	-14.01%	-70.80%
Jiangmen	-30.36%	-79.97%	-70.56%	-68.11%	n/a	-12.81%	-92.02%	-98.73%	-94.27%	-95.75%	-96.47%	-95.44%	-81.26%
Zhongshan	4.50%	-49.82%	-95.04%	-98.25%	-13.80%	n/a	-88.83%	-98.57%	-93.44%	-94.32%	-99.16%	-76.09%	-78.36%
Dongguan	-52.29%	-87.84%	-85.78%	-65.24%	-91.92%	-89.03%	n/a	-98.50%	-93.69%	-99.35%	-98.86%	-86.66%	-44.77%
Huizhou	-79.10%	-77.05%	-98.46%	-95.96%	-98.69%	-99.00%	-98.50%	n/a	-98.42%	-94.55%	-71.66%	-98.04%	-92.92%
Huiyang	-91.24%	-54.89%	-93.38%	-97.77%	-94.27%	-95.56%	-93.01%	-98.42%	n/a	-98.77%	-84.08%	-93.65%	-95.29%
Huidong	-74.68%	-78.53%	-93.85%	-94.84%	-95.75%	-96.09%	-99.22%	-45.68%	-98.76%	n/a	-77.53%	-99.24%	-70.53%
Boluo	-28.80%	-68.23%	-98.79%	-87.30%	-96.47%	-99.14%	-98.84%	-71.85%	-84.08%	-76.70%	n/a	-74.52%	-72.34%
Panyu	234.44%	-39.97%	-74.13%	-18.93%	-95.60%	-76.87%	-92.02%	-97.95%	-93.85%	-95.08%	-71.97%	n/a	-83.12%
Huadu	-83.31%	-70.19%	-72.81%	-72.42%	-81.26%	-78.93%	-44.77%	-92.92%	-95.05%	-70.53%	-72.34%	-84.38%	n/a
Zengcheng	-51.91%	-83.35%	-42.13%	-65.68%	-82.19%	-56.23%	-96.15%	-92.15%	-84.98%	-78.94%	-73.30%	28.94%	-97.43%
Conghua	-45.16%	-12.58%	-71.62%	-57.28%	-87.88%	-78.39%	-40.07%	-87.51%	-72.20%	-47.93%	-30.12%	-90.63%	-69.88%
Nanhai	178.18%	-27.63%	-70.96%	**1658.14%**	10.92%	-65.38%	17.89%	-87.19%	-91.75%	-88.34%	-50.41%	94.02%	-41.98%
Shunde	299.25%	-36.81%	-89.90%	-67.11%	10.85%	-86.86%	-22.53%	-90.92%	-93.17%	-94.29%	-76.87%	-63.68%	-63.41%
Gaoming	-73.50%	-87.92%	-78.67%	-88 08%	-99.71%	-76.15%	-96.82%	-99.82%	-97.85%	-97.99%	-99.53%	-89.59%	-98.40%
Sanshui	74.96%	-66.25%	-93.27%	-46.36%	-64.60%	-93.27%	-65.52%	-88.62%	-94.47%	-84.35%	-55.43%	-74.83%	-98.07%
Xinhui	11.81%	-44.33%	-4.96%	-61.98%	-39.78%	-34.63%	-74.32%	-95.86%	-82.54%	-81.20%	-91.26%	-87.10%	-70.86%
Heshan	-24 66%	9.07%	-38 81%	-57.84%	-96.62%	-3.60%	-95.66%	-99.13%	-83.93%	-79.97%	-97.90%	-93.48%	-82.40%
Enping	-85.14%	-81.75%	-92.02%	-94.80%	-93.99%	-91.40%	-97.16%	-99.30%	-97.02%	-97.07%	-98.38%	-95.60%	-94.49%
Kaiping	-60.23%	-58.50%	-78.51%	-82.55%	-70.25%	-69.13%	-93.01%	-98.57%	-93.60%	-94.02%	-96.63%	-94.33%	-86.37%
Taishan	-12.43%	-12.26%	-55.90%	-66.75%	-51.05%	-41.74%	-85.34%	-96.75%	-86.58%	-83.92%	-92.86%	-76.26%	-69.98%
Zhaoqing	-75.76%	-85.09%	-96.95%	-93.22%	-88.08%	-97.39%	-96.41%	-99.07%	-97.52%	-97.25%	-97.30%	-94.07%	-91.99%
Gaoyao	-90.83%	-94.25%	-98.80%	-97.42%	-90.08%	-98.99%	-89.66%	-97.24%	-99.01%	-92.30%	-91.62%	-97.75%	-96.97%
Sihui	-55.41%	-82.45%	-96.32%	-87.14%	-75.48%	-96.70%	-94.98%	-98.86%	-96.99%	-96.91%	-96.54%	-91.02%	-88.07%
Doumen	-87.14%	-82.33%	-13.17%	-97.61%	-58.20%	-95.50%	-89.42%	-99.48%	-97.75%	-97.70%	-98.53%	-95.07%	-97.81%
Average	-7.10%	-58.33%	-73.41%	-8.00%	-69.99%	-73.55%	-78.49%	-92.11%	-78.58%	-88 26%	-81.56%	-61.34%	-79.88%

	Zengcheng	Conghua	Nanhai	Shunde	Gaoming	Sanshui	Xinhui	Heshan	Enping	Kaiping	Taishan	Zhaoqing	Gaoyao	Sihui	Doumen	**Average**
Guangzhou	-43.22%	-44.59%	156.25%	291.93%	-75.35%	70.28%	13.48%	-22.29%	-85.01%	-60.05%	-11.18%	-69.50%	-90.64%	-65.20%	18.80%	-8.04%
Shenzhen	-83.49%	18.64%	-12.43%	-27.36%	-73 89%	-66.88%	-44.33%	9.07%	-81.75%	-59.57%	-12.26%	-81.43%	-94.19%	-86.32%	-52.43%	-43.74%
Zhuhai	-36.34%	-71.62%	-65.35%	-90.73%	-40.97%	-92.99%	-0.64%	-38.81%	-91.58%	-77.25%	-53.98%	-95.85%	-98.70%	-96.97%	-59.48%	-69.49%
Foshan	-92.40%	-55.34%	**1632.83%**	-66.24%	-82.72%	-47.89%	-61.98%	-57 14%	-94.70%	-82.55%	-66.75%	-91.49%	-97.40%	-90.05%	-99.05%	-9.33%
Jiangmen	-82.19%	-86 95%	14.75%	12.94%	-99.51%	-60.67%	-40.27%	-96.68%	-93.83%	-69.42%	-49.01%	-88.08%	-90.08%	-75.48%	-58.20%	-69.57%
Zhongshan	-56.23%	-78.39%	-62.32%	-87.48%	-49.33%	-93.58%	161.47%	-9.27%	-91.53%	-69.65%	-43.20%	-96.82%	-98.99%	-97.46%	-95.05%	-64.78%
Dongguan	-96.16%	-37.93%	22.05%	-20.31%	-89.29%	-67.94%	-73.95%	-95.53%	-97.14%	-93.01%	-85.14%	-95.48%	-88.05%	-96.06%	-89.22%	-77.67%
Huizhou	-92.05%	-87.51%	-86.53%	-91.30%	-99.54%	-87.59%	-95.86%	-99.09%	-99.29%	-98.57%	-96.75%	-98.83%	-96.82%	-99.12%	-98.56%	-93.69%
Huiyang	-86.56%	-72.20%	-91.10%	-92.83%	-97.35%	-94.83%	-82.54%	-83.93%	-97.02%	-94.18%	-86.58%	-96.75%	-99.01%	-97.74%	-94.66%	-91.02%
Huidong	-78.94%	-47.93%	-87.23%	-93.96%	-97.20%	-84.35%	-81.20%	-79.97%	-97.07%	-94.02%	-83.92%	-96.66%	-88.45%	-97.62%	-95.07%	-86.23%
Boluo	-73.30%	-30.12%	-50.41%	-79.18%	-99.45%	-55.43%	-91.26%	-97.90%	-98.38%	-66.30%	-92.86%	-96.58%	-91.62%	-97.28%	-98.43%	-80.58%
Panyu	28.94%	-90.63%	77.54%	-63.95%	-90.52%	-76.18%	-86.54%	-93.71%	-95.60%	-94.19%	-76.26%	-92.61%	-97.73%	-93.00%	-81.83%	-60.42%
Huadu	-97.43%	-69.88%	-47.20%	251.85%	-98.50%	-98.04%	-70.86%	-81.60%	-94.49%	-86.37%	-69.98%	-90.06%	-96.90%	-90.28%	-80.28%	-68.11%
Zengcheng	n/a	-92.46%	-77.75%	-8.29%	-98.60%	-96.55%	-71.01%	-93.75%	-95.61%	-90.39%	-79.04%	-90.16%	-69.66%	-91.86%	-21.39%	-72.30%
Conghua	-92.46%	n/a	-79.37%	-91.99%	-98.04%	-97.63%	-78.79%	-65.01%	-85.75%	-68.27%	-40.18%	-83.24%	-63.39%	-73.90%	-65.53%	-69.44%
Nanhai	-74.64%	-79.85%	n/a	**6963.76%**	-63.86%	101.02%	27.25%	53.14%	-83.07%	-40.60%	8.25%	-70.43%	-90.98%	-64.81%	-96.37%	293.49%
Shunde	-15.94%	-92.14%	662.44%	n/a	-73.46%	-62.16%	109.71%	241.60%	-88.45%	-60.77%	-26.29%	-89.11%	-96.59%	-89.47%	-97.56%	-9.39%
Gaoming	-98.54%	-97.88%	-59.22%	-70.69%	n/a	-96.66%	-97.59%	-99.39%	-94.61%	-81.86%	-68.14%	-99.00%	-99.10%	-95.37%	-53.47%	-88.72%
Sanshui	-96.76%	-97.66%	121.12%	-59.89%	-97.05%	n/a	-35.41%	-60.11%	-90.77%	-76.46%	-54.35%	-41.08%	-82.25%	42.85%	-90.46%	-58.09%
Xinhui	-71.01%	-78.79%	33.94%	118.83%	-97.59%	-35.41%	n/a	-85.47%	-84.01%	-17.52%	33.04%	-80.89%	-81.35%	-58.94%	178.29%	-40.14%
Heshan	-94.17%	-65.01%	53.14%	241.60%	-99.39%	-60.11%	-86.16%	n/a	-82.26%	-7.66%	44.84%	-89.71%	-91.30%	-80.94%	38.52%	-45.32%
Enping	-95.61%	-85.75%	-82.56%	-88.16%	-95.02%	-90.77%	-83.21%	-82.26%	n/a	-47.38%	-8.78%	-95.71%	-96.09%	-94.21%	-87.56%	-87.08%
Kaiping	-90.39%	-74.62%	-38.55%	-59.68%	-83.37%	-73.84%	-7.81%	-7.66%	-49.89%	n/a	-65.78%	-90.35%	-91.93%	-81.63%	-57.22%	-72.16%
Taishan	-79.04%	-40.18%	13.66%	-23.22%	-68.14%	-36.09%	44.12%	44.84%	-8.78%	-65 72%	n/a	-79.12%	-79.58%	-56.93%	-24.40%	-47.79%
Zhaoqing	-92.21%	-83.24%	-75.94%	-91.08%	-96.94%	-48.01%	-80.89%	-90.40%	-96.02%	-90.35%	-81.44%	n/a	33.08%	-98.74%	-95.48%	-85.10%
Gaoyao	-77.24%	-75.59%	-90.86%	-96.55%	-96.21%	-81.45%	-81.35%	-91.30%	-96.58%	-91.93%	-79.58%	27.47%	n/a	-98.93%	-98.18%	-87.53%
Sihui	-88.96%	-73.90%	-52.75%	-85.71%	-95.37%	99.99%	-69.21%	-83.32%	-94.21%	-81.63%	-67.70%	-99.00%	-99.16%	n/a	-94.10%	-79.33%
Doumen	-21.39%	-96.87%	-90.60%	-96.16%	-53.47%	-90.46%	178.29%	38.52%	-87.56%	-57 22%	-24.40%	-94.92%	-98.34%	-96.32%	n/a	-66.69%
Average	-73.25%	-69.94%	60.65%	236 89%	-85.56%	-56.45%	-32 83%	-45.46%	-87.22%	-71.22%	-49.53%	-83.90%	-86.49%	-82.29%	-61.05%	n/a

Differences greater than or equal to 1000% are in **bold**

6.3.6 Summary of the above five factors

Table 6.8 summarizes the findings of using population, GDP, GDP per capita, industrial output and retail sales. It concludes the overall pattern of the matrix and regions having lower and higher level of derivation from government data.

Concerning the overall pattern, it is believed that a great variety of data are considered by the planning bureau when determining the government estimation. This explains using population and GDP per capita in self-prediction will give a result greater than that of the government data. In other words, it means that if only population or GDP per capita is used, the result will over-exaggerate the desired trip distribution pattern. For GDP, industrial output and retail sales, the government estimation is greater. It reveals that these three factors are only an insignificant component contributing to trip distribution.

Concerning the level of derivation, larger cities tends to have less difference with government data and medium to small sized cities usually have greater difference. In particular, Guangzhou, Shenzhen and Zhuhai keep higher level of consistence with government data. It is suggested that the larger cities will have a higher chance of inter-city rail development. Therefore, the estimation by the government is more positive than smaller cities.

Table 6.8
Cities having lower and higher level of derivation from government data, by the five factors affecting trip distribution

Factors	**Overall pattern**	**Lower level of derivation**	**Higher level of derivation**
Population	Self-estimation > Government	Shenzhen Zhuhai Foshan Dongguan Huizhou Huadu	Nanhai Shunde Xinhui Taishan
GDP	Self-estimation < Government	Guangzhou Foshan Xinhui Heshan	Huizhou Huidong Nanhai Gaoming
GDP per capita	Self-estimation > Government	Guangzhou Shenzhen Enping	Sanshui Heshan
Industrial output	Self-estimation < Government	Guangzhou Shenzhen Zhuhai Zhongshan Panyu Zengcheng Conghua Sanshui Kaiping	Huidong Heshan Enping
Retail sales	Self-estimation < Government	Guangzhou Foshan	Huidong Enping Gaoyao

Note:

Self-estimation > Government means that the government estimation is lower i.e. **government might have under-estimated**

Self-estimation < Government means that the government estimation is higher i.e. **government might have over-estimated**

6.4. Special discussion of trip distribution in five selected PRD cities

Table 6.9 shows the additional distance matrix, based on the journey distances of inter-city bus services of the cities in discussion in this section. Together with the original distance matrix based on inter-city highway distances (table 6.1), extra predictions were generated since two types of distances are available. The comparison of own findings and the official figures are set out in individual graphs, while population, GDP, GDP per capita, industrial output and retail sales (table 6.10) are used to generate each output.

These five cities, Guangzhou, Shenzhen, Zhuhai, Zhongshan and Dongguan, are selected based on several criteria. From the previous part of the analysis, these cities have a lower level of derivation from government prediction of inter-city trips. The common characteristic of these cities is that they are larger ones in PRD. The possibility of inter-city rail will therefore be greater. Study of larger cities is of greater need. Furthermore, the data concerning the population, GDP, GDP per capita, industrial output and retail sales of these cities tends to have a higher level of accuracy and wider availability. More sources of data can ensure "counter check" of the correctness of data inputted.

Another reason for the combination of these five cities is their location. Apart from Guangzhou, the most important city in Guangdong Province, the remaining four cities are located on the eastern and western part of the PRD respectively. Shenzhen and Dongguan are the core cities on the east while Zhuhai and Zhongshan are on the west. It is an attempt that through taking a closer look of these cities, the possible strategies in planning the PRD region can be revealed.

Table 6.9
Distance matrix of PRD cities for further analysis (using inter-city bus distances) (km)

	Guangzhou	Shenzhen	Zhuhai	Zhongshan	Dongguan
Guangzhou	0	163	165	94	64
Shenzhen	163	0	191	167	102
Zhuhai	125	191	0	73.2	119.2
Foshan	42	190	134	79	122
Jiangmen	91	264	58.8	40.2	129.4
Zhongshan	94	167	79	59.4	97.6
Dongguan	64	102	150	97.6	84.4
Huizhou	157	80	234	130	156.4
Huiyang	201	167	106.2	137.2	127.6
Huidong	143.6	339	138	160	170.2
Boluo	99.6	133	119.6	117.6	136.4
Panyu	36	130	74	74.8	48.8
Huadu	45	175	124.2	39.6	87.6
Zengcheng	57	170	112.6	77.2	108.8
Conghua	67	120.4	138	74.4	117.6
Nanhai	45	110.8	92.2	116	50
Shunde	52	215	68.8	46.4	34
Gaoming	75	238	95.8	26.2	142
Sanshui	51	139.2	116.8	27.6	112.6
Xinhui	111	274	59.8	84.4	111.6
Heshan	71	118.4	144	31.8	159.8
Enping	200	340	227	121.6	88.2
Kaiping	130	299	88.2	82.4	44.4
Taishan	92	309	78.2	93.6	45.6
Zhaoqing	110	250	244	65.4	80
Gaoyao	115	260	138.2	66	79.6
Sihui	94	223	212	55.2	91.8
Doumen	97.4	201	28.8	54.8	44.8

(Source: direct observation from inter-city bus service schedule of the PRD)

Table 6.10
Population, GDP, GDP per capita, Industrial output and Retail sales of the cities studied in 2001

	Population	GDP (in 000's RMB)	GDP per capita (in RMB)	Industrial output (in 000's RMB)	Retail sales (in 000's RMB)
Guangzhou	**5769691**	**244899620**	**42827**	**265521470**	**116171890**
Shenzhen	**1320402**	**195465390**	**43355**	**350752580**	**60926290**
Zhuhai	**759317**	**36659420**	**29306**	**94953560**	**12844320**
Foshan	493999	16962180	35172	40821620	7149380
Jiangmen	438535	15651270	35815	35470070	3257140
Zhongshan	**1348312**	**36250160**	**26994**	**104669640**	**11953170**
Dongguan	**1538919**	**57893400**	**37777**	**109112260**	**19612000**
Huizhou	385943	14298260	37607	75215260	4207260
Huiyang	631461	13024630	20723	20158740	3304190
Huidong	697161	9847520	14210	12024400	4208620
Boluo	772941	9089610	11763	15569040	2175100
Panyu	910913	29405240	32006	65038050	8209270
Huadu	594774	15591800	23785	32215290	5361990
Zengcheng	824559	15812410	19340	30535380	4885950
Conghua	531729	7863710	14820	18157960	3332080
Nanhai	1102237	39389720	35854	82664480	14152360
Shunde	1094751	39221030	36042	93643430	11035030
Gaoming	281687	6352500	22615	13625730	1605290
Sanshui	385797	8463720	21613	19184210	3543290
Xinhui	873036	12541960	14371	33885450	4442100
Heshan	352465	6901320	19595	16348050	2542090
Enping	468012	4624780	9899	6500100	2646910
Kaiping	677823	10332280	15228	25832550	3590510
Taishan	997550	11592580	11588	30645960	5802650
Zhaoqing	472231	9037000	18502	19906210	4247280
Gaoyao	730670	11713210	16041	15995270	2141150
Sihui	418837	6187630	15622	9636620	2230860
Doumen	297423	4648370	13304	17894490	1968570

Cases studied in section 6.4 are in **bold**.
(Source: China Statistical Publishing House (2001a))

6.4.1 Guangzhou

The comparison using population (figure 6.3.1), GDP (figure 6.3.2), GDP per capita (figure 6.3.3), industrial output (figure 6.3.4) and retail sales (figure 6.3.5) shares similar pattern. One of the features of these graphs is that the horizontal axis is set out as increasing distance from the left to the right, this allows the user of the graph to understand if there is relationship between making trips with increasing distances from the origin.

From both self-predicted figures (marked as green for using highway distance and blue for using inter-city bus distance), the peaks of the trip are found towards the origin of travel. More trips are generated at Panyu, Shunde and Nanhai. The curves drop down after the peak of the first five cities. Sharp "secondary peaks" are observed at Dongguan (figures 6.3.2, 6.3.4 and 6.3.5) and Zengcheng (figures 6.3.1. and 6.3.2). Further away from Guangzhou the change in the number of trip is little. Shenzhen, the major city towards the south of PRD, does not attract much trips except a small "hill-shape" peak is found from figures 6.3.2, 6.3.4. and 6.3.5.

The official prediction does not follow the curve of the own findings for the pairs of city closer to Guangzhou. The most obvious case is that Panyu and Nanhai were not recognized as important destination of trips from Guangzhou in the plan. From the view of inter-city rail, where most of the travelers are taking longer distance service, it is not surprising that the forecasted number of inter-city rail passengers – not the total amount of trip makers – is lower for Panyu, Foshan, Shunde and Nanhai.

The "peak" for the government's figures is perhaps the case of Huadu (figure 6.3.2). The recent development of the new airport of Guangzhou is located near to the existing city of

Huadu, though it is on the midway between Guangzhou and Huadu. From the view of planning future extension of rail to the airport, a better forecast of patronage may be necessary. The new airport will not only generate more airline passengers, but also activities linked to airport operation. Hence, the effect of the new airport of Guangzhou deserves much attention.

Planning Guangzhou from its view is strategic. Rapid development in the PRD may give rise to regional disparities even within the delta region. The role of Guangzhou is to make a balance of all interests, and to ensure the leading role of the major city at the same time. It is, therefore, not surprising that Shenzhen, which is at the margin of the PRD, does not attract much trips from Guangzhou in official figures.

The figures generated by population, GDP and industrial output are put into the same graph (figure 6.3.6) for a closer analysis. The figure further illustrates the "anti-distance-decay" in official prediction. For the first few pairs of cities near to Guangzhou, the estimated trips are not significant. The peaks of trips appeared at Huadu and Dongguan which are further away from Guangzhou. Other cities far away from Guangzhou are not significant.

On the other hand, trips generated using population are extremely high near to Guangzhou. This proves that the self-estimated data follow the concept of distance decay. For self-estimated data, the results from population gives greater amount of trips, followed by industrial output and GDP. It can be suggested that the government estimation of Guangzhou shows careful planning of the spatial configuration and accessibility pattern of the whole PRD.

Figure 6.3.1
Comparing official prediction and self predictions (using population of 2001)
- Guangzhou -

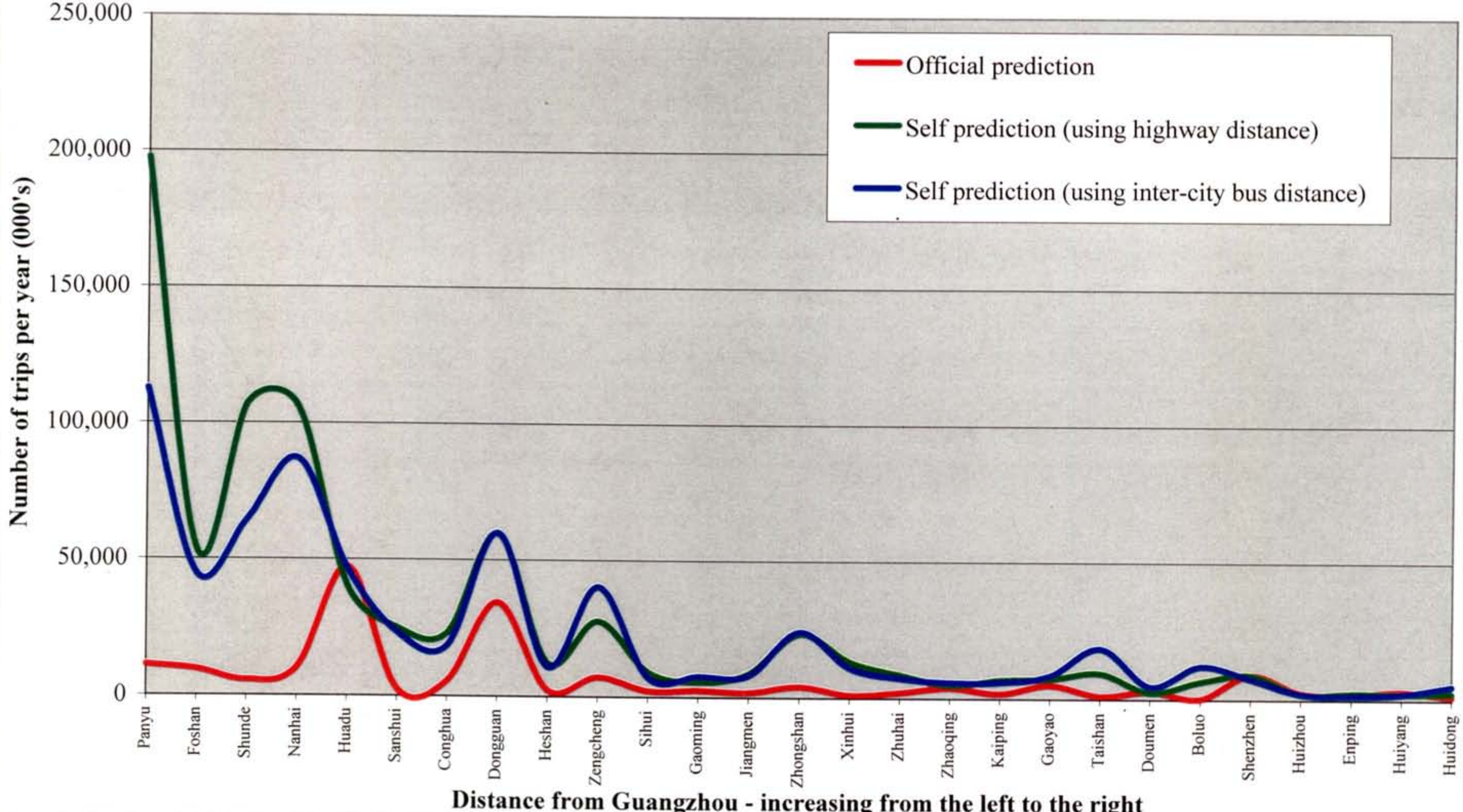


Figure 6.3.2
Comparing official prediction and self predictions (using GDP of 2001)
- Guangzhou -

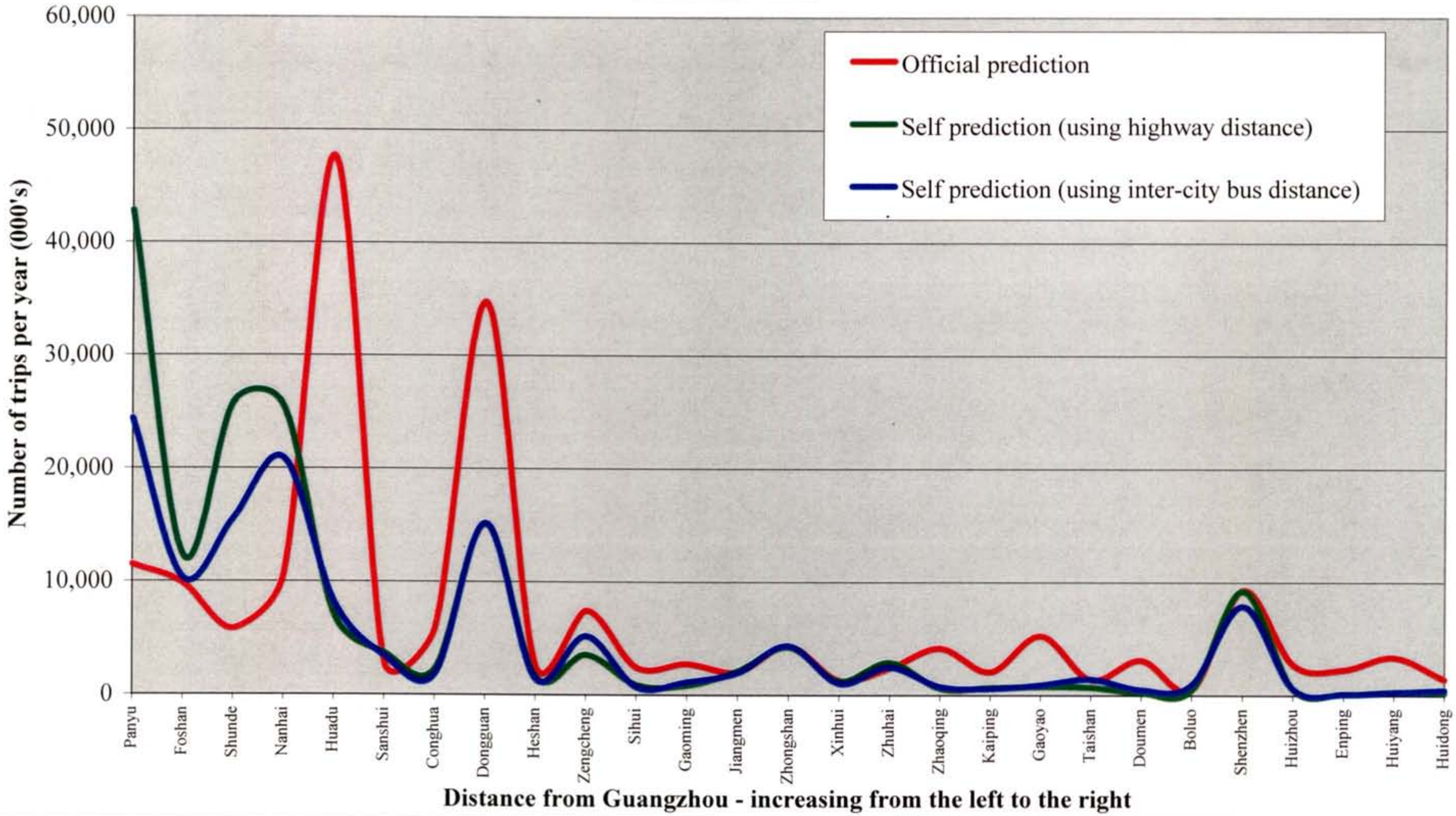
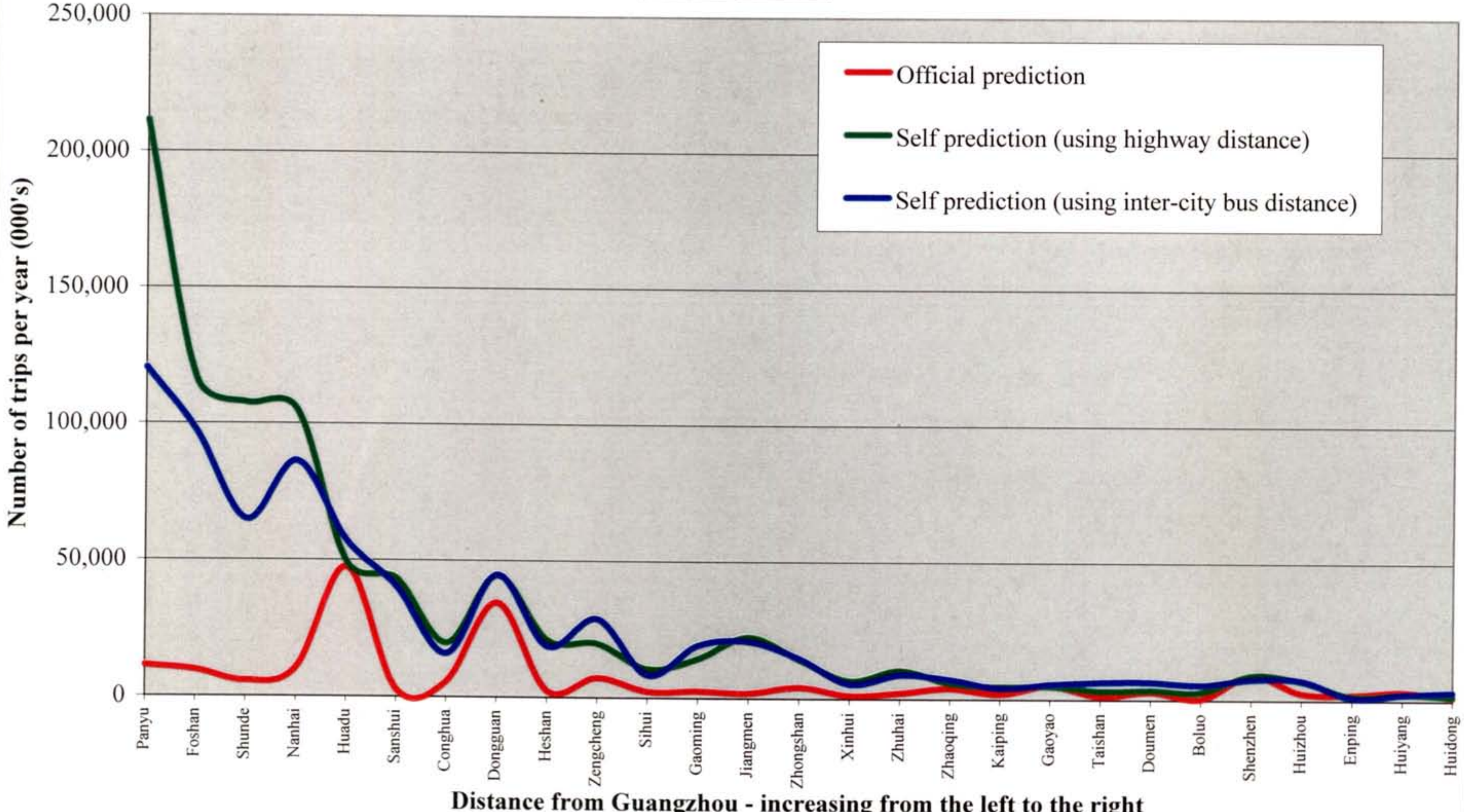


Figure 6.3.3

Comparing official prediction and self predictions (using GDP per capita of 2001)

- Guangzhou -



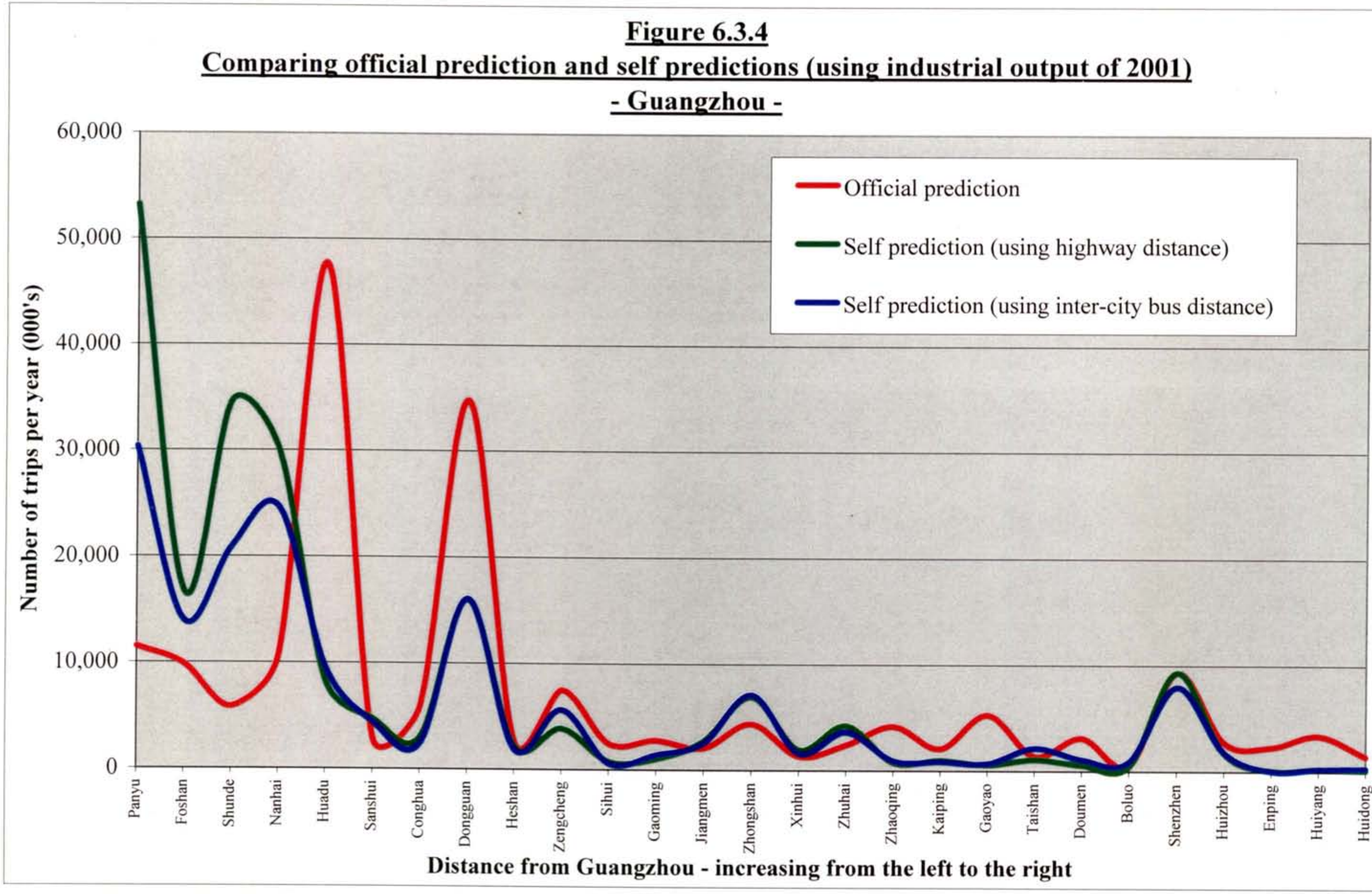
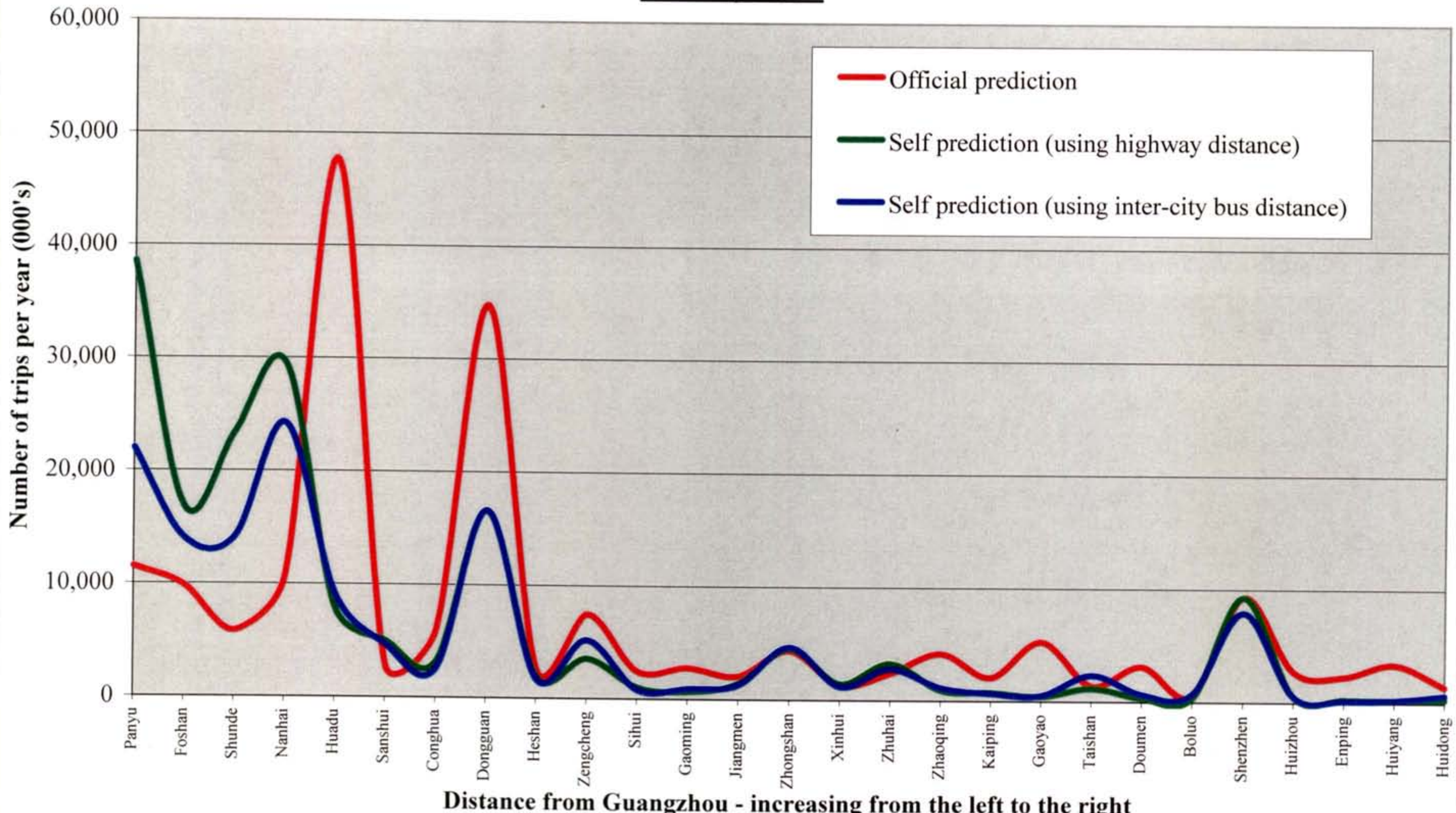


Figure 6.3.4
Comparing official prediction and self predictions (using industrial output of 2001)
- Guangzhou -
60,000
50,000
40,000
30,000
20,000
10,000
0
Number of trips per year (000's)
Official prediction
Self prediction (using highway distance)
Self prediction (using inter-city bus distance)
Panyu
Foshan
Shunde
Nanhai
Huadu
Sanshui
Conghua
Dongguan
Heshan
Zengcheng
Sihui
Gaoming
Jiangmen
Zhongshan
Xinhui
Zhuhai
Zhaoqing
Kaiping
Gaoyao
Taishan
Doumen
Boluo
Shenzhen
Huizhou
Enping
Huiyang
Huidong
Distance from Guangzhou - increasing from the left to the right

Figure 6.3.5

Comparing official prediction and self predictions (using retail sales of 2001)

- Guangzhou -



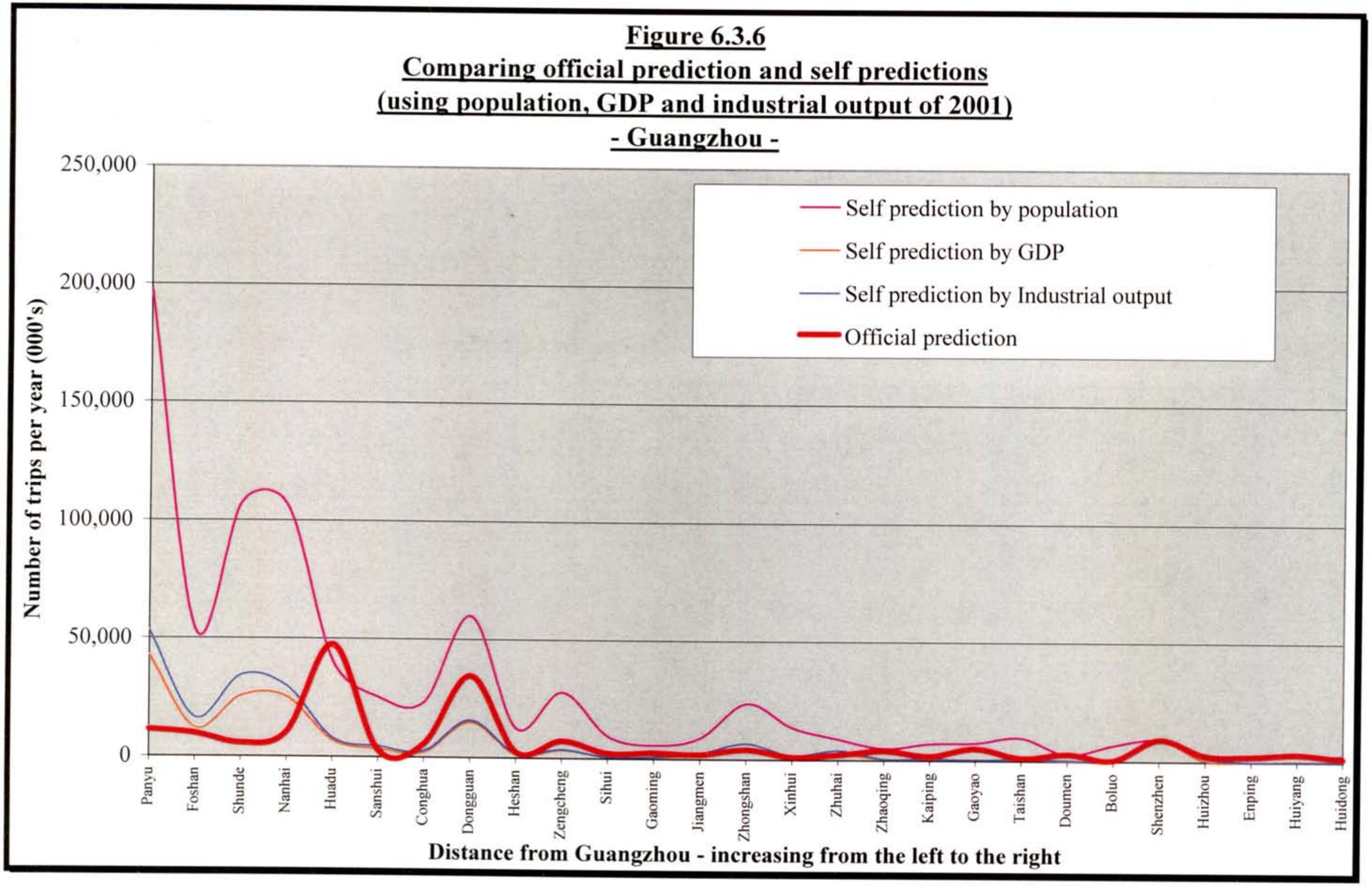


Figure 6.3.6
Comparing official prediction and self predictions
(using population, GDP and industrial output of 2001)
- Guangzhou -
250,000
200,000
150,000
100,000
50,000
0
Number of trips per year (000's)
Self prediction by population
Self prediction by GDP
Self prediction by Industrial output
Official prediction
Panyu
Foshan
Shunde
Nanhai
Huadu
Sanshui
Conghua
Dongguan
Heshan
Zengcheng
Sihui
Gaoming
Jiangmen
Zhongshan
Xinhui
Zhuhai
Zhaoqing
Kaiping
Gaoyao
Taishan
Doumen
Boluo
Shenzhen
Huizhou
Enping
Huiyang
Huidong
Distance from Guangzhou - increasing from the left to the right

6.4.2 Shenzhen

The comparison using population (figure 6.4.1), GDP (figure 6.4.2), GDP per capita (figure 6.4.3), industrial output (figure 6.4.4) and retail sales (figure 6.4.5) shares similar pattern, with some variations in figure 6.4.3 when compared with others.

Contrast to the case of Guangzhou, the self prediction trips does not record very high with closer distance with Shenzhen. The reason for this may be the relatively isolated physical location of Shenzhen. Residential settlements outside Shenzhen are not as populated as Shenzhen. Some cities, although are listed as the first few cities nearest to Shenzhen, are indeed on the west side of the PRD, while Shenzhen is on the east side. Heshan, although is the 4th city nearest to Shenzhen, is located on the west side. This explains the division of the river makes its relatively low trips being distributed.

Own findings shows that Guangzhou (figure 6.4.1, 6.4.2, 6.4.4 and 6.4.5) and Huizhou (figures 6.4.1, 6.4.3 and 6.4.4) are the peaks of the trip distribution. The former is believed as the core of activities in the PRD, therefore attracting more trips. The later is located also on the east side of PRD. Existing highway network around Shenzhen are more connected. This may suggest that the ease of travel might shape this pattern.

When compared with government's figures, Dongguan, the second city nearest to Shenzhen is at the peak of the trips estimated. Even Guangzhou does not record the peak of so great in value. This can be linked with one of the strategy of Guangzhou that to develop with Dongguan in the creation of metropolis region of linear residential zone. From the official prediction graph, other cities do not attract very significant trip distribution.

The figures generated by population, GDP and industrial output are put into the same graph (figure 6.4.6) for a closer analysis. From the government estimation, Dongguan and Guangzhou were the majority of trips from Shenzhen. As Dongguan is an important urban concentration to Shenzhen, the amount of trips should be greater. Moreover, the number of trips of the cities immediately next to Dongguan falls sharply although distance does not increase much. In contrast, for the peak of Guangzhou, the amount of trips to cities have distances greater than from Guangzhou does not falls as sharp as the case of Dongguan. It can be argued that Dongguan is shaped as the regional core near Shenzhen.

For the results of own findings, it shows the presence of distance-decay at Huizhou where the distance from Shenzhen is close enough for high number of trips, and Dongguan for the larger population and relatively close distance. There is another peak at Guangzhou although it is far away. Self-estimation match quite well with the government figures for Shenzhen.

Figure 6.4.1

Comparing official prediction and self predictions (using population of 2001)

- Shenzhen -

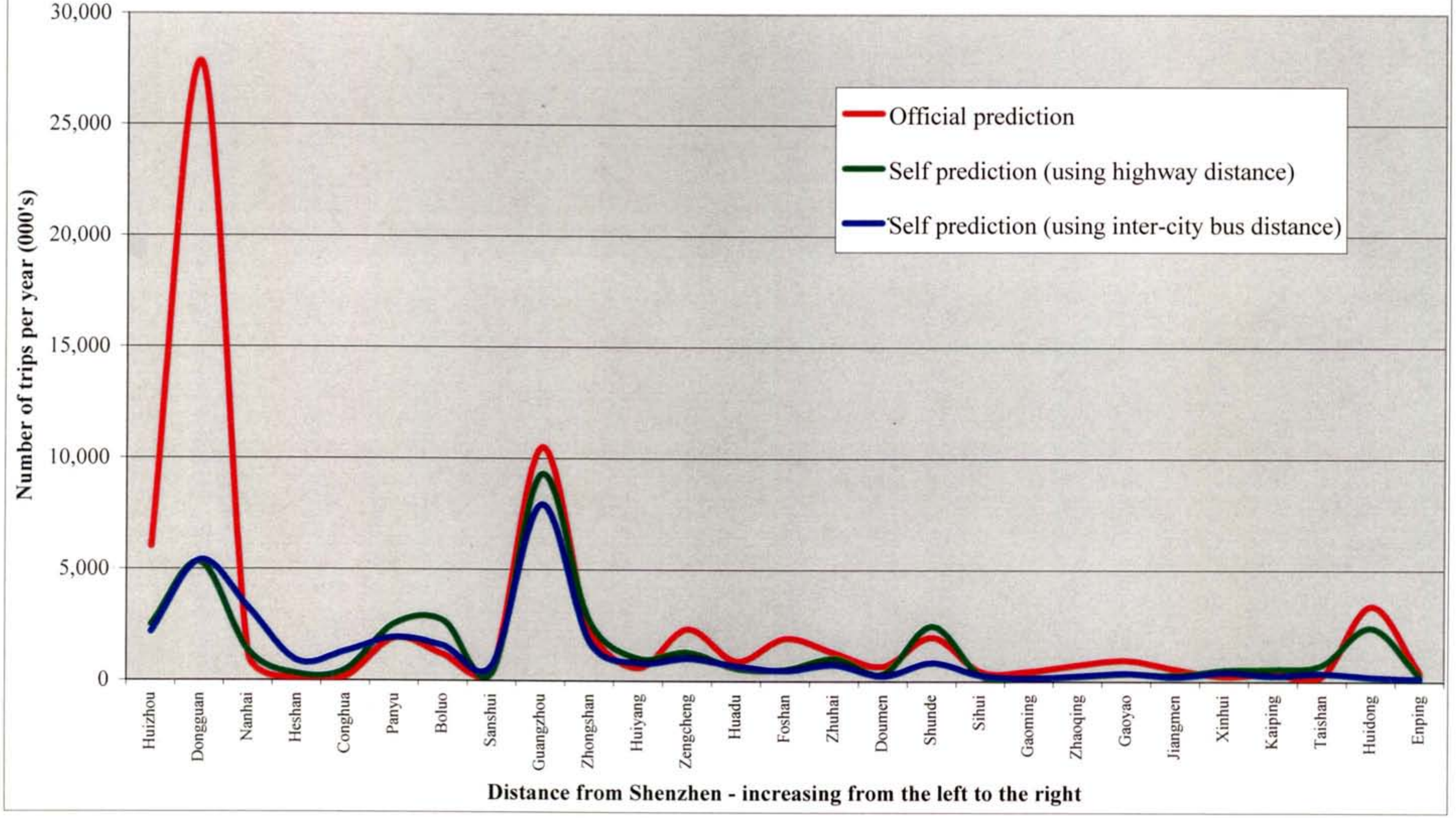


Figure 6.4.2
Comparing official prediction and self predictions (using GDP of 2001)
- Shenzhen -

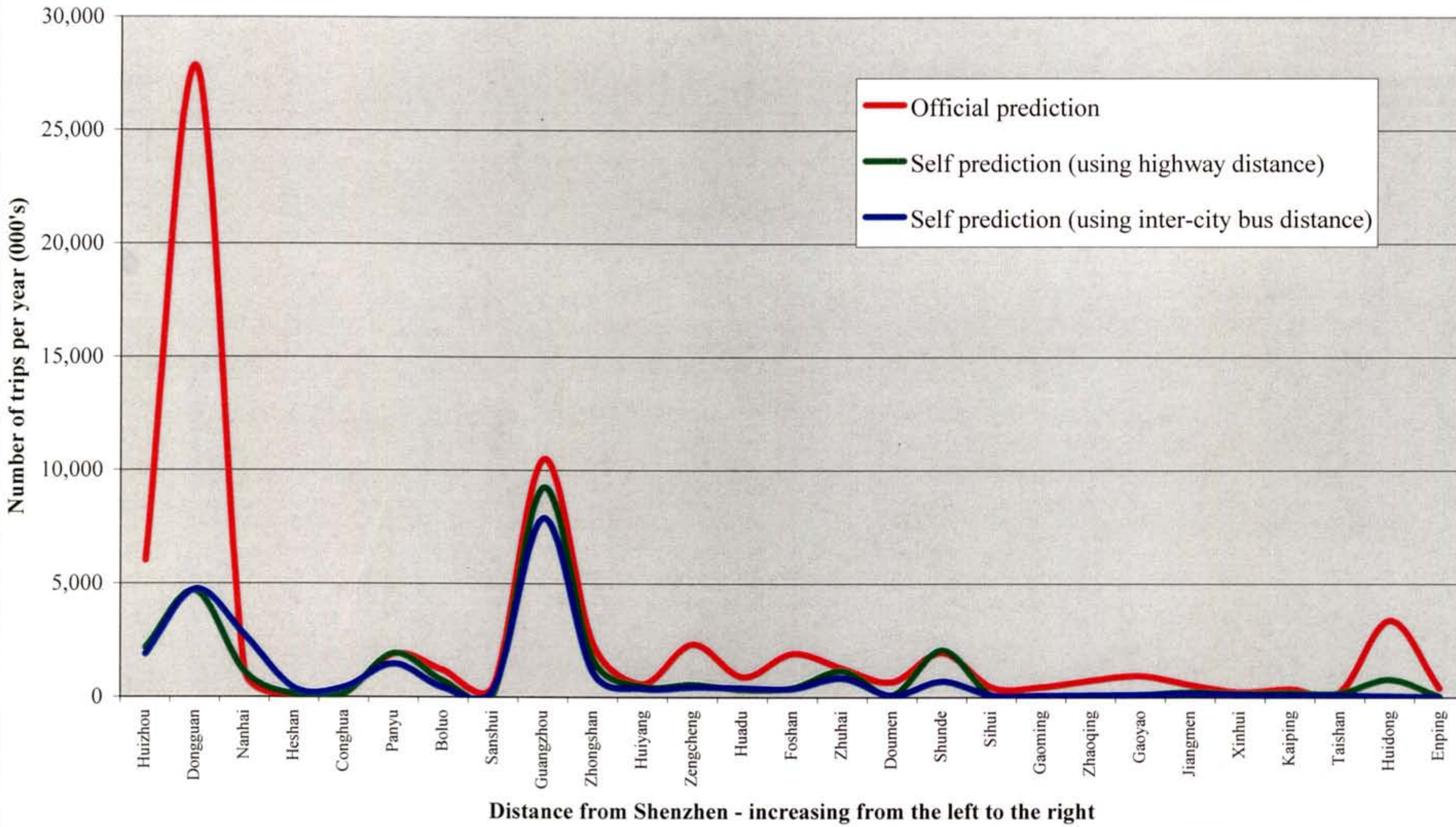
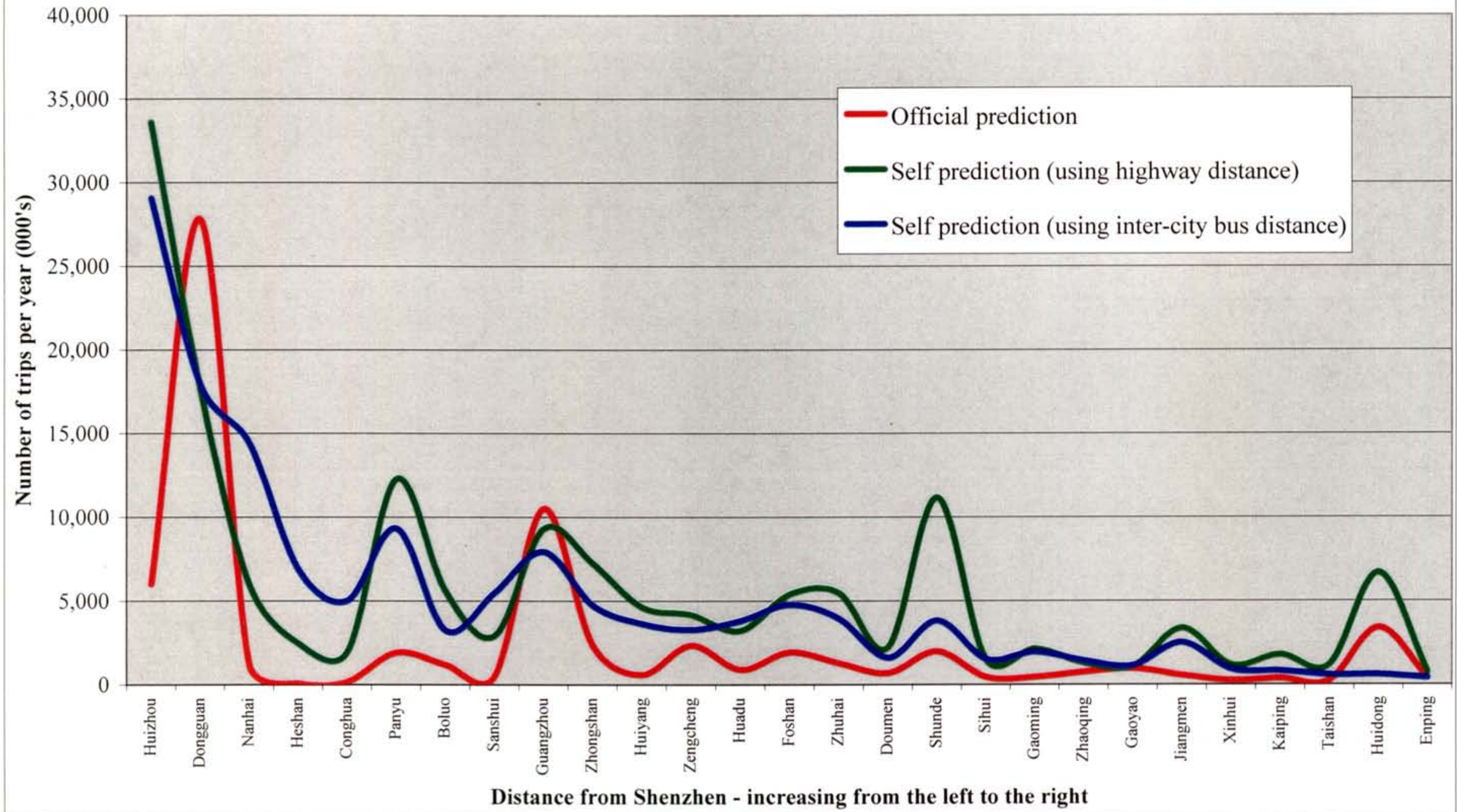


Figure 6.4.3

Comparing official prediction and self predictions (using GDP per capita of 2001)

- Shenzhen -



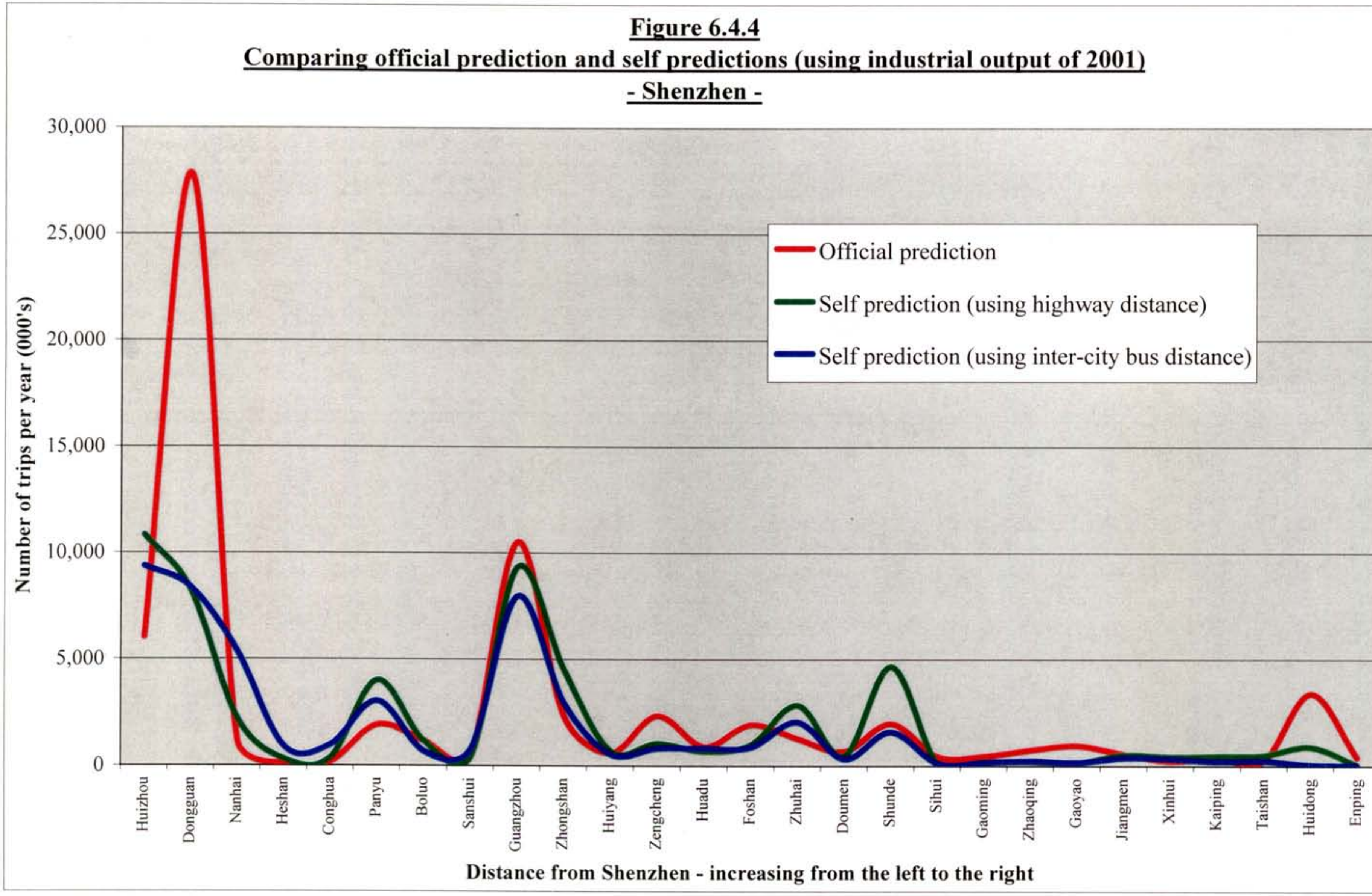


Figure 6.4.4
Comparing official prediction and self predictions (using industrial output of 2001)
- Shenzhen -
30,000
25,000
20,000
15,000
10,000
5,000
0
Number of trips per year (000's)
Official prediction
Self prediction (using highway distance)
Self prediction (using inter-city bus distance)
Huizhou
Dongguan
Nanhai
Heshan
Conghua
Panyu
Boluo
Sanshui
Guangzhou
Zhongshan
Huiyang
Zengcheng
Huadu
Foshan
Zhuhai
Doumen
Shunde
Sihui
Gaoming
Zhaoqing
Gaoyao
Jiangmen
Xinhui
Kaiping
Taishan
Huidong
Enping
Distance from Shenzhen - increasing from the left to the right

Figure 6.4.5
Comparing official prediction and self predictions (using retail sales of 2001)
- Shenzhen -

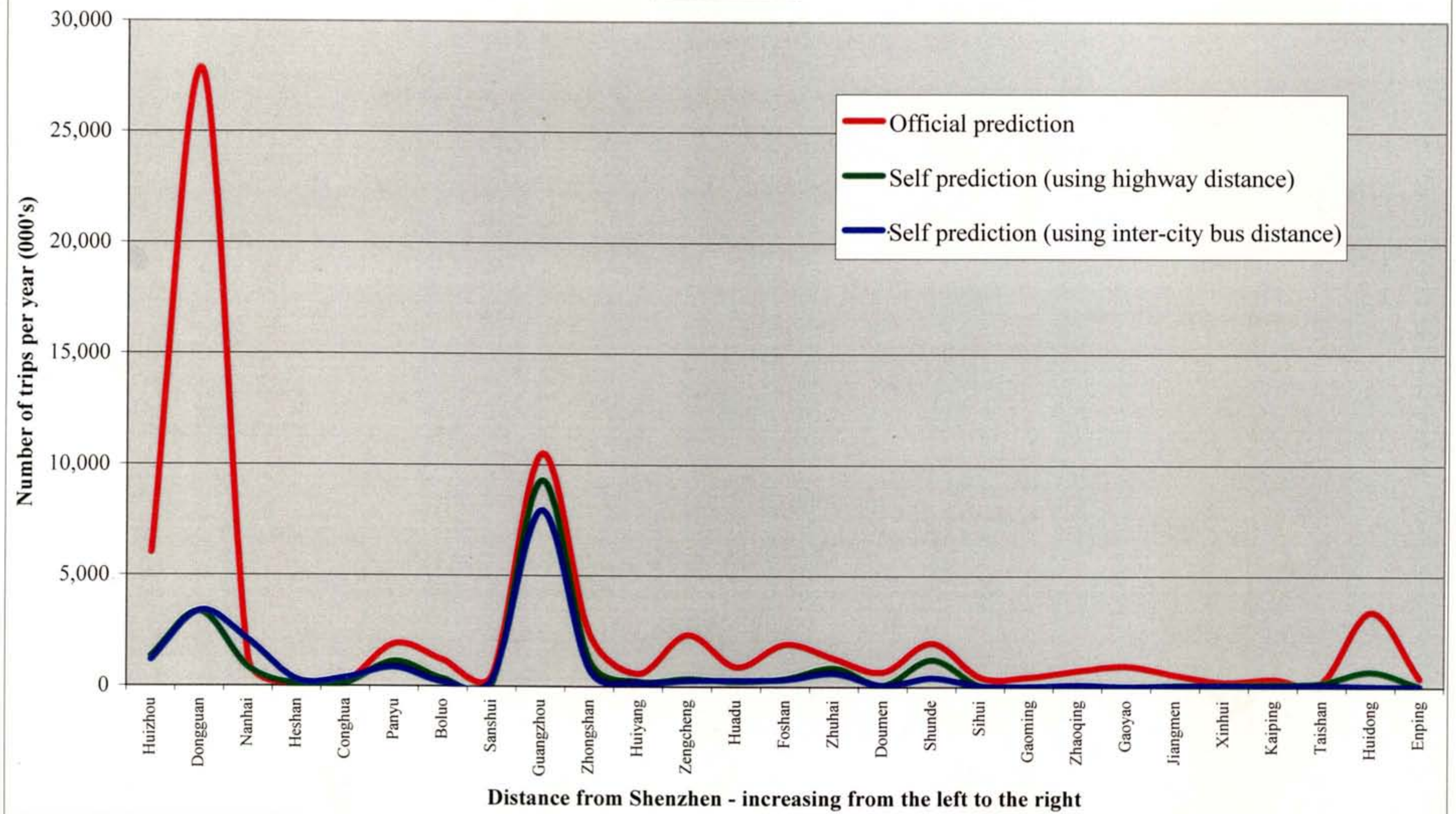
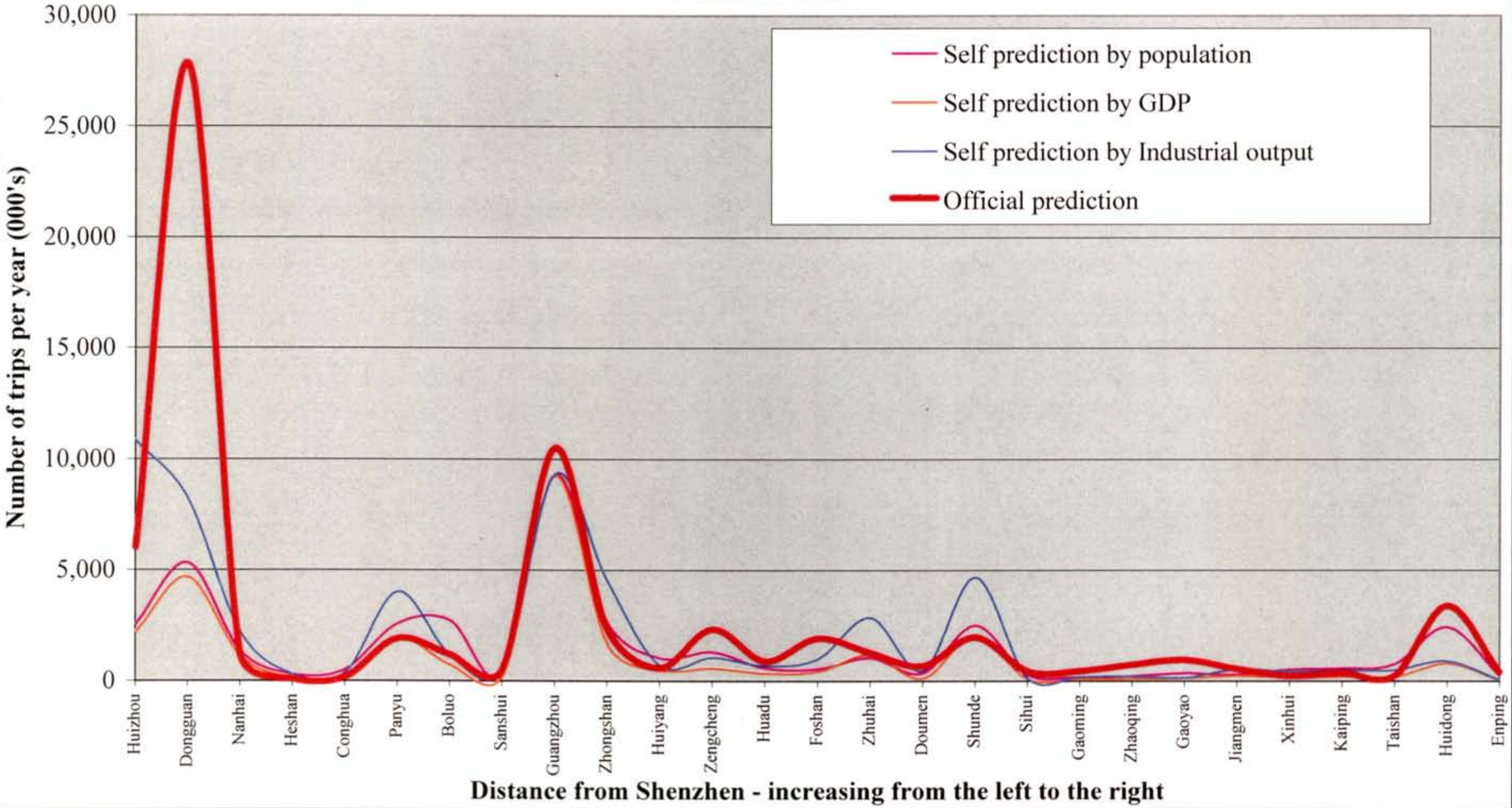


Figure 6.4.6
Comparing official prediction and self predictions
(using population, GDP and industrial output of 2001)
- Shenzhen -



6.4.3 Zhuhai

The comparison using population (figure 6.5.1), GDP (figure 6.5.2), GDP per capita (figure 6.5.3), industrial output (figure 6.5.4) and retail sales (figure 6.5.5) shares similar pattern, with some variations in figure 6.5.3 when compared with others.

The own findings match with the government statistics quite well. In particular, all three curves have the common trend to their peak at Zhongshan and Guangzhou. Curves of the own finding when using GDP per capita in analysis resulted a peak towards Doumen, the first city next to Zhuhai. Although official prediction does not favour with this finding, it still proves the presence of distance decay.

Since Zhongshan is the regional core of activities near Zhuhai, it is natural that the trip distribution curve rises and official prediction gives a much more optimistic estimation. The most interesting point of the official prediction in figure 6.5.1 is that Taishan and Kaiping, having their position next to Zhongshan in increasing distance from Zhuhai, have a particularly low trip distribution figure. This implies an important role of Zhongshan when looking the result in this way.

Furthermore, official prediction also emphasizes the role of Foshan (figures 6.5.1 and 6.5.5) and Dongguan (figure 6.5.1). The pattern of own findings also have similar pattern which have a higher level of trip distribution in Dongguan, Guangzhou (figure 6.5.3 and 6.5.4). Contrasts with the previous two cities, the official prediction does not have a peak at Guangzhou.

The figures generated by population, GDP and industrial output are put into the same graph (figure 6.5.6). Government estimation continue to disregard distance decay at the cities near Zhuhai. There is a extreme peak at Zhongshan, which the distance is close from Zhuhai. However, the other two peaks at Guangzhou and Foshan were further away.

Self-estimated figures follow distance decay where the peak is near Zhuhai. Doumen, Jiangmen and Xinhui are close to Zhuhai for greater amount of trips generated. The figures also rise at Zhongshan, Dongguan, Guangzhou and Shenzhen, where they are all larger cities in PRD.

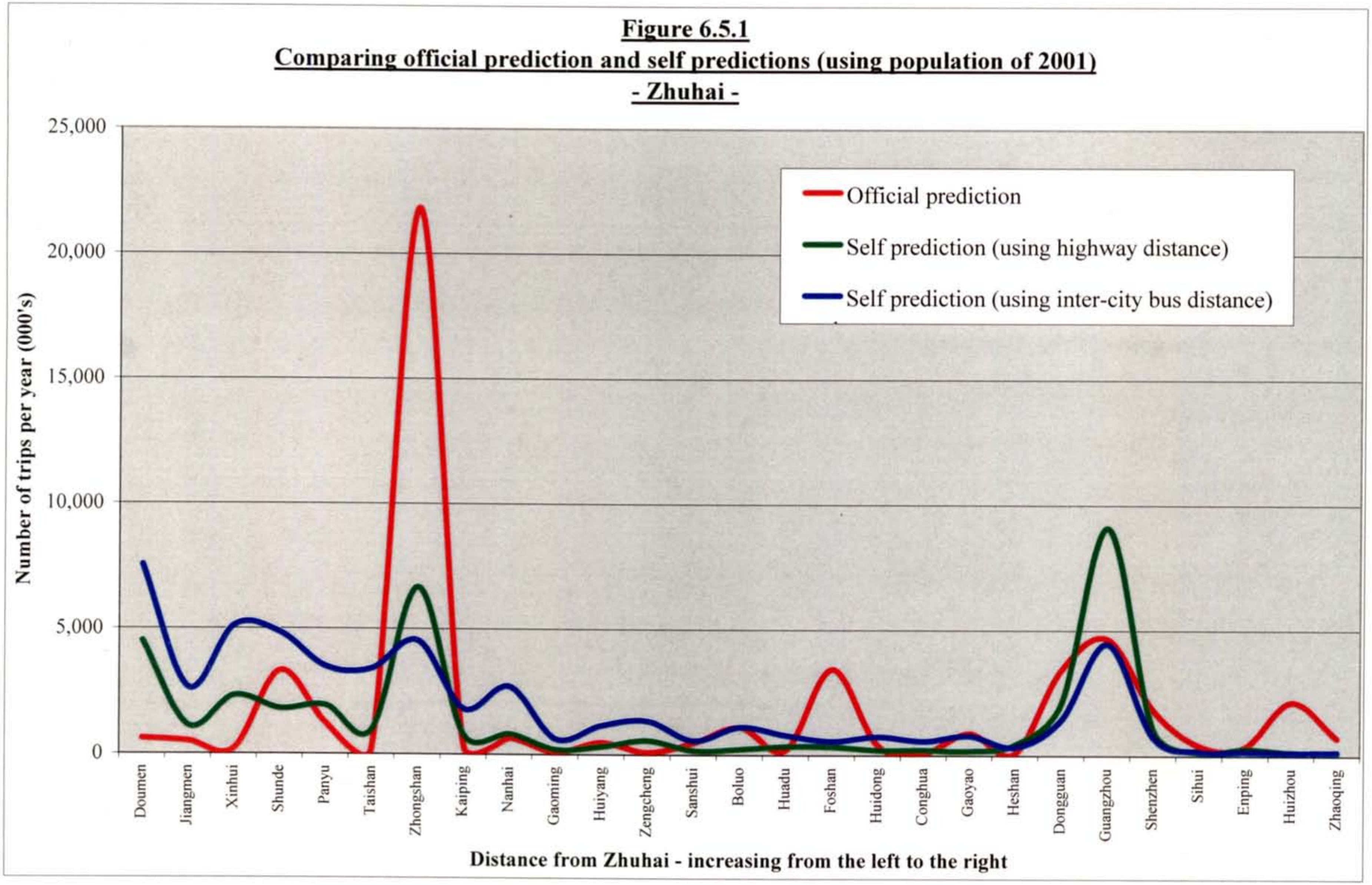
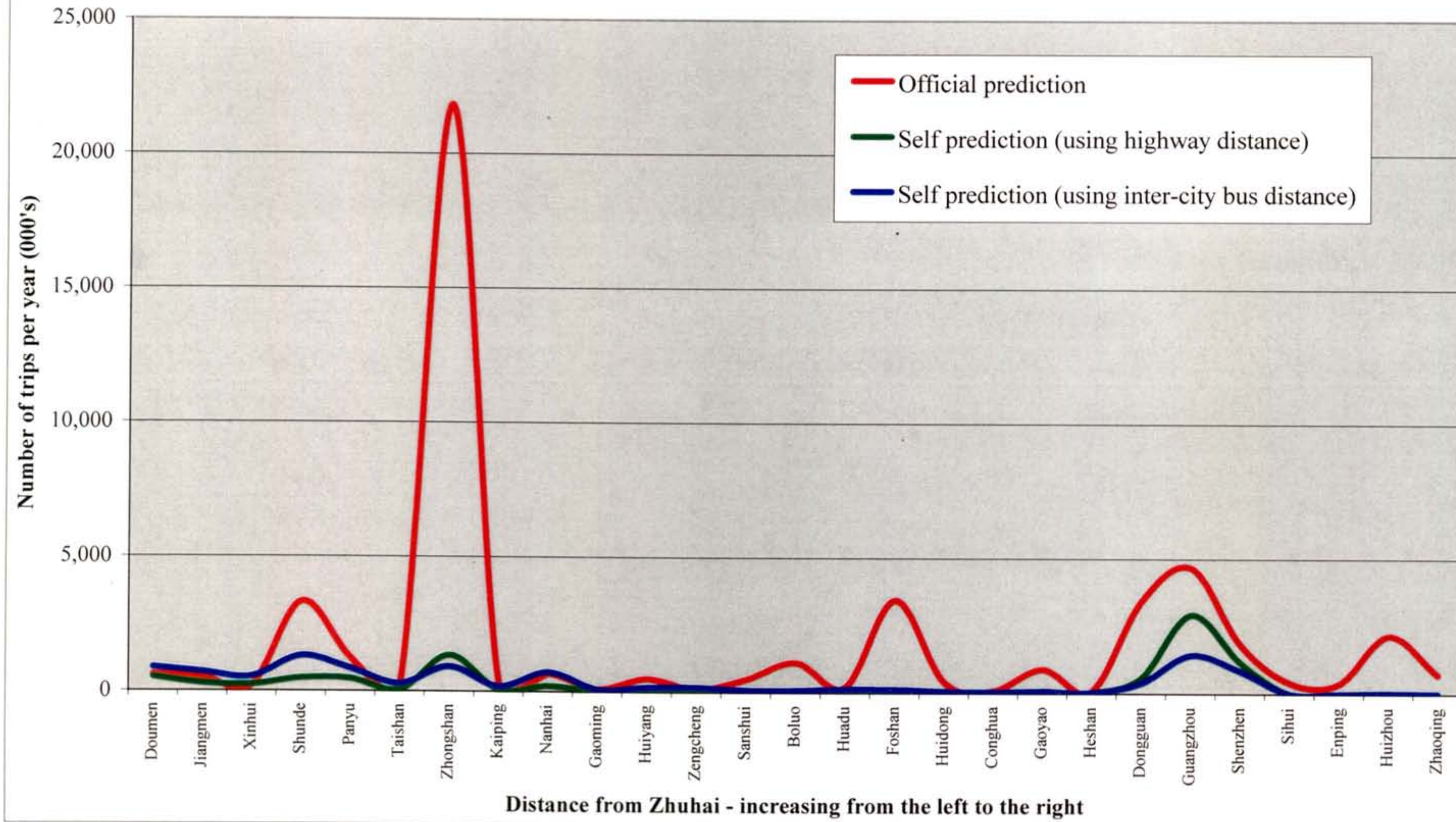


Figure 6.5.1
Comparing official prediction and self predictions (using population of 2001)
- Zhuhai -
Official prediction
Self prediction (using highway distance)
Self prediction (using inter-city bus distance)
Number of trips per year (000's)
25,000
20,000
15,000
10,000
5,000
0
Doumen
Jiangmen
Xinhui
Shunde
Panyu
Taishan
Zhongshan
Kaiping
Nanhai
Gaoming
Huiyang
Zengcheng
Sanshui
Boluo
Huadu
Foshan
Huidong
Conghua
Gaoyao
Heshan
Dongguan
Guangzhou
Shenzhen
Sihui
Enping
Huizhou
Zhaoqing
Distance from Zhuhai - increasing from the left to the right

Figure 6.5.2
Comparing official prediction and self predictions (using GDP of 2001)
- Zhuhai -



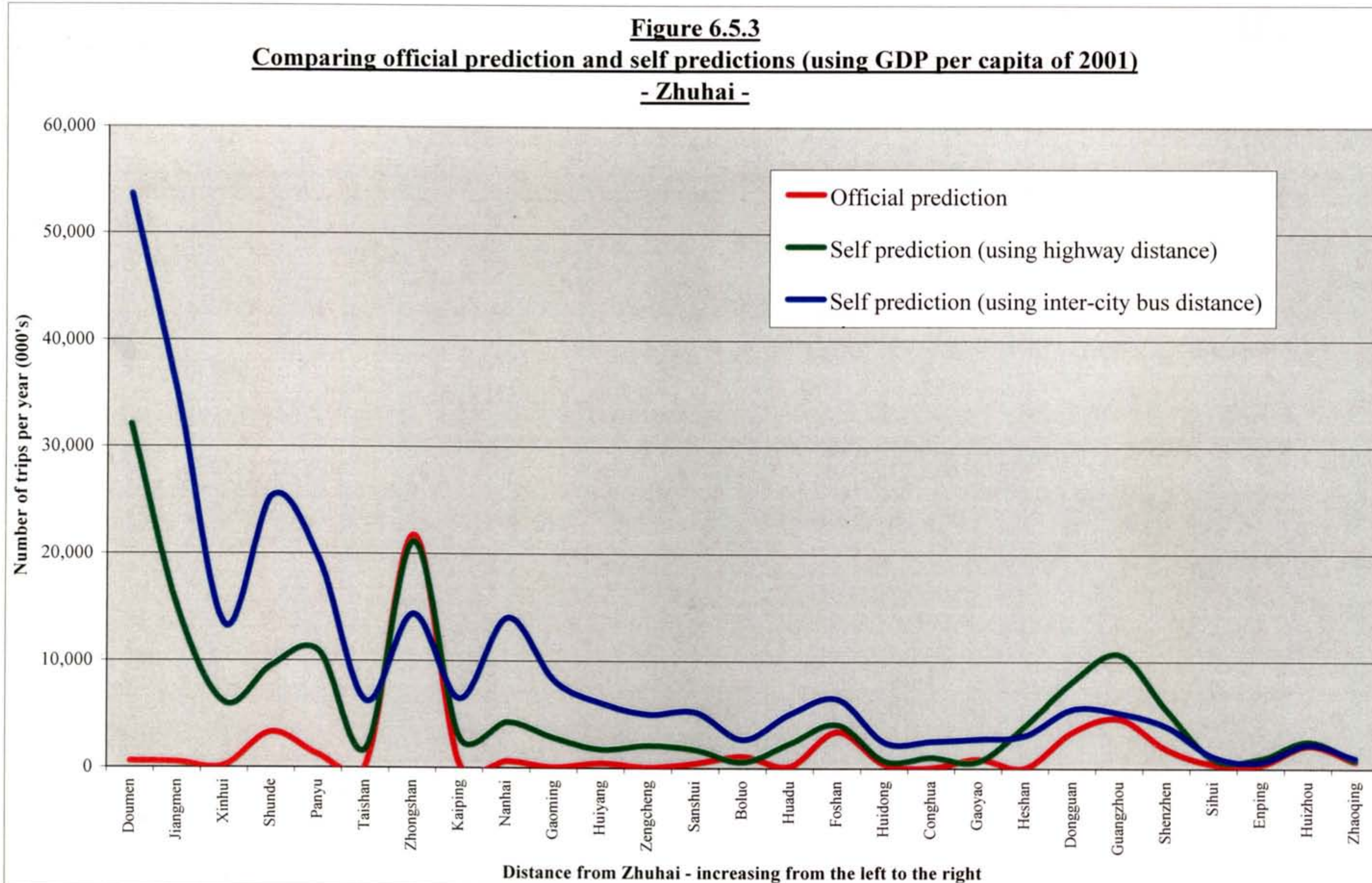


Figure 6.5.3
Comparing official prediction and self predictions (using GDP per capita of 2001)
- Zhuhai -
60,000
50,000
40,000
30,000
20,000
10,000
0
Number of trips per year (000's)
Official prediction
Self prediction (using highway distance)
Self prediction (using inter-city bus distance)
Doumen
Jiangmen
Xinhui
Shunde
Panyu
Taishan
Zhongshan
Kaiping
Nanhai
Gaoming
Huiyang
Zengcheng
Sanshui
Boluo
Huadu
Foshan
Huidong
Conghua
Gaoyao
Heshan
Dongguan
Guangzhou
Shenzhen
Sihui
Enping
Huizhou
Zhaoqing
Distance from Zhuhai - increasing from the left to the right

Figure 6.5.4
Comparing official prediction and self predictions (using industrial output of 2001)
- Zhuhai -

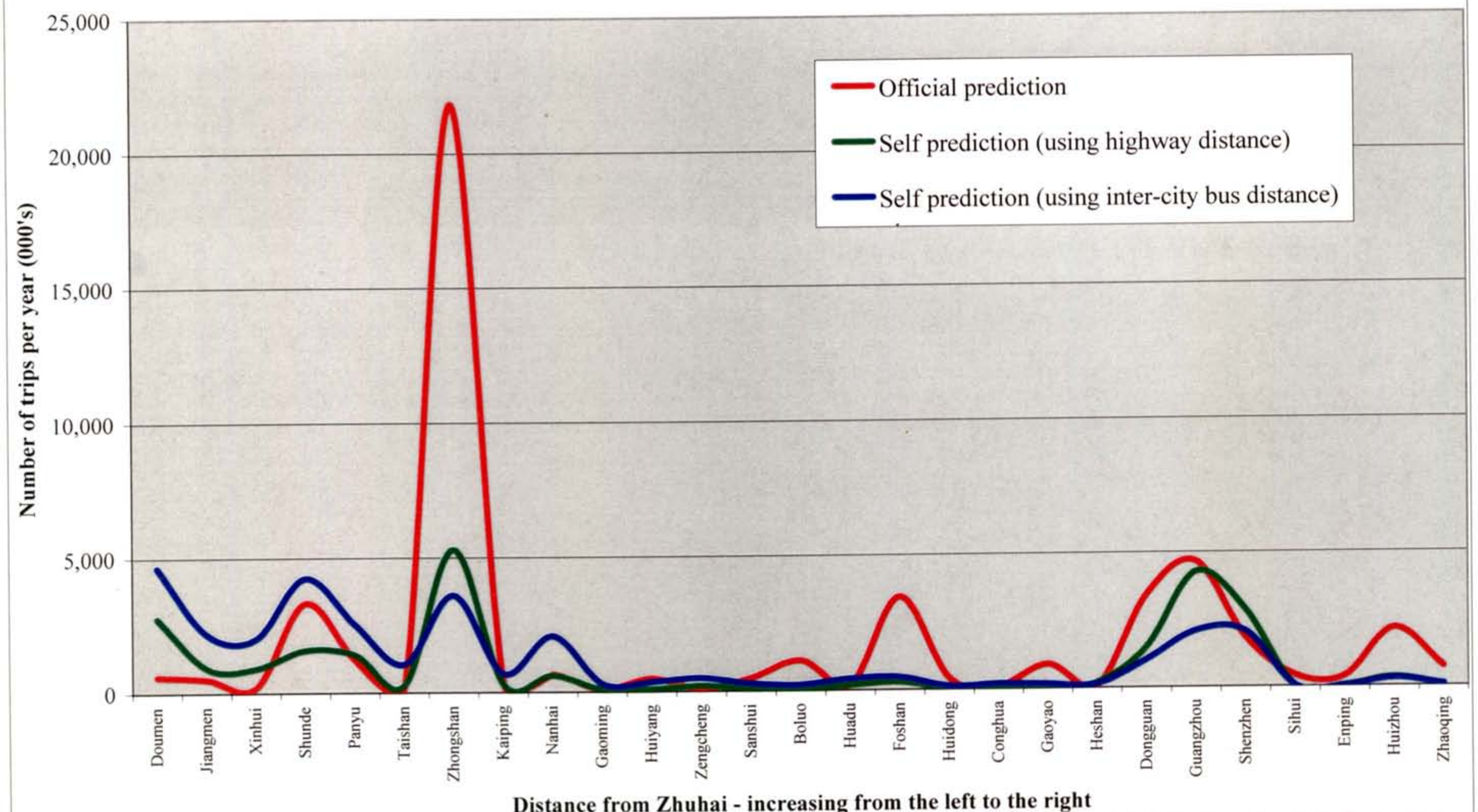
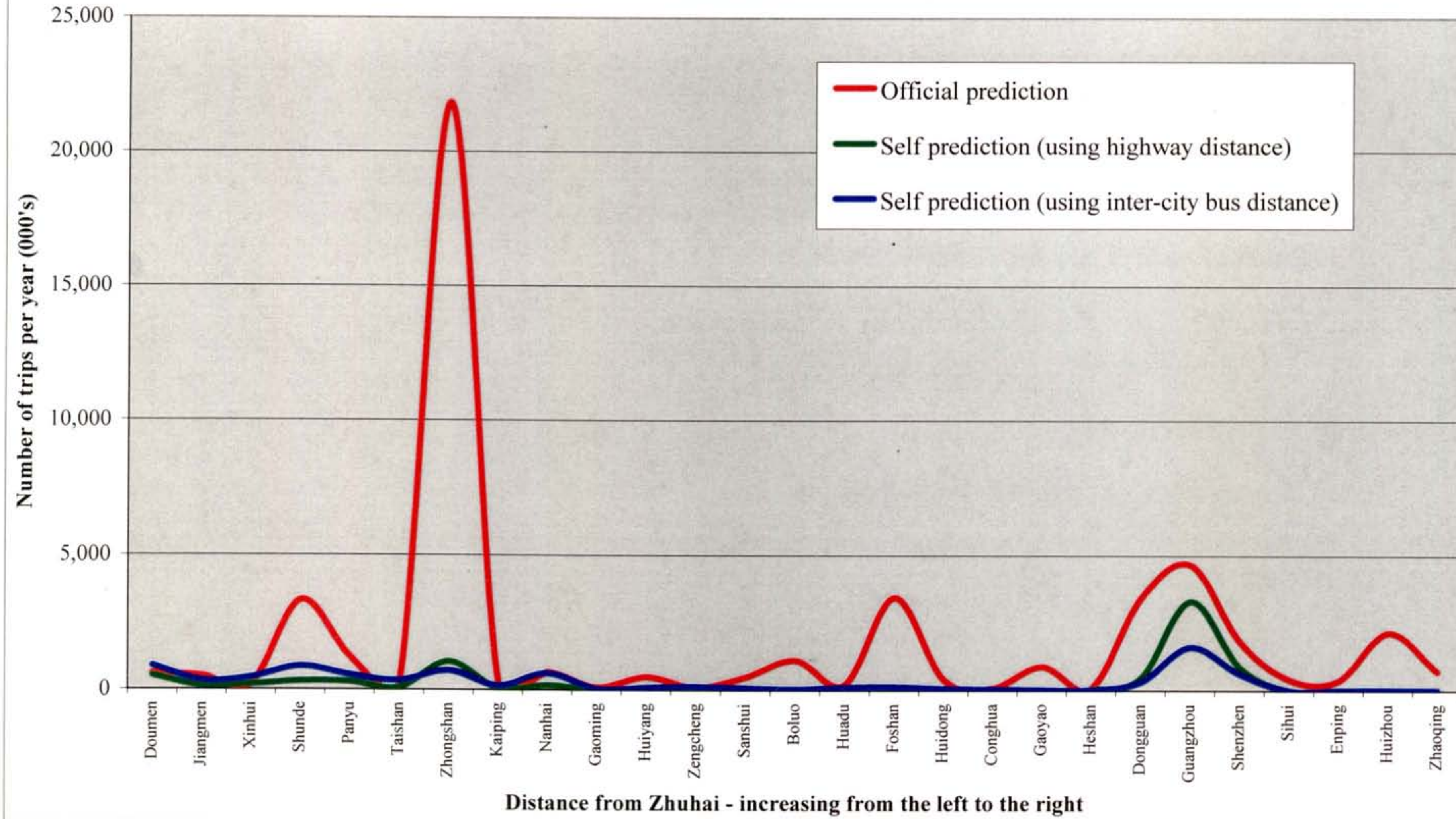


Figure 6.5.5

Comparing official prediction and self predictions (using retail sales of 2001)

- Zhuhai -



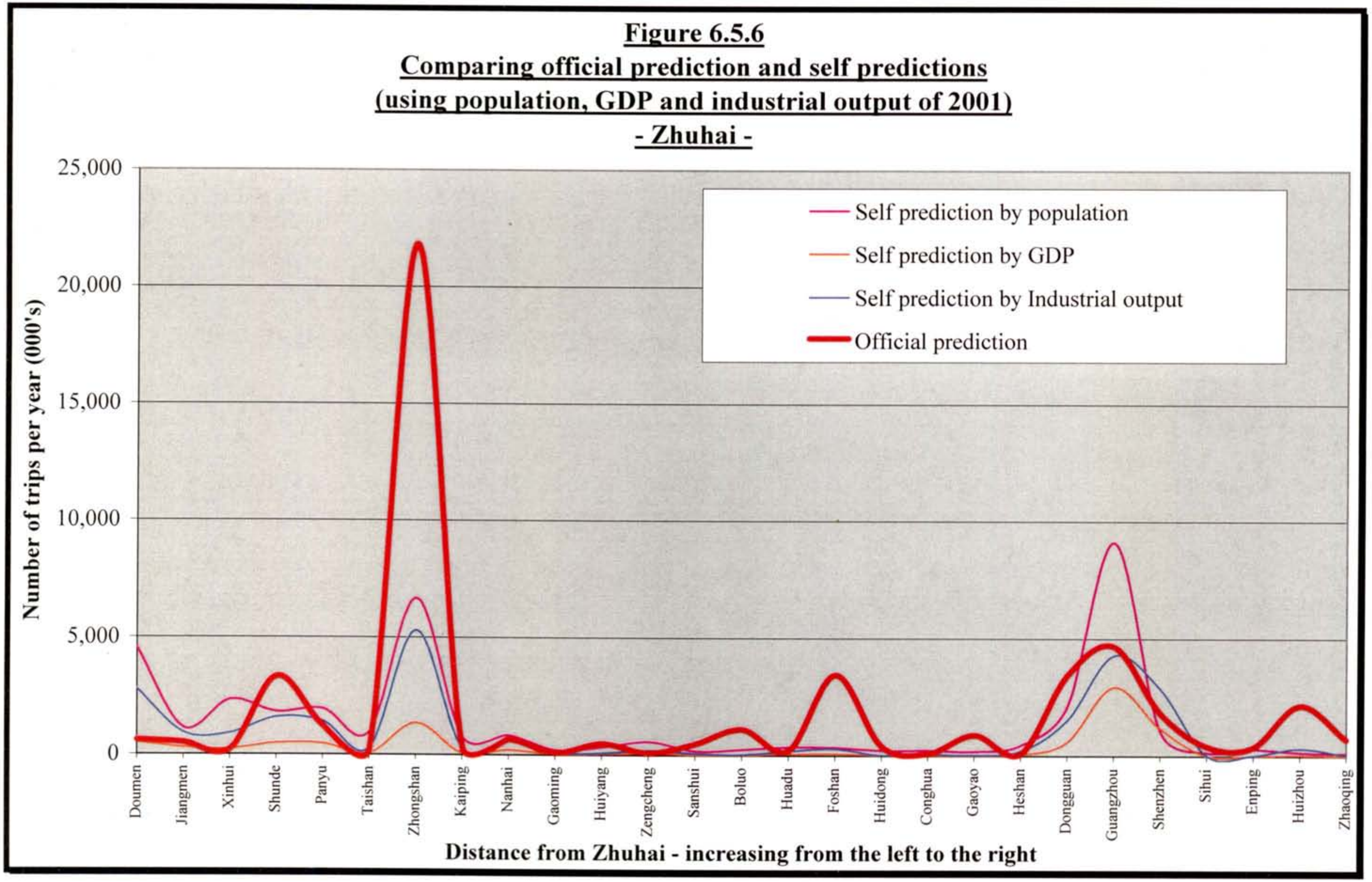


Figure 6.5.6
Comparing official prediction and self predictions
(using population, GDP and industrial output of 2001)
- Zhuhai -
Self prediction by population
Self prediction by GDP
Self prediction by Industrial output
Official prediction
Number of trips per year (000's)
25,000
20,000
15,000
10,000
5,000
0
Doumen
Jiangmen
Xinhui
Shunde
Panyu
Taishan
Zhongshan
Kaiping
Nanhai
Gaoming
Huiyang
Zengcheng
Sanshui
Boluo
Huadu
Foshan
Huidong
Conghua
Gaoyao
Heshan
Dongguan
Guangzhou
Shenzhen
Sihui
Enping
Huizhou
Zhaoqing
Distance from Zhuhai - increasing from the left to the right

6.4.4 Zhongshan

The comparison using population (figure 6.6.1), GDP (figure 6.6.2), GDP per capita (figure 6.6.3), industrial output (figure 6.6.4) and retail sales (figure 6.6.5) shares similar pattern, with some variations in figure 6.6.1 when compared with others.

The findings about Zhongshan reveals the trip distribution curvers are less uniformed than others. All curves in figure 6.6.1 are having "great fluctuations" especially those having close distance with Zhongshan. Own findings shows that Shunde (figures 6.6.1, 6.6.3 and 6.6.4) and Guangzhou (figures 6.6.1 and 6.6.4) are having sharp trip distribution peaks. While the official findings of the peak sounds different where Zhuhai (figures 6.6.1, 6.6.2, 6.6.4 and 6.6.5), Foshan (figures 6.6.2, 6.6.4 and 6.6.5) are the location of the peaks. The symbolizes another different planning methodology in Guangzhou's mind.

There are still some similarities in certain parts of the findings comparison. The pattern of Dongguan (figures 6.6.2 and 6.6.5) and Guangzhou (figure 6.6.5) between the curves are very similar. Another point which deserves a note is the similar pattern for the last two pair of cities, Huidong and Shenzhen, especially all three curves of Shenzhen goes upwards (figures 6.6.1, 6.6.2, 6.6.3, 6.6.4 and 6.6.5).

The results confirms the relative importance of Zhuhai and Shunde in the planning by Guangzhou. As these two cities and Zhongshan are located between the central and the west of PRD, their cooperation can strengthen the formation of the development core apart from Guangzhou itself.

The figures generated by population, GDP and industrial output are put into the same graph (figure 6.6.6). Government data shows the peaks at Zhuhai and Doumen, which are relatively closer to Zhongshan. Although there is a peak at some cities near Zhoungshan, other cities like Jiangmen and Xinhui do not show any peak while their distances from Zhongshan are also relatively close. Other peaks further away from Zhongshan are Dongguan, Foshan and Guangzhou.

Self-estimated figures shows distance decay where Jiangmen share a great amount of trips. Other peaks are Shunde, Dongguan and Guangzhou. All of these peaks are located on the western side of PRD, which is the same as Zhongshan.

Figure 6.6.1

Comparing official prediction and self predictions (using population of 2001)

- Zhongzhan -

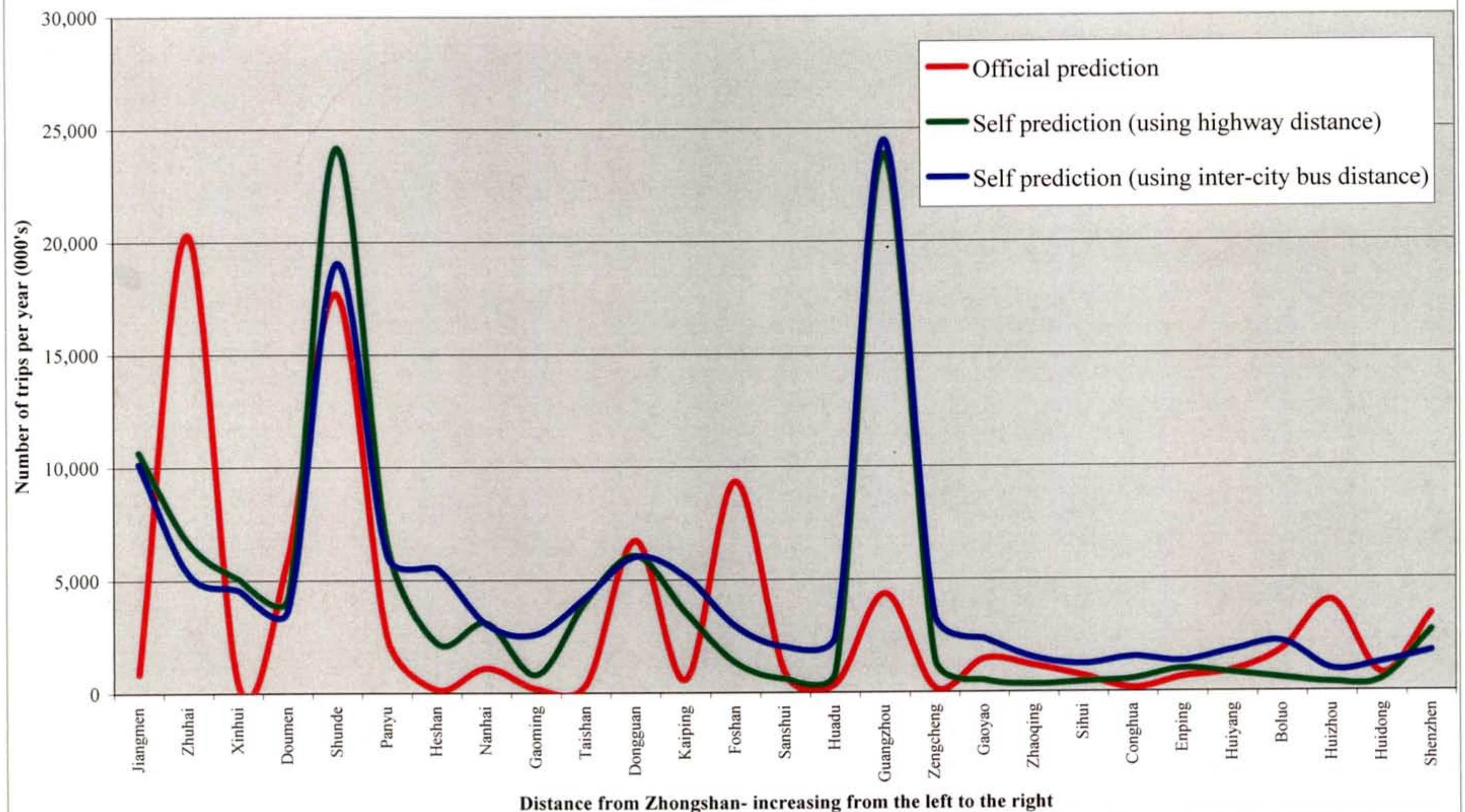


Figure 6.6.2
Comparing official prediction and self predictions (using GDP of 2001)
- Zhongzhan -

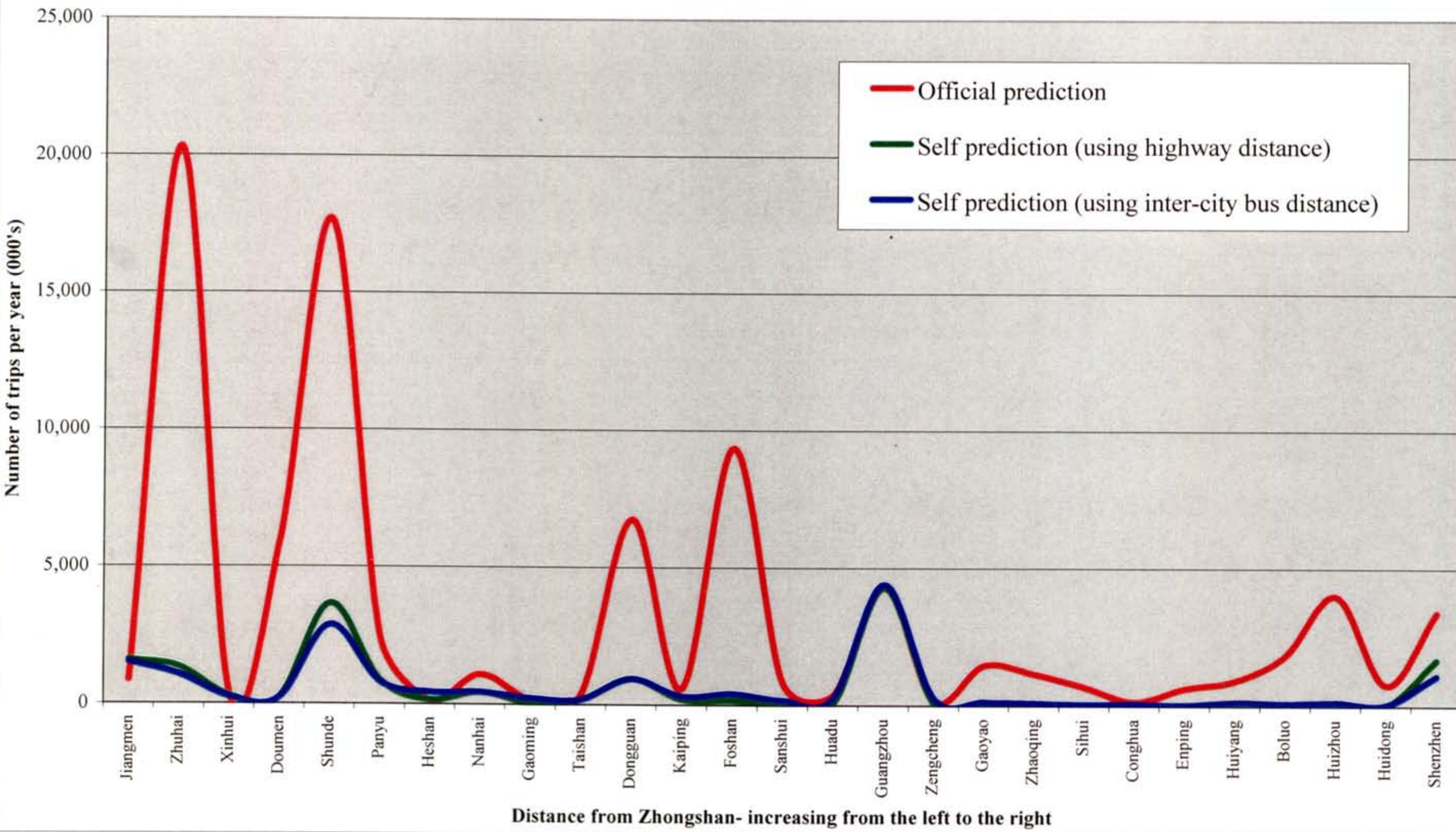


Figure 6.6.3
Comparing official prediction and self predictions (using GDP per capita of 2001)
- Zhongzhan -

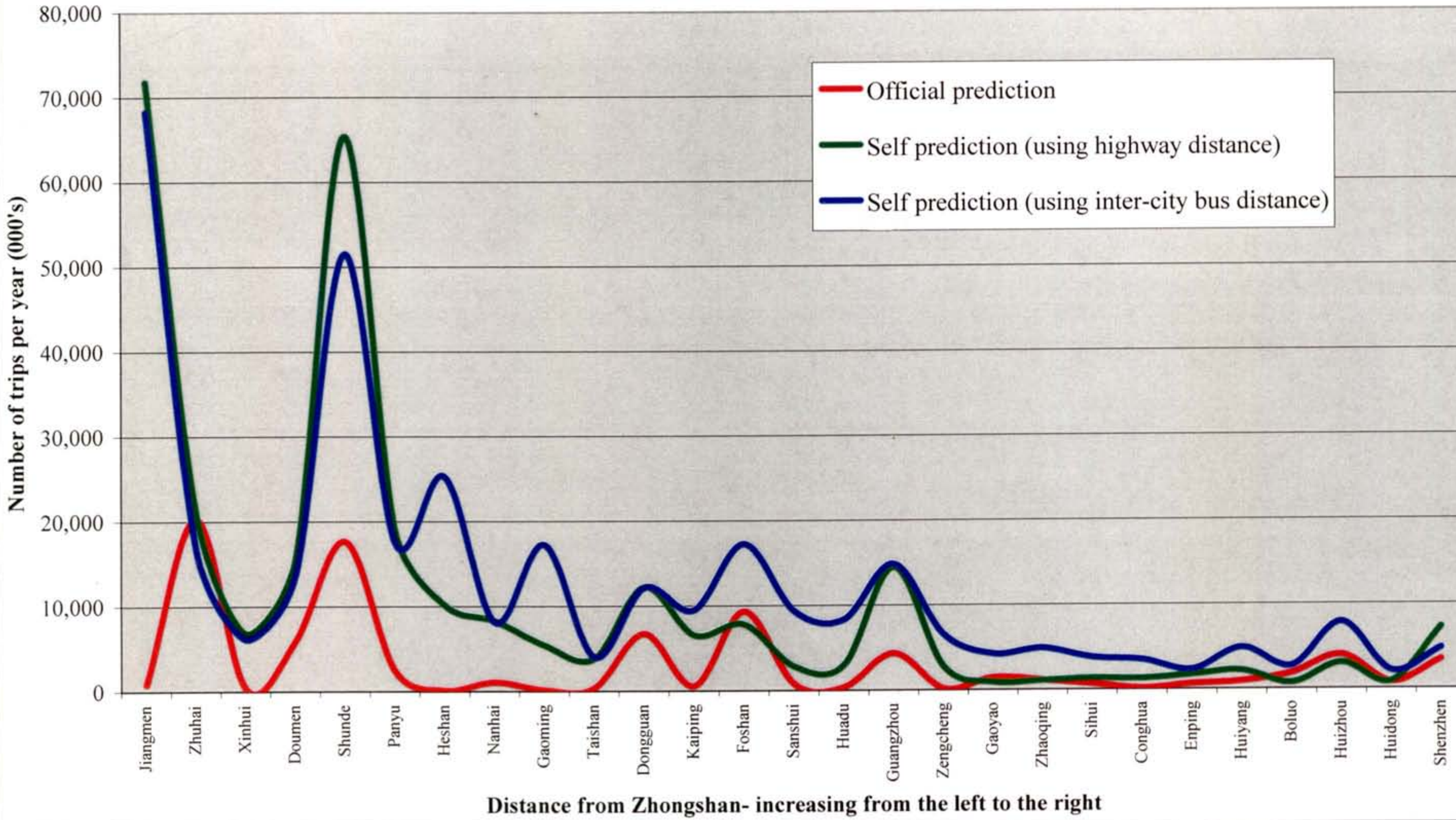
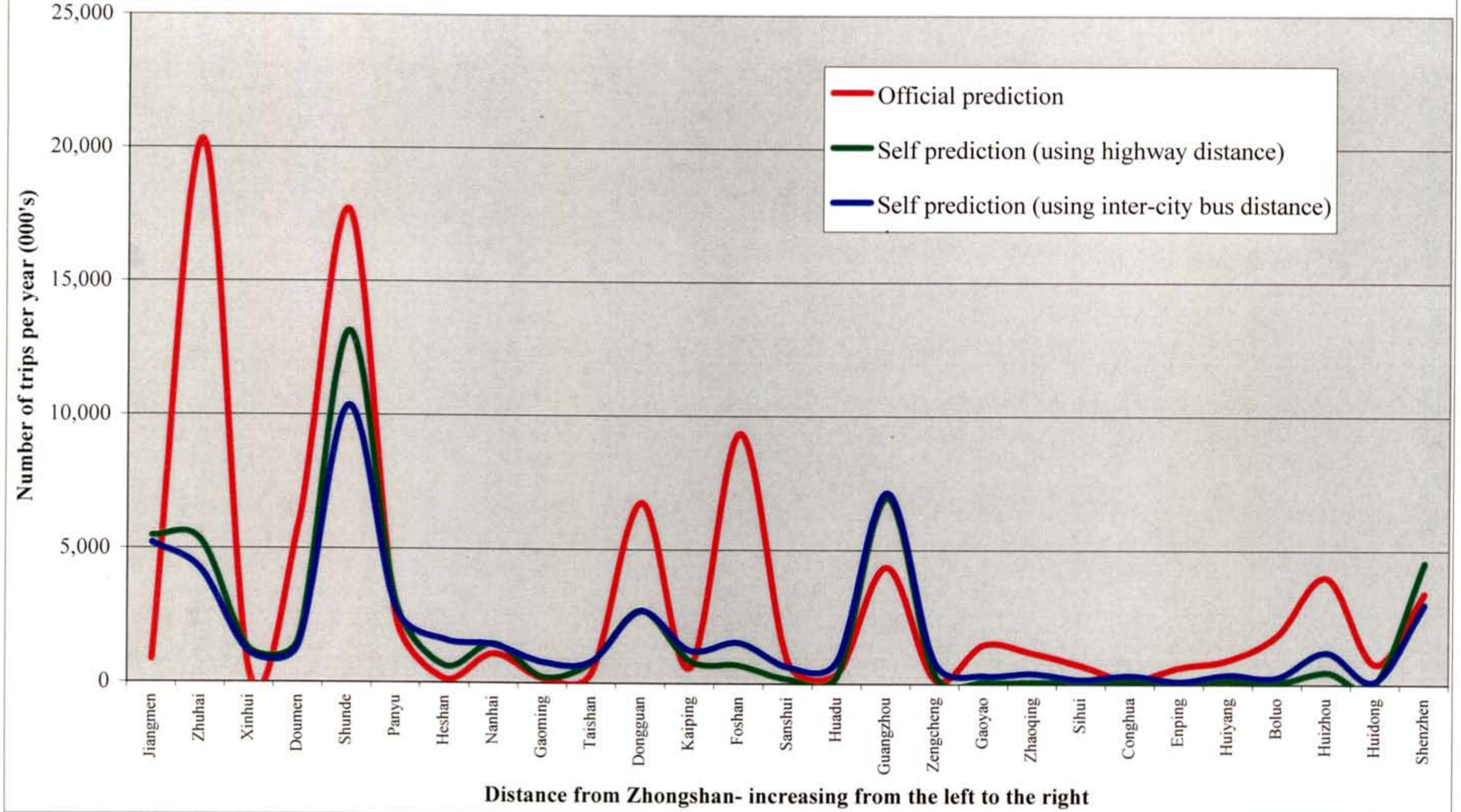


Figure 6.6.4

Comparing official prediction and self predictions (using industrial output of 2001)

- Zhongzhan -



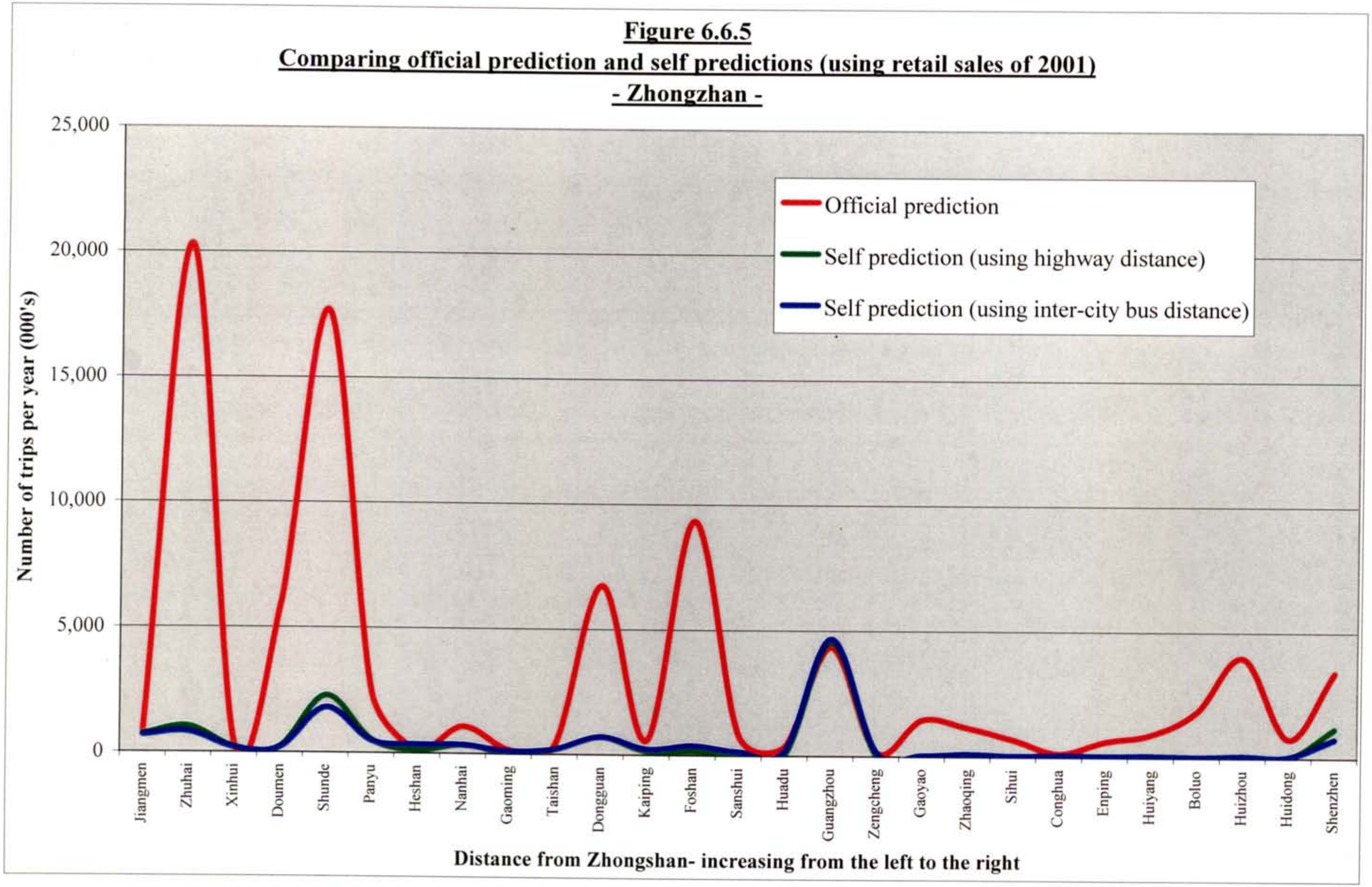


Figure 6.6.5
Comparing official prediction and self predictions (using retail sales of 2001)
- Zhongzhan -
25,000
20,000
15,000
10,000
5,000
0
Number of trips per year (000's)
Official prediction
Self prediction (using highway distance)
Self prediction (using inter-city bus distance)
Jiangmen
Zhuhai
Xinhui
Doumen
Shunde
Panyu
Heshan
Nanhai
Gaoming
Taishan
Dongguan
Kaiping
Foshan
Sanshui
Huadu
Guangzhou
Zengcheng
Gaoyao
Zhaoqing
Sihui
Conghua
Enping
Huiyang
Boluo
Huizhou
Huidong
Shenzhen
Distance from Zhongshan- increasing from the left to the right

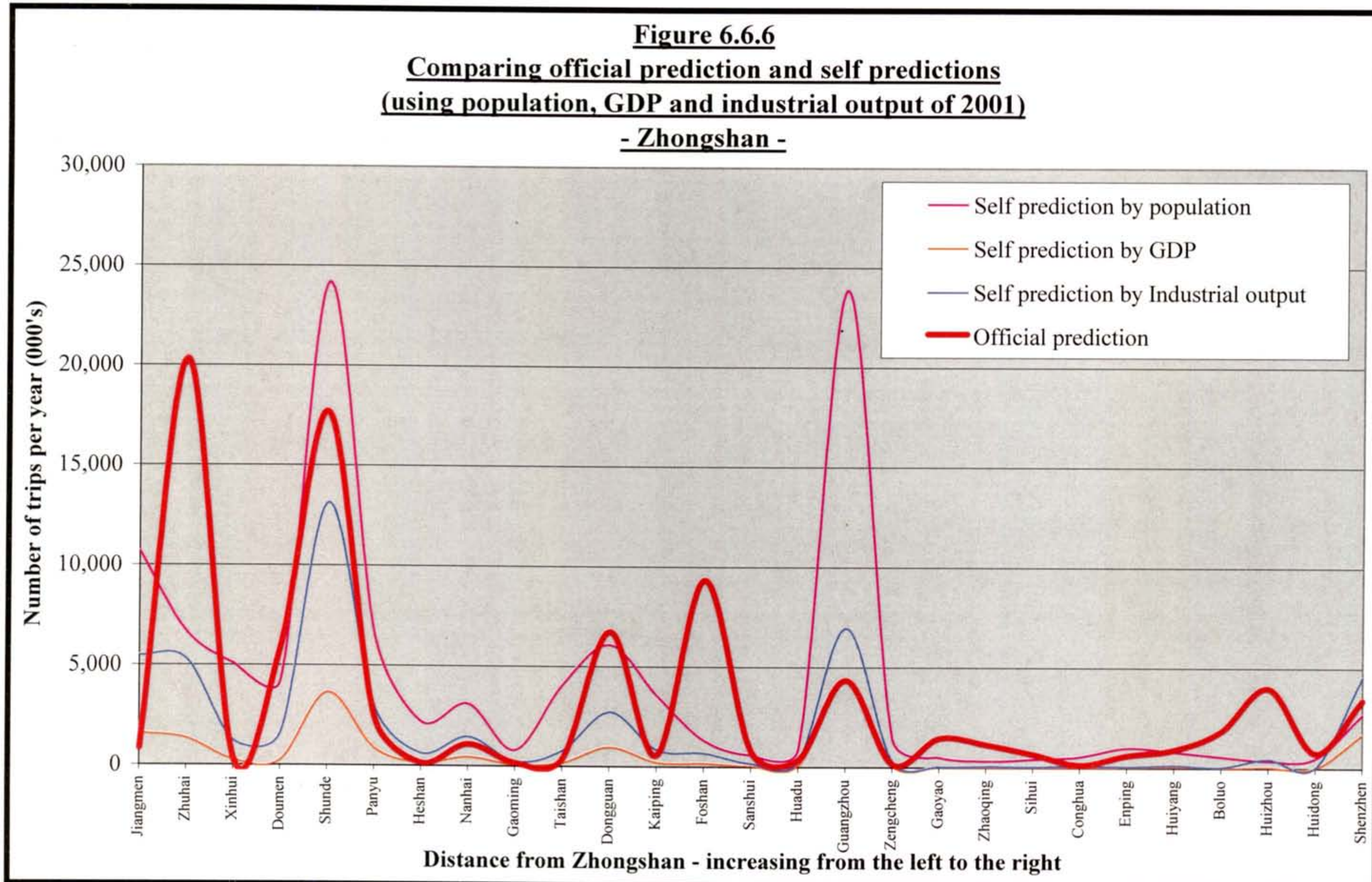


Figure 6.6.6
Comparing official prediction and self predictions
(using population, GDP and industrial output of 2001)
- Zhongshan -
Self prediction by population
Self prediction by GDP
Self prediction by Industrial output
Official prediction
Number of trips per year (000's)
30,000
25,000
20,000
15,000
10,000
5,000
0
Jiangmen
Zhuhai
Xinhui
Doumen
Shunde
Panyu
Heshan
Nanhai
Gaoming
Taishan
Dongguan
Kaiping
Foshan
Sanshui
Huadu
Guangzhou
Zengcheng
Gaoyao
Zhaoqing
Sihui
Conghua
Enping
Huiyang
Boluo
Huizhou
Huidong
Shenzhen
Distance from Zhongshan - increasing from the left to the right

6.4.5 Dongguan

The comparison using population (figure 6.7.1), GDP (figure 6.7.2), GDP per capita (figure 6.7.3), industrial output (figure 6.7.4) and retail sales (figure 6.7.5) shares similar pattern, with some variations in figure 6.6.3 when compared with others.

Similar pattern is observed from both the own findings and official predictions (figures 6.7.1, 6.7.3, 6.7.4 and 6.7.5). There is indication for a small peak at the cities near Dongguan, where the trip distribution have a focus at Panyu and Shunde, the 1st and 3rd cities nearest to Dongguan. Guangzhou, again ranks high in trip distribution. Self prediction even gives a more favourable level of interaction (figures 6.7.1 and 6.7.4). In contract to the official prediction, own findings on other cities are very uniform except at the peaks. The share of trip distribution in the majority of the cities is not much.

A special finding is that the official estimation have several peaks along the curve, apart from Guangzhou, peaks also appear at Zengcheng (figures 6.7.2, 6.7.4 and 6.7.5), Huidong (figures 6.7.1, 6.7.2, 6.7.4 and 6.7.5) and Shenzhen (figures 6.7.1, 6.7.2, 6.7.4 and 6.7.5). From the section of Shenzhen, it was discussed that Shenzhen is another major urban core nearest to Dongguan. However, it may takes more time to understand the reasons for Zenfcheng and Huidong to have a higher level of interaction with Dongguan.

Figure 6.7.3 stands out with the patter with other graphs. However, the curves show the distance decay pattern. The peak of self prediction using inter-city bus distance is extremely high at Panyu. Differs with the case of Zhuhai (figure 6.5.3), the case of Dongguan is the curves "slow down" more gradually. In particular, the own findings also have several smaller peaks with increasing distance from Dongguan.

The figures generated by population, GDP and industrial output are put into the same graph (figure 6.7.6). For government estimation, the small peak at Panyu shows distance decay to a certain extent. However, there are quite a number of cities also share high amount of trips. Guangzhou being the highest, followed by Shenzhen, Zengcheng, Huidong, Zhongshan and Huizhou. As Guangzhou is the sixth city next to Dongguan, the number of trips are not surprisingly high. The proximity of Zengcheng from Guangzhou may also explain the greater share of trips. Concerning Shenzhen, it is also close to Huidong, which give rise to the amount of trips.

On comparison, self-estimated figures shapes Guangzhou, Zengcheng and Shenzhen as the peaks. The majority of the trips are lower than official prediction, except the case of using population in predicting the trips of Guangzhou. For most city pairs, self-estimated figures have a similar trend with government figures.

Figure 6.7.1
Comparing official prediction and self predictions (using population of 2001)
- Dongguan -

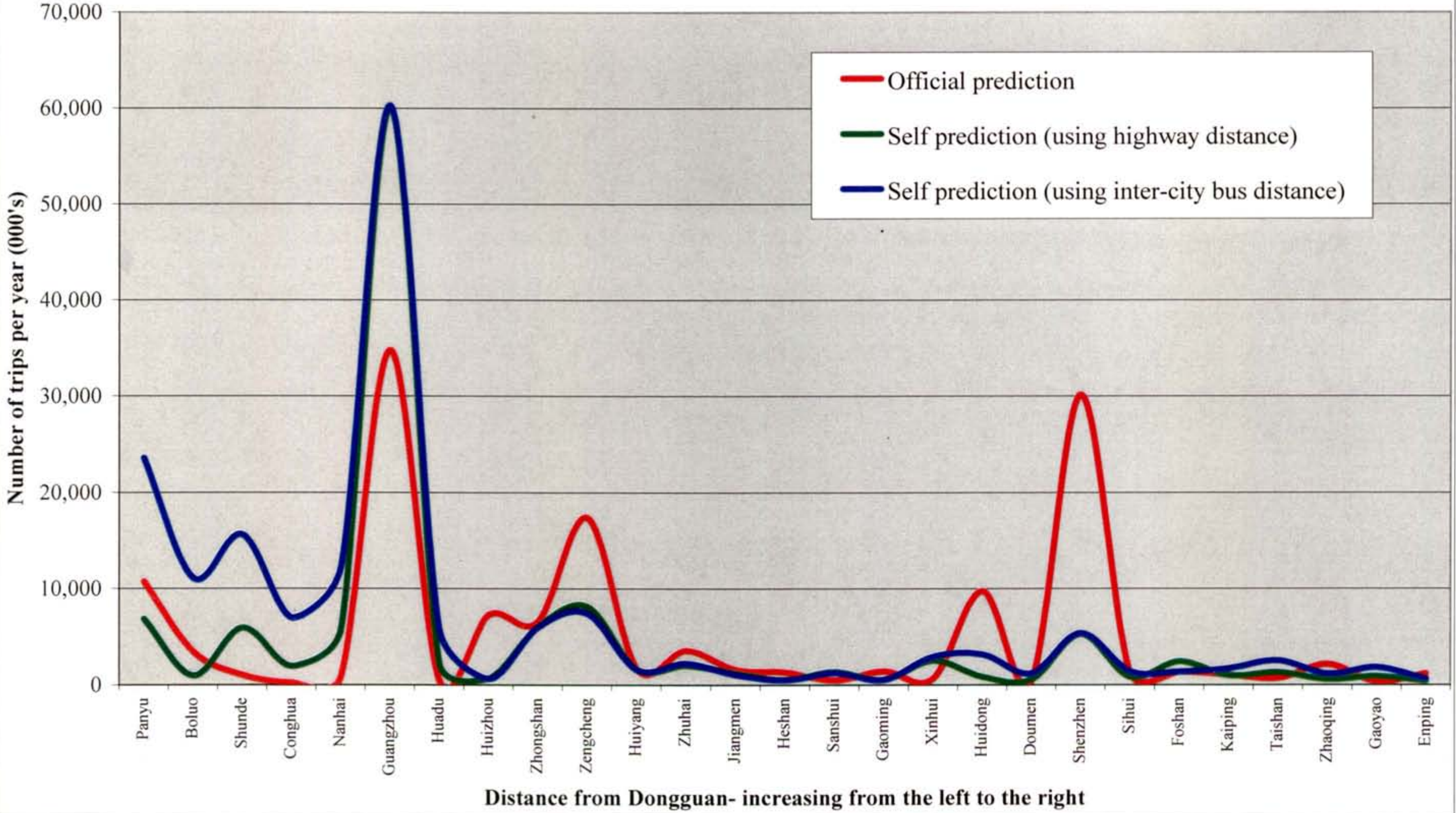
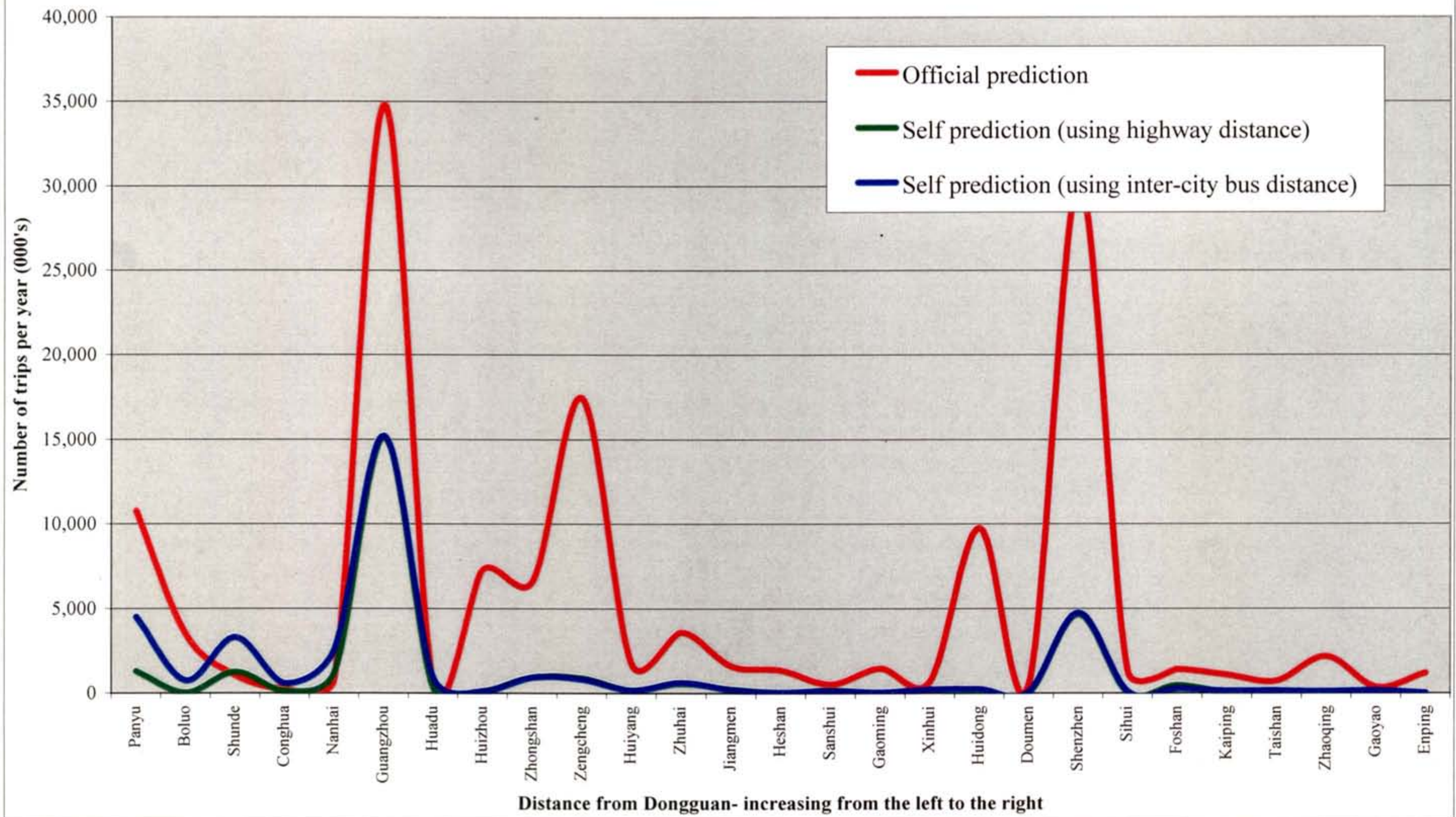


Figure 6.7.2
Comparing official prediction and self predictions (using GDP of 2001)
- Dongguan -



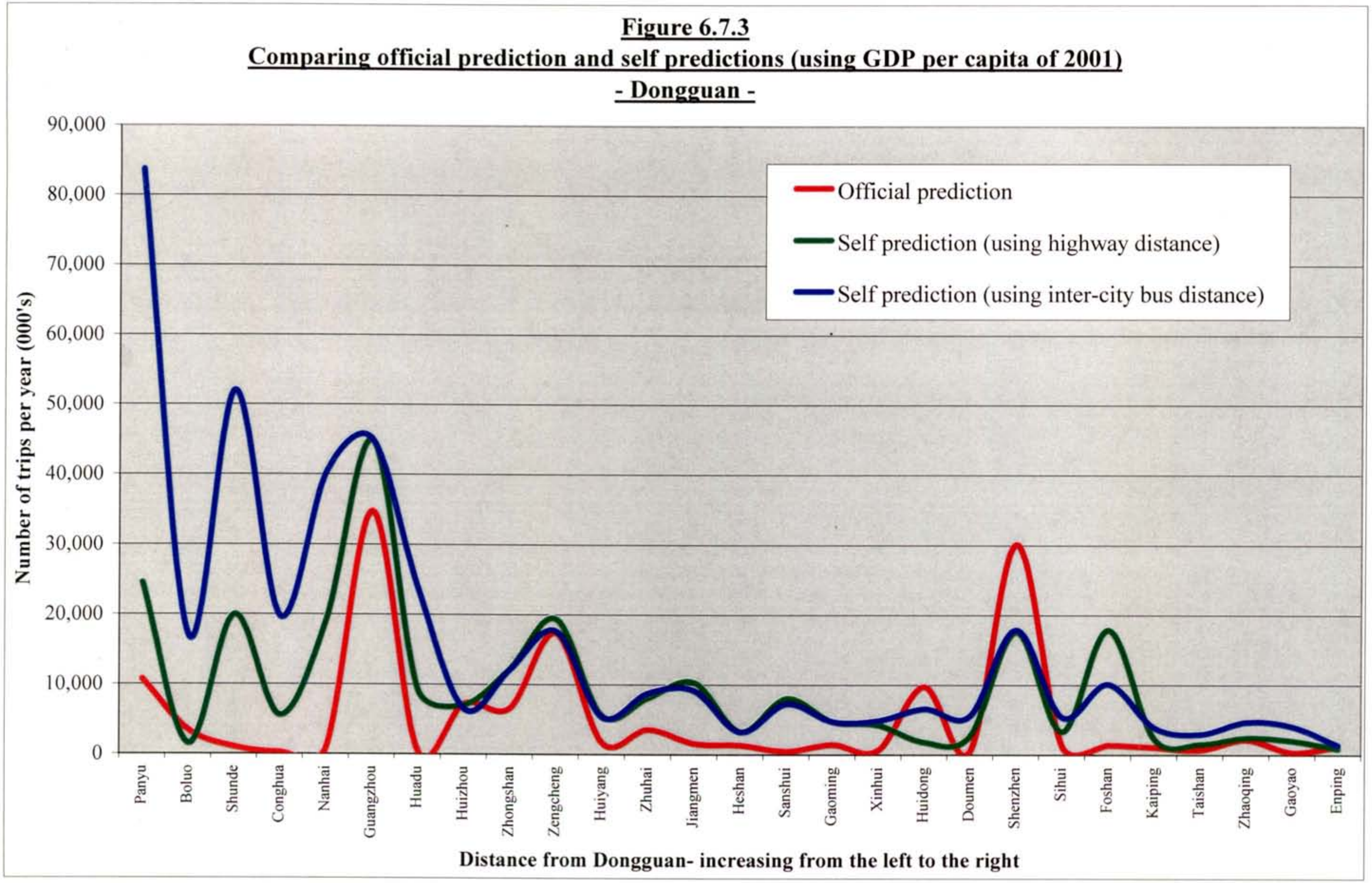


Figure 6.7.3
Comparing official prediction and self predictions (using GDP per capita of 2001)
- Dongguan -
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Number of trips per year (000's)
Official prediction
Self prediction (using highway distance)
Self prediction (using inter-city bus distance)
Panyu
Boluo
Shunde
Conghua
Nanhai
Guangzhou
Huadu
Huizhou
Zhongshan
Zengcheng
Huiyang
Zhuhai
Jiangmen
Heshan
Sanshui
Gaoming
Xinhui
Huidong
Doumen
Shenzhen
Sihui
Foshan
Kaiping
Taishan
Zhaoqing
Gaoyao
Enping
Distance from Dongguan- increasing from the left to the right

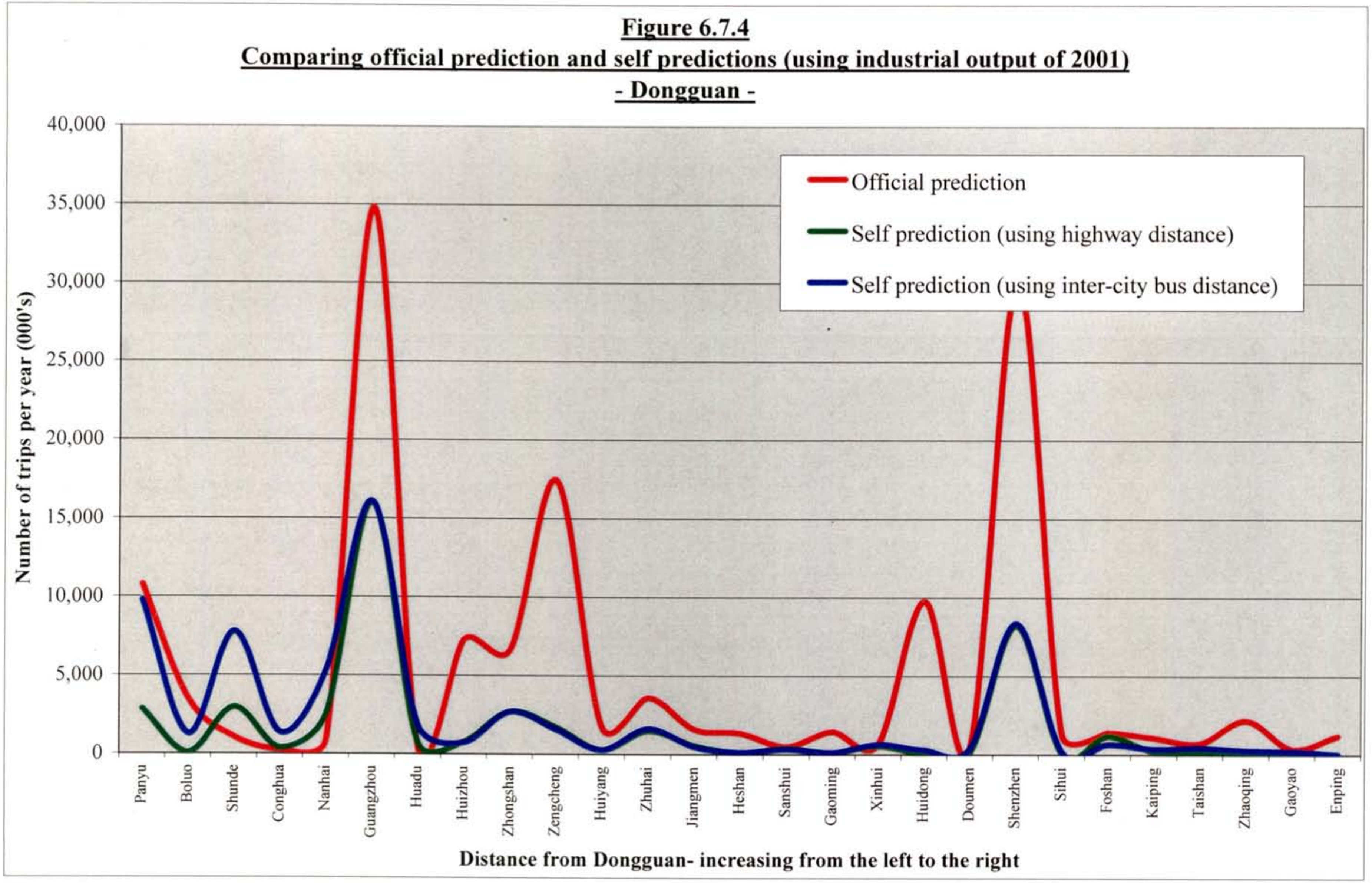
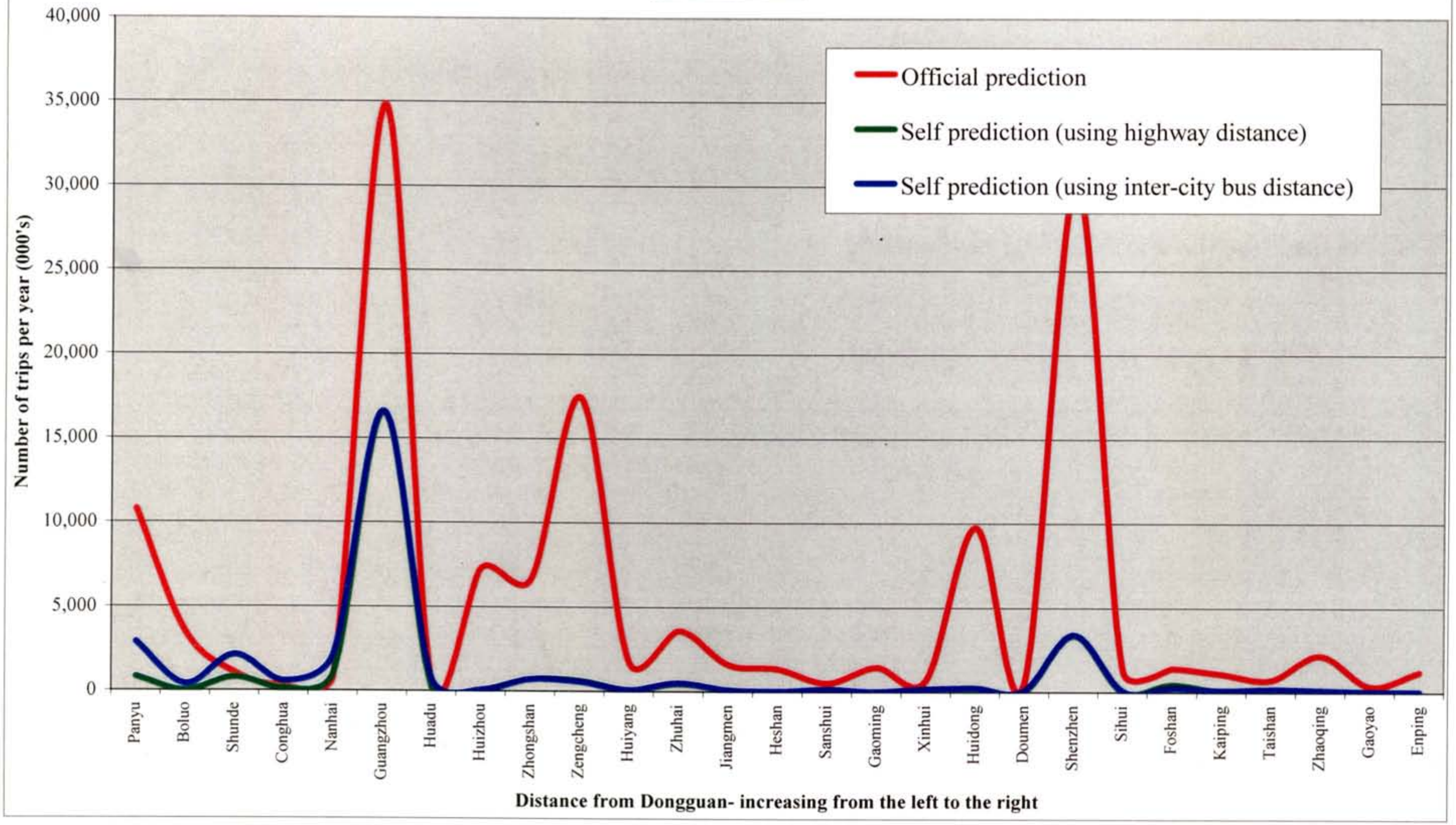


Figure 6.7.4
Comparing official prediction and self predictions (using industrial output of 2001)
- Dongguan -
Official prediction
Self prediction (using highway distance)
Self prediction (using inter-city bus distance)
Number of trips per year (000's)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Panyu
Boluo
Shunde
Conghua
Nanhai
Guangzhou
Huadu
Huizhou
Zhongshan
Zengcheng
Huiyang
Zhuhai
Jiangmen
Heshan
Sanshui
Gaoming
Xinhui
Huidong
Doumen
Shenzhen
Sihui
Foshan
Kaiping
Taishan
Zhaoqing
Gaoyao
Enping
Distance from Dongguan- increasing from the left to the right

Figure 6.7.5
Comparing official prediction and self predictions (using retail sales of 2001)
- Dongguan -



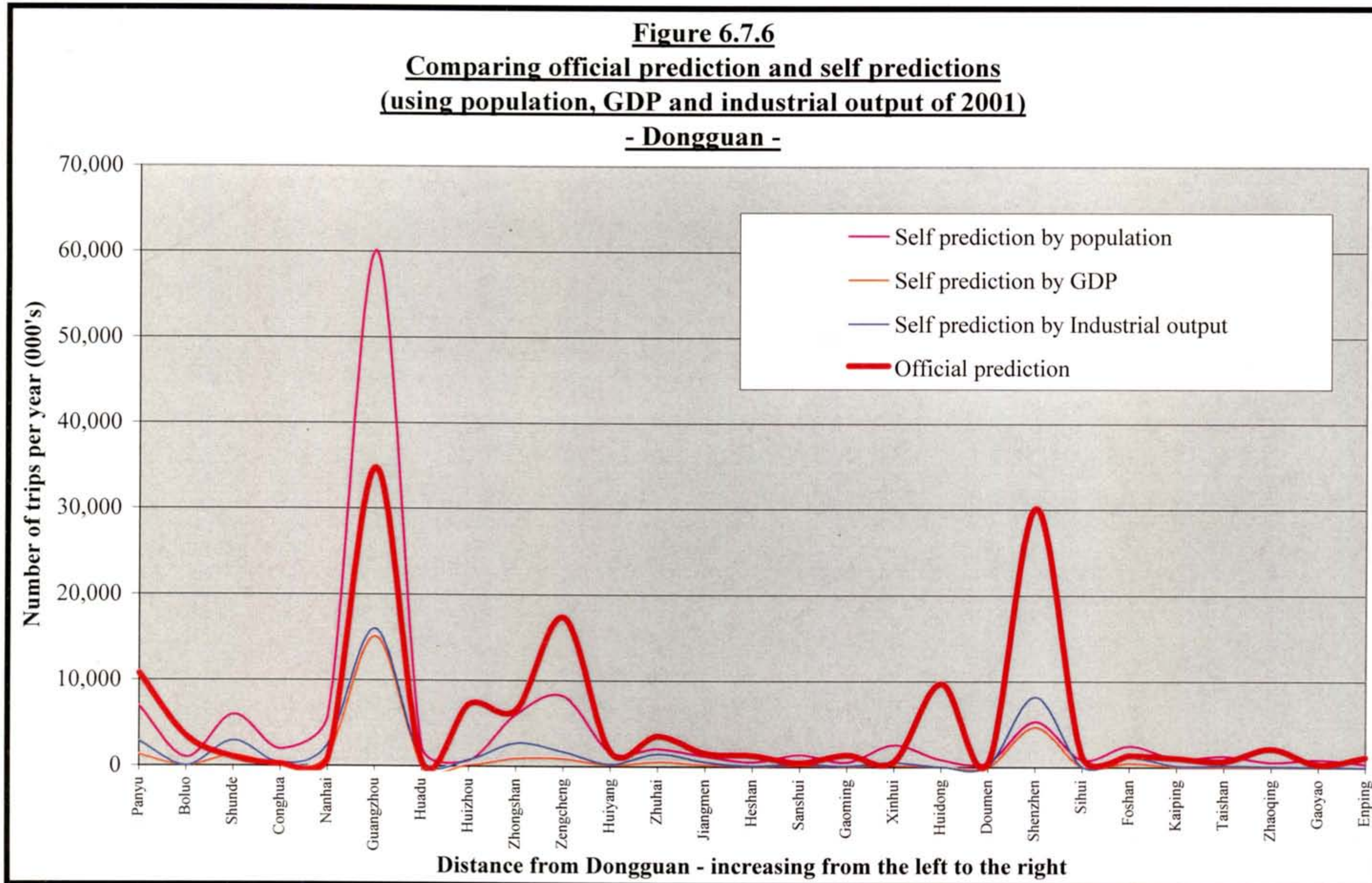


Figure 6.7.6
Comparing official prediction and self predictions
(using population, GDP and industrial output of 2001)
- Dongguan -
Self prediction by population
Self prediction by GDP
Self prediction by Industrial output
Official prediction
Number of trips per year (000's)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Panyu
Boluo
Shunde
Conghua
Nanhai
Guangzhou
Huadu
Huizhou
Zhongshan
Zengcheng
Huiyang
Zhuhai
Jiangmen
Heshan
Sanshui
Gaoming
Xinhui
Huidong
Doumen
Shenzhen
Sihui
Foshan
Kaiping
Taishan
Zhaoqing
Gaoyao
Enping
Distance from Dongguan - increasing from the left to the right

6.4.6 Summary of the above five cities

Table 6.11 summarizes the findings of the above five cities. It shows the cities having greater amount of trips in government prediction and own prediction. As the own prediction is based on the gravity model where the distance decay concept is followed, the table will highlight if there is any difference of government prediction and our own. It will also suggests the reasons for such differences.

For Guangzhou, greater trips go to Huadu and Dongguan in government prediction. As discussed in section 6.4.1, the new airport at Huadu will generate more trips. The case of Dongguan may be the attempt that Guangzhou is planning to expand the urban core to the surrounding cities. It may be a strategy that Dongguan will be integrated to the "mega-urban" region of Guangzhou.

For Shenzhen, there are not many large cities surrounding. It is not surprised that Dongguan, Guangzhou and Huidong have greatest amount of trips in government prediction. Firstly, these cities also have greatest amount of trips in self-prediction. This is caused by the distance from Shenzhen and their population. On the other hand, cities towards the west of PRD are not estimated to have closer contact with Shenzhen. This can be described as the concentration of development of Guangzhou-Dongguan urban core.

For Zhuhai, trips go to Shunde, Zhongshan, Foshan and Guangzhou according to official prediction. All of these cities are close to Zhuhai. This implies a concentration of development of these cities on the west of PRD. Own prediction suggests that Shenzhen and Dongguan should have more trips to Zhuhai. It is clear that the contact between east and west of PRD is not realized in official planning.

Zhongshan shows the case of Zhuhai, Shunde, Dongguan and Foshan have greater amount of trips. Zhuhai, Shunde and Foshan are relatively close to Zhongshan. This is similar to the point mentioned in the case of Zhuhai where this clustering of cities in PRD west is planned. Findings from self-prediction support that Shunde and Dongguan are close enough to have more trips.

Lastly, the city of Dongguan have more trips to Guangzhou, Zengcheng and Shenzhen in both official and own prediction. It is because of the intermediate location of Dongguan which is between Guangzhou and Shenzhen. The case of Zengcheng is simply because of the distance from Dongguan. Indeed, the expansion of Guangzhou urban area will be an attraction force of Dongguan in future when more trips are generated between them.

Table 6.11
Cities having greater amount of trips in government prediction and own prediction, by the five major cities in PRD
(listed according to increasing distance from the original city)

Cities	Peaks in government prediction	Peaks in own prediction
Guangzhou	Huadu *Dongguan*	Panyu Shunde Nanhai *Dongguan* Zengcheng Zhongshan
Shenzhen	*Dongguan* *Guangzhou* Huidong	Huizhou *Dongguan* Panyu *Guangzhou*
Zhuhai	Shunde *Zhongshan* Foshan *Guangzhou*	Doumen *Zhongshan* Dougguan *Guangzhou* Shenzhen
Zhongshan	Zhuhai *Shunde* *Dongguan* Foshan	Jiangmen *Shunde* *Dongguan* Guangzhou
Dongguan	*Guangzhou* *Zengcheng* *Shenzhen*	*Guangzhou* *Zengcheng* *Shenzhen*

Note:
Italics refers to the city being the peak in both government and own predictions.

Chapter Seven

Summary of findings and conclusion

7.1 Research findings

This study is an attempt to demonstrate different methods in trip distribution in transport modeling for planning the inter-city rail in PRD. The understanding of the diversified trends of inter-city travel implies the possible difficulties in giving a full picture of estimating the future demand of it. With the conceptual framework of the gravity model and emerging technologies of GIS, this research proves that modeling of inter-city travel using urban transport modeling techniques is possible.

The findings of this study not only proved the importance of gravity model as a basic concept of transport modeling, but also show that there are different approaches in deriving transport demand. It is clear that the "official estimated figures" are not derived from the basis of gravity model. However, the majority of the findings have the same trend as the estimated figures. It confirms that there are other "hidden" terminologies behind the output of the government figures.

The question on whether inter-city rail is feasible in PRD comes to the problem of actual planning, construction and operation. Having a concentration of a population over 50 million in the PRD, inter-city rail can be constructed with accordance with the potential passengers demand. Rail systems of different capacities are feasible. Light rail of a capacity of few hundred can serve settlements which are widely apart, while heavy rail are recommended for high density urban corridors. The common aim of constructing the inter-city rail is to achieve a higher degree of sustainability in transport development.

7.2 Implications of the study

This research has sought to fill the gap of the possibilities of making inter-city rail in the PRD feasible from observing the trip distribution pattern. Indeed, issues implicated to the study of the rapidly developing PRD are always impossible to have a full list of them. An important issue raised from the discussion of the own findings and the official predictions is that, are there any hidden meanings from the estimation of the government, from the view of planning? The PRD is having a complex political structure. Although Hong Kong and Macau are not included in the study, actual planning for infrastructure already involves many jurisdictions. The success of the inter-city rail shall no longer be technical or environmental issues, but the techniques to let all involved parties to discuss towards a common goal.

Nevertheless, this study reveals that an inter-city rail network is not present in the PRD. Heavy reliance on inter-city buses results a problem particular during long weekends and holidays. With increasing integration between all cities in the PRD, an efficient transport network is always valuable. The competitiveness of a region depends much from the enabling infrastructure.

7.3 Suggestions for further study

This study has already initiated the method to estimate an inter-city travel pattern. Owing to the limited time, many linked issues of inter-city travel were not introduced. More research is anticipated in this field.

It is most worth studying the possible development trend of public transport in China. Having the increasing affordability for more mobility means, the number of private cars has been increasing rapidly in China. There are concerns for how public transport modes can maintain their competitive power and to attract more patronage. Increasing urban traffic jams are depriving the rights of public transport to use the "common road". Transport planning will be vital for China's metropolises.

Metropolises imply inter-city movement of people, and also goods. In the history of transport research, the movement of freight seems to be ignored. However, freight movement is actually the source of people's daily activity. The movement of goods to the supermarkets and retail stores for our daily consumption are good examples.

Concerning the application of GIS in inter-city travel, there can be investigation on providing real time transport information for transport users. Modes in the inter-city travel vary in types, price, comfort and other factors. A system which helps the potential user of inter-city travel in choosing their own origin and destination helps a lot. Considering the situation of Hong Kong, there are already many types of internal transport modes. There are far too many choices on how to go from one place to another. Guidance to the user not only increase the user-friendless of the transport mode, but also encourage the overall usage of them as more people know the easier or cheaper way to get to a place.

It is hoped this study can give a better understanding on the feasibility of inter-city rail in PRD, with the ability of modeling an inter-city travel pattern. More studies on inter-city movements in the world are expected in the future.

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