UNIVERSITY OF Southampton
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FACULTY OF ENGINEERING AND THE ENVIRONMENT

School of Civil Engineering and the Environment

A BEHAVIOUR STUDY OF TRANSPORT IMPACTS OF MEGA EVENTS

By

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ABSTRACT

FACULTY OF ENGINEERING AND THE ENVIRONMENT

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The impact of mega events such as the Olympic Games on the host cities is a matter of continuing debate and controversy. The expectations for increasing the profile of the city as well as the opportunities to improve infrastructure and transport operations are widely recognized. Their effects on the city transport patterns particularly towards sustainable urban transport have proved to be significant. By reviewing the challenges and impacts of previous Olympic Games to the transport system of host cities, it is found that understanding the travel behaviour changes along with mega events can improve future transportation planning, including for the increasing number of special events. In addition, the potential of 'legacy planning' is identified. This can help to optimize the background transport system and contribute to the development of transport facilities with far-reaching significance and value on the urban transportation development towards sustainability. In the absence of the continuing records and sufficient knowledge of travellers' responses towards the changes of transport facilities and policies, many host cities had to repeatedly face similar challenges in forecasting, planning and running the mega events. This lack of knowledge in the travel behaviour changes associated with the Olympic Games and potential concerns have been the main motivation for this research.

On the basis of understanding what the short-term and long-term impacts on transportation have been in previous Olympic Games, this thesis investigates the travel behaviour changes under the circumstance of the Beijing Olympics 2008 by examining the information from a series of continuous Beijing residents household travel surveys and supplementary surveys. The comparison found that the local residents' daily travel pattern was interrupted by the Travel Demand Management (TDM) measures and significantly changed during the Olympic Games. Though some impacts seemed to continue after the Games, most changes the residents made during the Games didn't appear to have a lasting effect on local travel patterns.

Using Weighted-Euclidean distance Probability Mass function (PMF) tests and cluster analysis, the individual behaviour changes were examined in terms of trip rates, primary travel modes and commuting trips. This showed that travellers with different demographic characteristics might have significantly different behaviour changes and responses to the Games-related Travel Demand Management (TDM) measures. Particularly, the car users and the public transport passengers reacted differently to the changes brought by the Olympics, in both the short-term and the long-term. The data analysis also indicated the travellers' actual behaviours were significantly different from what they planned before the Games, especially on walking and subway. Understanding the difference between groups of travellers is essential for future planning and strategic decisions.

Supervised by **Professor Mike McDonald** and **Professor John Preston**

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DECLARATION OF AUTHORSHIP

I, Kangjing HE declare that this thesis entitled:

A Behaviour Study Of Transport Impacts Of Mega Events, and the work presented in it are my own and has been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;

2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;

3. Where I have consulted the published work of others, this is always clearly attributed;

4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;

5. I have acknowledged all main sources of help;

6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;

7. Either none of this work has been published before submission, or parts of this work have been published as: [please list references below]:

Signed: ....

Date: ....

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TERMINOLOGY

Accreditation The process of registering, producing, distributing and validating the Olympic identity and accreditation card that permits the holder access rights and other privileges for the Olympic Games. The OCOG may establish a functional area dealing with Accreditation aspects (International Olympic Committee, 2004).

Broadcasters A broadcast organisation, television and/or radio, that owns the exclusive right to broadcast the Olympic Games within a given country or territory (International Olympic Committee, 2004).

Games Services Games Services a generic term commonly used to group functional areas that provide a range of specialty services for Olympic facilities, to members of the Olympic Family and/or the general public, such as Accommodation, Accreditation and Security (International Olympic Committee, 2004).

Games Time A period of time defined as beginning of the Opening Ceremony and ending with the end of the Closing Ceremony (International Olympic Committee, 2004).

International Federation (IF) In this report, IF refers to the constituent group of Technical Officials, other than International non-governmental organisations (identified as IFs below) when describing transport services. 'Technical Officials' are those people identified by each International Federation who have the technical authority required to stage and administer the competition. Typically technical officials include judges and referees in addition to other sport-specific officials. There may be both international and national technical officials, depending on the rules and regulations of each particular sport (International Olympic Committee, 2004).

IFs International non-governmental organisations administering their respective sport at a world level and encompassing organisations administering sport at a national level. They are responsible for the development of their sport and for the organisation of the competitions at the Olympic Games (International Olympic Committee, 2004).

International Olympic Committee (IOC) The International Olympic Committee (IOC) is the supreme authority of the Olympic Movement. The IOC is an international non-governmental non-profit organisation whose mission is to lead the Olympic Movement and the promotion of Olympism in accordance with the Olympic Charter (International Olympic Committee, 2004).

NOCs The National Olympic Committees, National Olympic Committees (NOCs) are the IOC recognised organisations, which develop and protect the Olympic Movement in their respective countries in accordance with the Olympic Charter. NOCs must be established in accordance with the Olympic Charter and their statutes must be approved by the IOC (International Olympic Committee, 2004).

Official Report/ Post Games Report Upon completion of the Games, the OCOG prepares the Official Report that details the planning, organisation and celebration of the Olympic Games. This report also includes the official competition results of the Games. The correct wording for the Official Report of the Summer Games is shown in the following example: The Official Report of the Games of the XXVII Olympiad. This report is a host city contract requirement of the OCOG. (International Olympic Committee, 2004)

Olympic Family Olympic Family is a general term used to group together various constituents of the Olympic Movement. Any specific interpretation or application of the term is to be verified with the IOC (International Olympic Committee, 2004).

Olympic Village The Olympic Village is a safe and secure accommodation complex reserved exclusively for athletes and accompanying officials (International Olympic Committee, 2004).

Organising Committee for the Olympic Games (OCOG) An Organising Committee(s) for the Olympic Games and/or the Olympic Winter Games. The staging of the Games is entrusted by the IOC to the NOC of the host country. The host country NOC forms the OCOG as the organisation that is responsible for managing the operations necessary for the staging of the Games (International Olympic Committee, 2004).

ORN Olympic road network (ODA, 2007).

Rights Holding Broadcast Organisations (RHB) An organisation that has been granted, by the IOC, the exclusive television and/or radio rights to broadcast the Olympic

Games in a particular territory 'RHBs'. Also called Rights Holders (International Olympic Committee, 2004).

Spectators The constituent group 'Spectators' refers to the physical patrons of the Olympic Games or Olympic Games related activities. Spectators may be ticketed or non ticketed, and may be local (within the host city region), national (within the host country and outside the host city region) or international (originating from outside the host country) (International Olympic Committee, 2004).

TDM Travel Demand Management.

Trip A trip is the movement of an individual person from one place to another to achieve a purpose or to undertake an activity at the destination. The activity is (usually) unrelated to the process of travel itself, and the trip finishes when the destination is reached. There may, however, be intermediate stops on the way that are necessary for the traveller to change from one method of travel to another. (TFL, 2009)

Trip rate Trips per person per day.

Stage A journey stage is a part of a trip made by a single mode of transport. Bus journey stages are counted as starting a new journey stage each time a new bus is boarded. Underground journey stages are counted by station entries; interchanges within stations are ignored. (TFL, 2009)

Walk only Walks are counted only when they form complete trips (ie walking all the way), not when they are part of trips using other modes of transport. (TFL, 2009)

Chapter 1

INTRODUCTION

The impact of mega events such as the Olympic Games on the host cities is a matter of continuing debate and controversy (Cashman, 2002). The expectations for the high profile of the city as well as the opportunities for infrastructure and the city operation systems are widely recognized. The Games brings the host cities great opportunities to develop their urban transport systems, including upgrading transport facilities, improving public transport services, and facilitating information integration and improving accessibility for persons with restricted mobility. The effects on the city transport patterns, particularly towards sustainable urban transport, have been significant (Bovy, 2007a). Understanding residents' travel behaviour changes along with mega events will not only have broad implications in improving the future transportation planning for the quickly growing special events sector, but more importantly, they provide great potential opportunity in "legacy planning", which helps to optimize the background transport system and contribute to the development of transport facilities with far-reaching significance and value on the urban transportation development towards sustainability (Ritchie, 2000). On the basis of understanding what short-term and long-term impacts on transportation have been in previous Olympic Games, this research investigates the local travel behaviour changes under the circumstance of the Olympics, focusing on the case of Beijing 2008 Olympic Games. The information from a series of large household and in-street surveys held in Beijing prior to, during, and after the 2008 Olympic Games will be used to compare and analyze for better understanding the public response on transport in the context of mega events and how their travel behaviour changes immediately with relevant 'hard' measures and 'soft' policies, and how the longer term impacts are dealt with. The results will have strategic implications for future planning and evaluations of mega events, for short-term demand forecasting and further destinations with long-term benefits.

1.1. Background

Hosting the Olympic Games has a significant impact on the host city, as the Games enrich people's lives, improve cultural facilities, bring global focus, and provide an intense period of investment and construction of transport facilities and systems improvements, thereby benefiting the cities in short term. On the other hand, the huge superposition of the event transportation and traffic flow onto the existing congested local transport brings the hosts unprecedented challenges.

For longer term, the games leaves lasting marks in all social, economic, and environmental aspects, from tangible infrastructure construction such as competition venues and transport facilities and the image of the host cities, to the intangible influences on the culture, worldwide perceptions of the city, as well as the local life style (Chalkley & Essex, 1999).

On the other hand, mega events like the Olympics are considered 'real scale, live laboratories' to experiment with new transport policies and advanced traffic management schemes, offering great opportunities in advancing soft improvement on urban transportation as well as encouraging sustainable travel behaviours for the local public (Bovy, 2007a; Dimitriou, et al., 2006).

While individual response and acceptance are considered as the important accordance for planning mega city transportation, and the key determinants for the efficiency of strategies (Fujii & Gärling, 2003), the travel behaviour research, which was short in empirical evidence concerning Beijing transportation as well as previous Olympics, draws more and more focus for its efficiency and extent in solving the existing problems, by integrating demand management, transport economy, and psychology. It is interesting to explore efficient ways in explaining actual travellers' demands, moving from vehicle-oriented to traveller-oriented approaches for transportation planning, and promoting public transport to be more preferred over car use.

Beijing presents a very interesting case for both sustainable urban transport and mega event transport issues, with significant developments in the economy, a fast increase in the number of cars, severe congestion, and the shortage in efficient public transport - especially subway - during the last decade. Beijing undertook substantial infrastructure improvement with special focus on subway construction and other public transportation improvement in anticipation of the 2008 Olympic Games. The Beijing subway system in operation, which had 2 lines/ 43 stations/ 54 km for 30 years before 2001, reached 8 lines/123 stations/200 km in 2008. In other words, 6 lines, 80 stations, and 146 km were built in the period 2001 to 2008. The bus system and complementary travel information systems were also greatly improved. There were significant improvements in travel accessibility before the Games, including handicap-access entrances for the subway stations, around 2,800 handicap-accessible low floor buses, over 1,500km blind paths, and handicap-accessible parking space. During the Games, the largest Travel Demand Management (TDM) schemes in Olympic history were carried out for the city transport operation. All the changes in the city transport brought Beijing a big challenge as well as opportunity in improving the travel experience of local residents. The experience as well as the hidden implications will be worth looking into for future mega events.

1.2. Objectives

The principle aims of this research are to investigate the Olympic Games' influences on the travel behaviours of the residents. Specific objectives are:

- Identify and quantify the transport impacts of past Olympic Games on the host cities during and subsequent to the Olympics.
- Understand behaviour changes of local residents with the upgraded urban transport system and the impact of TDM measures introduced during the Games from the Beijing Olympics database.
- Determine the legacy effects of past Olympic Games and lasting impacts of the TDM measures towards the behaviour changes where longer-term legacy effects can be optimized.

The above objectives will be addressed with specific references to the Beijing Olympics.

1.3. Methodology

This research will include four parts as follows: literature review, case study, survey work and data analysis, as shown in Figure 1-1.

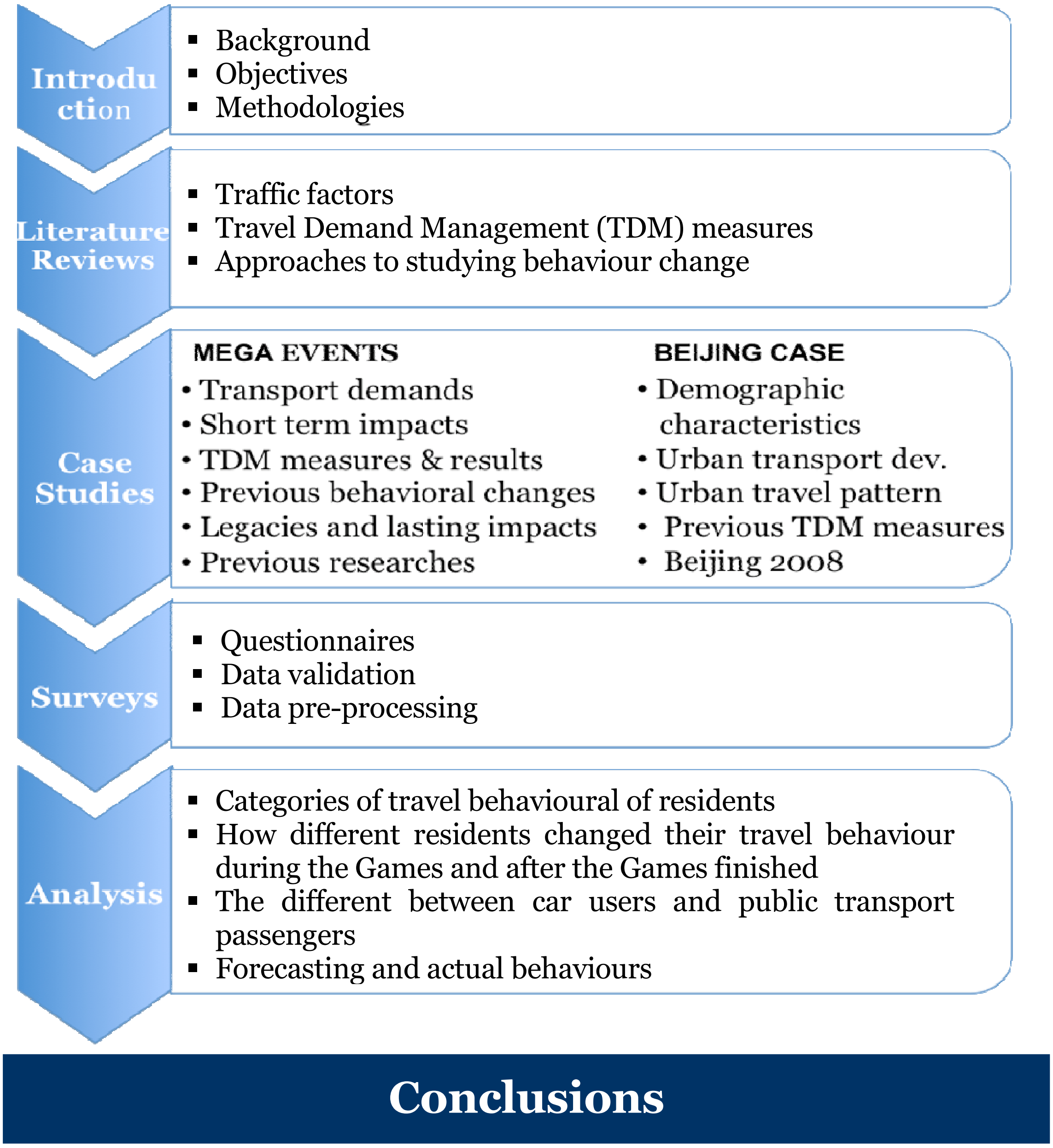
The literature review in Chapter 2 starts with the introduction of traffic factors, behaviour change and the impact of Travel Demand Management (TDM) measures for better understanding of travel patterns and behaviour change. Different approaches of studying behaviour changes are then reviewed and introduced, including Probability Mass Function (PMFs) and Cluster analysis. These give the foundation for subsequent study, survey, and analysis. Through the review, influencing factors to investigate will be identified.

Based on this, the research moves on to Chapter 3 for reviewing the Olympic history from 1896 to 2008 as well as some comparable events, to comprehend what have been the short-term and lasting transport impacts of the Olympic Games on the host cities. It will also examine the methods that have been taken to deal with the impacts and their outcomes. The knowledge from this chapter is vitally important for the subsequent studies on behaviour changes in such specific circumstance. Moreover, TDM measures applied in mega events and their subsequent impacts will be specifically focused on, while relevant comparison will be carried out for better understanding of the Games' demands and performances.

In Chapter 4, the detailed information collected on Beijing travel patterns will be outlined in terms of the existing behaviour as well as developing trends. Demographic characteristics and travel habits of the residents and the general information of Beijing 2008 Olympic Games will be compiled together to offer an essential knowledge base for the next step of studying and exploring the hidden implications from the survey.

Chapter 5 focuses on the surveys taken in Beijing, including the questionnaires, methodologies, data validation, and data pre-processing. In Chapter 6, the preliminary findings from the surveys and relative information on the travel pattern changes in Beijing are summarized, with an emphasis on behaviour changes under the pretext of the Olympic Games. Following that, details of data analysis will be laid out in Chapter 7-9, to identify the categories of behaviour changes, and the different changes between the residents with various characteristics. Particularly, in order to examine the behaviour changes of the people with different car ownership status, the car users and public transport passengers are singled out for further examination in Chapter 8. The analysis in Chapter 9 identifies the difference between the forecasted and actual behaviours, which has been a significant challenge on the demand analysis and planning process for mega events.

Figure 1-1 Structure



Chapter 2

UNDERSTANDING TRAVEL PATTERNS AND BEHAVIOUR CHANGES

This chapter reviews the basic theories for travel patterns and models used for studying travel behaviour changes in previous research. This review of travel behaviour literature starts with an overview of the factors for describing travel patterns and choices and the variables that may influence travel behaviour changes. In addition, we look at behaviour change models in empirical studies to help understand how the changes take place and move across the population. At the end of this chapter, an overview on the history and practice of Travel Demand Management (TDM) is given. This chapter provides fundamental knowledge and information for the discussions that follow.

2.1. Travel patterns

2.1.1. Introduction

A successful public transport system is thought to have high patronage, increasing usage, profitable operation, and good access for ranges households including low income groups, and less congestion (Ceder, 2004; Mackett & Babalik, 1998). Many efforts have been provided by governments, NGO, and other economic entities in many countries, while several past or present strategies worldwide appear inefficient for the lack of public acceptance or discordance with political feasibility. How people respond is a key point for the efficiency and success of various measures on transportation in metropolitan areas under both normal circumstance as well as event periods (Fujii & Gärling, 2003).

In order to well represent the travel mode choice behaviour, research regarding factors influencing travel behaviour and the factors evaluation draw worldwide concentration. This issue is considered to be a most important element in transportation planning study and will greatly improve the understanding of decision processes and attitudes for modal choice. Unlike the traditional models, which are based on the identification of relationship between observed travel behaviour and engineering measures of travel characteristics like time and cost and demographic characteristics, the integrated models investigate more deep psychological attributes, concerning individuals' perceptions, such as convenience and other satisfaction measures, by combining the influences of demographic characteristics and clients specifications (Johansson et al., 2005).

According to present studies in identifying the factors influencing mode choice concerning the transport facility characteristics, there are six key areas that are commonly recognized: Time, Cost, Reliability, Convenience, Comfort, and Security, with following related contents (Ortuzar & Willumsen, 2001).

2.1.2. Traffic Factors

Time

Time valuation analysis generally comes from three sources: the pure time allocation theories, the home production framework and literature on travel demand. It is often distinguished between subjective (or behavioural) and evaluation values of time, where the subjective value of time including in-vehicle travel time, walking time to and from stops, the waiting time at stops, parking time, the interchange time, and queuing time for ticket purchase, while evaluation values refers to the different levels of time savings between alternative models (Ortuzar & Willumsen, 2001). In the utility function for discrete travel choice models, subjective value of time and saving, connected to the individual wage rate and social price of time is estimated in one unit in terms of willingness to pay for reducing travel time, etc. (Jara-Díaz & Guevara, 2000).

Cost

Cost in transport planning is usually measured in two ways, one is direct monetary value, and the other is indirect. However, this research will only use the direct monetary cost measures, such as ticket fare, parking fee, and fuel consumption while compared with car usage, etc. Basically, the monetary costs do not depend directly on distance but in general on the distribution of travel location and on the route choice as well (Ortuzar & Willumsen, 2001). The cost factor is always a most important index in both traditional and current transport research, for its easy observation.

Reliability

Reliability in transport mode choice research mainly consists of Punctuality, Route accordance, and information accuracy. Punctuality is the first and important component of reliability measures, which often refers to timetable schedule, including the variability of waiting time and in-vehicle time. Besides, route accordant is also an indication of reliability, as well as the variability of pre-trip information on telephone or Internet communication while information for trip planning becomes a more important determination for people's choice (Ortuzar & Willumsen, 2001). Reliability is usually treated as a big advantage of subway system, compared with surface traffic with congestion risks.

Convenience

Convenience is stated to refer to efficiency and effectiveness with which a person can be transported from origin to destination (Stopher et al., 1974). And according to the survey work carried out by the TRG of the University of Southampton, convenience is identified as the third most important travel factor (Transportation Research Group, 2000), while sometimes, the definition of convenience factor is closely connected to factors such as time, reliability etc. (Neveu et al., 1979). In this research, we adopt the definition of convenience in three scopes concerning public transport application: time relevant, mode relevant and information relevant. Regarding to time relevant, it is usually characterized in distance of access and egress for the stations; the mode relevant includes transferring platforms, integration between modes, park & ride, pick up service and other transfer facilities; the information part normally refers to pre-trip information provision, in-station assistance and other sorts of indicating signs (Ceder, 2004; Wardman & Tyler, 2000). Research showed that most car users did not consider making the journey by rail for the perceived inconvenience and inflexibility reasons, while convenience is considered to be the major disadvantage of public transport system compared with private car usage, due to its fixed service and difficulty in providing door to door service. Public transport has a long way to go to be able to provide choice and convenience to the desire by the modern citizen, while the convenience issue should be the most focus point in the study of how to make public transport alternatives more attractive (Hiscock et al., 2002; Huey & Everett, 1996; Wardman, 1997).

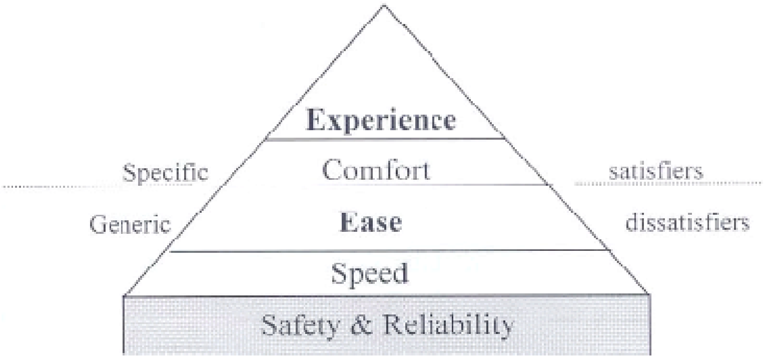
Comfort

Comfort is seemed to be the most 'soft' factor among these five and hard to clearly define, while it is an essential component of measure for satisfaction. The main topics relevant mainly focus on in-vehicle circumstance such as crowding, seats and handles, tea, coffee or newspaper availability. Even though it is revealed that the satisfaction standards for different person, different journey purpose and different location are vary and unclear so far, the requirement of comfort becomes more and more important as the lifestyles and social spatial relations engage in by many people. It is evidenced that in the case of patronage loss, comfort requirement played a crucial role, and crowding is thought to be a main factor causing public transport journey agony (Ceder, 2004; Huey & Everett, 1996), particularly in the event transport operations.

Security

Security includes public security and personal security. In Maslow's pyramid of factors importance ranking of rail station, safety is taken as an absolute requirement together with reliability (Peek & van Hagen, 2002).

Figure 2-1 Relationship between passenger requirements and desires in stations



Source: Peek & van Hagen (2002)

Improving and insuring the security situation especially for personal security in vehicle and at station is a base requirement of passengers' during daily operation, while for event transportation organizing, the factors of security and safety are extremely emphasized, together with greatly increasing challenges.

Others (Communication/Culture)

Additionally, a factor named 'communication/culture' will be investigated as an influencing factor in this study. The communication factor here will refer to the connection strategies connecting different clients by providing information, promoting attendance and a series marketing means to encourage the public acceptance of sustainable transport alternatives or event specific transport arrangements. The definition of communication in influencing mode choice concerning with the transport facility characteristics might sometimes overlap with other factors mentioned above. However, its efforts on the accessing to ranges of clients and encouraging the public acceptance have been emphasized in recent years, especially for events transport preparation and operation (Official Report of the Games of the XXVII Olympiad, 2000).

According to data analysis process, the factors are normally divided between quantitative, such as time, cost, reliability and security sometimes, while convenience and comfort are marked as qualitative. Although time and cost are usually the dominant factors in mode choice and easy to quantify, others' influence are far from being sufficiently observed. People's perceptions are usually based on their past experience and ways they organize their normal lives, implying that weights should be sensitive to this fact (Tudela, Akiki, & Cisternas, 2006). As Heiner (1983) pointed out, it may be the case that the value of saving travel time should be a lot or equal to zero. It is very difficult so far to find ways in qualifying and weighting performance of such as the level of service of public transport in empirical research, due to the various situations and unobserved individual attributes. There is still a tremendous gap between descriptive behavioural theory and ability of statistical models to reflect these behavioural hypotheses, considering institutional and cognitive constrains.

2.2. Travel behaviour change

2.2.1 Introduction

As the social and environmental impacts associated with the growing level of traffic have raised several concerns about the sustainability of such trends throughout the world, researchers and policy makers have tried to encourage travellers to choose alternative methods instead of using car for travel. Understanding why people travel by various modes and what prompts travel behaviour change are essential for relevant planning. Travel behaviour change is rapidly becoming an emerging category of mobility management initiative to encourage individuals to be more aware of their travel options and to reduce private car use (Litman 2001, Scuderi 2005, Cairns et al. 2008, Goodwin 1996, Rose and Ampt, 2003). The research in transportation and behaviour change covers several disciplines, from civil engineering and transport planning to social studies, economics and psychology, which dates back to 1945 with Liepmann, who first pointed out the effectiveness of time, cost and purpose on mode choice for travelling, by analyzing 1930s data on work travel in England (Scuderi, 2005).

In recent years, there has been growing interest in a range of transport measures such as Travel demand management measures, which are designed to encourage alternatives to driving alone. In particular, 'soft' factors, which are described as 'smarter choice' measures or 'mobility management' tools, have attracted wide attention for their ability to influence people's travel behaviour towards more sustainable and efficient options (Rose and Ampt, 2003, Abu-Lebdeh & Benekohal, 2003).

In order to further this research, a series of surveys were taken before, during, and after the Beijing 2008 Olympic Games. We then observe how the travel behaviours of Beijing residents changed over time. With the travel behaviour change theories, we might understand and interpret these changes and their correlations with the influencing factors much more clearly.

2.2.2 Factors influencing behaviour change

Reviewing the discussions on travel behaviour changes, there are mainly three kinds of influencing factors: urban form, socio-demographic and lifestyle factors, and psycho-social factors (Hamilton et al, 1991; Friedman, et al, 1994; Ewing, R., 1995; Schimek P. 1996; Badoe & Miller, 2000; Hiscock et al, 2002; Ellaway et al, 2003; Guiliano & Narayan, 2003; Zhou & Yang, 2005; Curtis & Perkins, 2006; Wang & Gan, 2010).

2.2.2.1 Urban form

Urban form generally refers to the physical layout and design of the city, which is the human modification of natural environment or wilderness into built environment for various functions such as residential, commercial, retail, industrial, institutional and green spaces (Pan, H. et al, 2009). Urban factors such as area population density, mix of land use, locations of residential and work, connectivity and street configuration have been proven to strongly impact travel behaviour or change thereof (Cervero, 2002; Guiliano & Narayan, 2003; Zhou & Yang, 2005; Litman & Steele, 2011). In most research reviewed here, the terms 'urban form', 'land use', and 'built environment' are used interchangeably.

It has been emphasized in previous research that there is strong connection between built environments and travel behaviour. Cervero (2002) pointed out that parameters within the built environments (Density, Diversity and Design) significantly influence the decision of residents in their choices of travel modes such as driving alone, car sharing, or using public transport.

In particular, the connection between residential density and travel behaviour has been emphasized by researchers over the world. Although its impact alone is not significant, it is usually associated with other factors such as accessibility, parking management, transport facilities, etc (Litman & Steele, 2011). There is ample evidence that people living in high-density areas or near city centres are more likely to use non-motorized travel modes such as walking and cycling, as well as public transport. When choosing destinations, they prefer those closer destinations, rather than travelling far away (Friedman et al. 1994; Badoe & Miller, 2000; Guiliano & Narayan, 2003; Naess, 2003; Naess & Jensen, 2004; Srinivasan & Rogers, 2005). Furthermore, Goudie (2002) found from his research that, residents in less dense areas (suburb) had less sustainable travel behaviours than those living close to city centres.

People living in mixed-use areas or city centres usually travel less frequently and over shorter distances than others. They also appear more interested in choosing alternative travel methods like walking and cycling for their trips. Zhou & Yang (2005) revealed that the average distance for non-motorized trips or public transport trips is about 3.5 km or less from dense centres, while those car or taxi users live much farther away. It is reported by Litman & Steele (2011) that mixed-use areas typically have 5-15% less vehicle travel. It is interesting that the impact was found to be much more significant for residential locations compared to business places.

It is also found that roadway design and walking/cycling conditions impact residents' daily travel patterns. Stronger urban planning and design controls including well-developed sidewalks and roads might encourage commuters to reduce car travel and choose sustainable transport methods, or switch to car sharing (Cervero, 2002; Guiliano & Narayan, 2003; Litman & Steele, 2011).

Connectivity and public transport services are also important factors influencing residents' travel behaviour and behaviour changes. Litman & Steele (2011) suggested that residents in areas with good transit services tend to own 10-30% fewer vehicles, drive 10-30% fewer miles and use alternative modes 2-10 times more than in automobile-oriented areas.

However, Boarnet, et al in America found that the relationship between land use variables and travel behaviour was not statistically significant for the non-work car trips, by using travel diary data for Southern California residents. Within the limited evidence, geographic scale is crucial as it impacts the price of travel (Boarnet & Sarmiento, 1996; Boarnet & Crane, 2001).

As seen in this research, Olympic host cities such as Beijing usually receive a boost in urbanization as shown later in Chapter 3 and 4. The enormous and intensive transportation improvement always bring significant change to travel patterns in the host cities.

2.2.2.2 Socio-demographic factors

Many studies find that socio-demographic factors' impact on travel patterns is even more significant than that of urban forms (Boarnet & Sarmiento, 1996; Dieleman, et al, 2002). In particular, variables such as age, gender, household size and income are found to be strongly relevant to travel behaviour (Curtis and Perkins, 2006).

From previous studies, younger people are found to be more active in daily travel. The elderly travel less frequently and over shorter distances (Newbold, et al, 2005; Zhang, et.al, 2007). According to the research by Colia, et al (2003) and Zhang, et al (2007), old people in developed countries are more likely to travel by car, while old people in developing countries like China usually go out on foot. The difference in trip rate between age groups is partly due to their employment status. The retirees don't have commuter trips. They normally travel for leisure purpose or shopping. O'Fallion & Sullivan (2009) also found that the older travellers prefer to travel during off-peak period, and rarely during late evening.

Gender is also thought to be an important determinant for travel behaviour studies. Research has indicated that gender does not lead to significant difference in travel frequency, but females have very different travel purposes for their journeys from male travellers, and they usually travel shorter distances than men. It might be because they usually handle more child-care duties and housework, even though they still undertake full-time work (Best & Lanzendorf, 2005; Moriarty & Honnery, 2005). Polk (2003) found from his research in travel behaviour in Sweden that females were more likely to choose sustainable methods for travelling. Looking at senior age group (65+), male travellers travel significantly more than females (Colia, et al, 2003; Zhang, et al, 2007).

Household composition is thought to be another important factor in determining travel behaviour (Dieleman et al, 2002; Ryley, 2005). Ryley (2005) used Scottish Household Survey non-motorised mode data for Edinburgh to reveal that households with children were particularly car dependents. They might own bicycle at home but do not necessarily use it. However, Best & Lanzendorf (2005) found that mothers were less likely to use a car than childless women, which meant having a child in a household might increase the propensity for males to travel by car. As observed by Ryley (2005), students have higher propensity of using bicycle for their daily travel. On the other hand, the employment status and flexible time availability within a household present notable effects on people's travel behaviour, such as duration of journey, etc (Lee, et al, 2007).

Factor of household income usually attracts attentions of behavioural researchers (Dieleman et al, 2002; Guiliano & Narayan, 2003; Moriarty & Honnery, 2005; Ryley, 2005). People with higher income usually have higher travel demands (Dieleman et al, 2002; Moriarty & Honnery, 2005). The high-income households are more likely to depend on cars due to their economic status and their interests in attending out-of-home activities (Ryley, 2005). Guiliano & Narayan (2003) also pointed out in the UK the travel distance increases with income, while the change in daily trip rate is not significant.

2.2.2.3 Psycho-social factors

Not many studies examined the influence of psycho-social factors on travel behaviour. Hiscock et al (2002) presented an in-depth analysis in this field based on interviews with car owners and non-car owners in Scotland. They suggested that psycho-social benefits including protection, autonomy and prestige may help to explain people's dependence on car usage. In particular, convenience and feeling of being in control are important psychosocial benefits perceived by car users. It is also revealed from previous research that travel methods, particularly for car use, relate to lifestyle of residents (Prettenthaier & Steininger, 1999; Cullinane S., & Cullinane K., 2003; Gan, L. 2003). Both Jensen (1999) and Hiscock et al (2002) pointed out travellers with varying characteristics acquired different psychosocial benefits from using cars. The projects of encouraging alternatives to car use need to be more targeted. This was not observed in the surveys conducted for this paper. It is very important for the marketing/ communicate projects of mega events.

2.2.3 Process of behaviour change

Theories for behaviour change in previous research focused on the following fields:

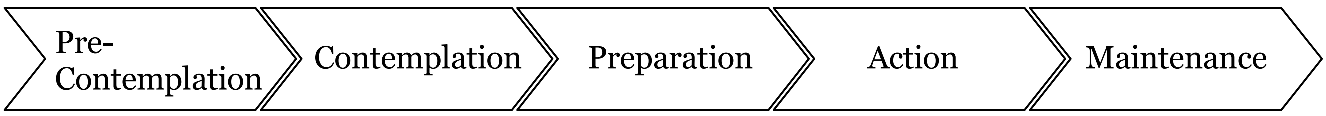
- How an individual makes a change
- The factors that influence an individual's behaviour change
- How the behaviour changes take place across a community

The Transtheoretical model by Prochaska, et al and Ajzen's Theory of Planned Behaviour are widely accepted and applied in both academic research and practical programmes, while Gladwell's concept for 'Tipping point' explains how the changes move across the population and communities (Fishbein & Ajzen, 1975; Ajzen, 1991; Prochaska et al, 1992, 2001; Littell & Girvin, 2002; Smart travel Sutton, 2009).

2.2.3.1 The Transtheoretical model

Prochaska and his colleagues first raised the Transtheoretical model, which is widely accepted to help explain the stage of change for individual behaviours. In this model, the individual behaviour change could be divided into five stages: Pre-contemplation (not thinking about change within 6 months), Contemplation (thinking about /intending to make change within the next 6 months), Preparation (intending to take action in the next 30 days), Action (behaviour change), and Maintenance (made overt changes more than 6 months ago) (Prochaska et al, 1992, 2001; Littell & Girvin, 2002; Smart travel Sutton, 2009).

Figure 2-2 The Transtheoretical Model



Source: Prochaska et al, 1992

According to Prochaska et al (2001), the stage status of people's behaviour change and relevant movement are thought to be influenced by (a) the perceived pros and cons of a problem behaviour and the decision balance between them, (b) confidence in one's ability to change the problem behaviour, (c) temptations to revert to the problem behaviour, and (d) ten 'processes of change'. The ten 'processes of change' was developed by Prochaska (1979) for understanding behaviour change, which could be defined below:

1. Consciousness Raising: Becoming more aware of a problem and potential solutions;
2. Dramatic Relief: Emotional arousal, such as fear about failures to change and inspiration for successful change;
3. Self Re-evaluation: Appreciating that the change is important to one's identity, happiness, and success;
4. Self Liberation: Believing that a change can succeed and making a firm commitment to the change;
5. Environmental Reevaluation: Appreciating that the change will have a positive impact on the social and work environment;

6. Reinforcement Management: Finding intrinsic and extrinsic rewards for new ways of working;
7. Counter Conditioning: Substituting new behaviours and cognitions for old ways of working;
8. Helping Relationships: Seeking and using social support to facilitate change;
9. Stimulus Control: Restructuring the environment to elicit new behaviours and inhibit old habits; and
10. Social Liberation.

This theory for behaviour change can be used to understand and reduce the target population's resistance to change, potentially increase participation in change, and enhance the implementation for movements (Prochaska et al, 2001). As suggested by Hsu & Lin (2008), often times resistance is caused by poorly planned implementation of change initiatives. Understanding the behaviour change process is very essential and important for planning the approaches to encourage individuals to make actual changes. For the Olympic transport planning and operation, it is helpful to explain the progress of residents' behaviour changes, which help implement the 'migration' plan for targeted groups to switch from their original travel pattern to the alternatives stage by stage.

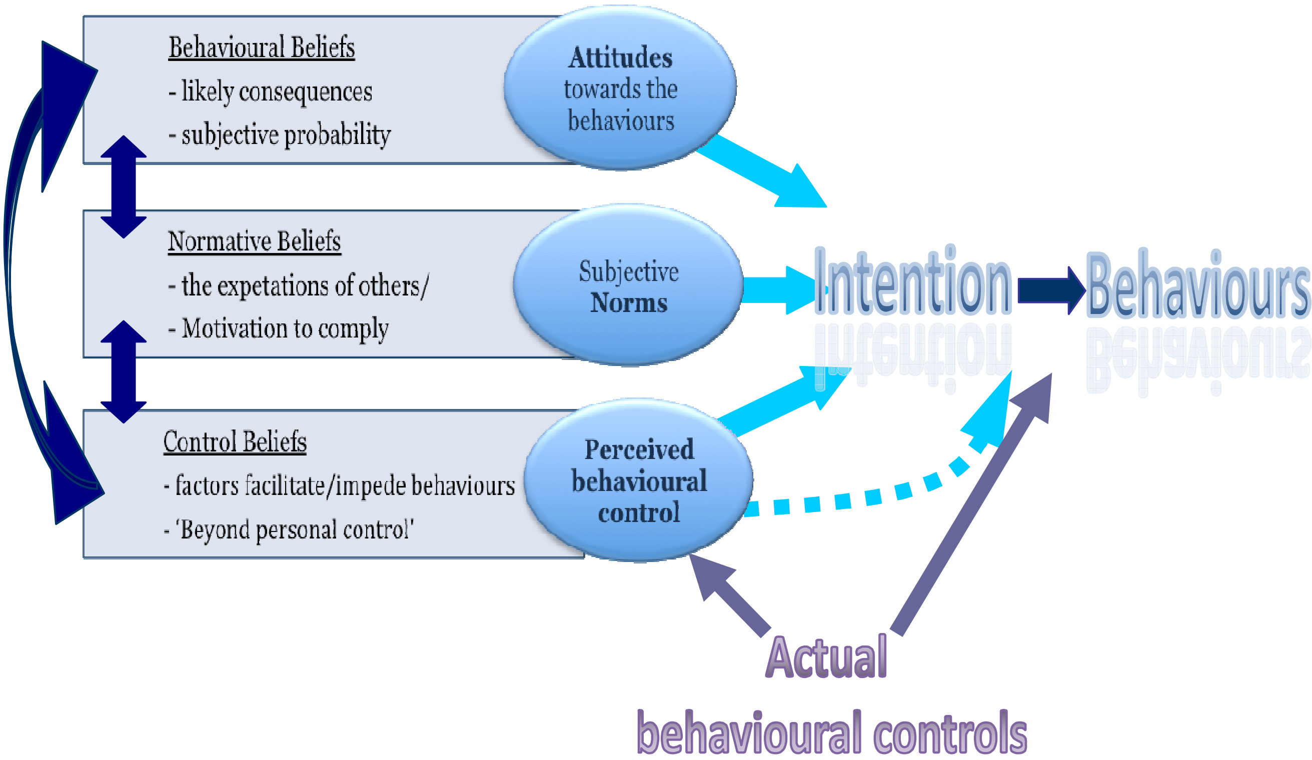
However, there is some limit on this Transtheoretical Model. Major arguments have focused on the status when someone is involved in more than one stage (McConnaughy et al., 1983; Littell & Girvin, 2002). As Littell & Girvin (2002) pointed out, people are observed to be possibly in more than one stage, then the concept of stages loses its meaning. Thus, how to identify the status between stages in the movement needs carefully considered when applying this model. Similar situations exist in this research.

2.2.3.2 Theory of planned behaviour

The Theory of planned behaviour, which was developed from the Theory of reasoned action, comes with the central factor that the individual intends to perform a given behaviour. The idea that behavioural achievement depends jointly on motivation (intention) and ability (behavioural control) is by no means new, but provides potential opportunities in predicting a specific behaviour in a given situation, and improves the fact that aggregation does not explain behavioural variability across different cases (Ajzen, 1991).

In this theory, intentions are assumed to capture the motivational factors that influence a behaviour, indicating how hard people are willing to try, how much of an effort they are planning to exert, in order to perform the behaviour. As a general rule, the stronger the intention to engage in a behaviour, the more likely its performance (Ajzen, 1991).

Figure 2-3 Theory of planned behaviour model



Source: TPB Diagram by Ajzen (2006).

This theory also provides the theoretical basis for a relationship between social norm and user behaviour. Empirical studies have found that social norms positively affect an individual's behaviour (Hsu & Lin, 2008). According to social identity theory, people classify themselves into social categories. Roles and norms are common standards for group members' behaviour. When people participate in a social system, they identify with and assume a role in it, and behave as expected by other members (Ellis & Fisher, 1994).

Referring to the travel behaviour study, measures of past behaviour is typically found to significantly improve the prediction of future behaviour, over and above the effects of intentions and perceptions of behaviour control, while frequency of past behaviour could be used as an independent predictor of future action (Ajzen, 1991; Ajzen, 2006; Bamberg et al., 2003).

Due to the lack of information on perceived behaviour controls in the surveys learnt in this research, the Theory of planned behaviour is suggested for future studies instead. However, information on social norms in this theory is helpful for our research, and will be used for the future discussion.

2.2.3.3 The Diffusion of Innovation model and the 'Tipping point'

The Diffusion of Innovation model, which originated from the theory of process of diffusion by Gabriel Tarde (1903) and was expanded upon by Ryan & Gross (1943), was explained by Rogers (1995) into five stages: Awareness, Interest, Evaluation, Trial and Adoption. In order to explain how a new project is adopted by a population, Rogers (1995) classified individuals into five categories according to their willingness to innovate: Innovators, early adopters, early majority, late majority, and laggards. This model has been widely used to predict the purchase of new products, and helps with the understanding of how programmes influence change and how the changes take place across a community (Ryan & Gross, 1943; Katz, 1999; Smart travel Sutton, 2009; Rogers, 1995). Researchers from varying fields have been interested in applying this model and revealing factors affecting the diffusion process (Coleman el al, 1957; Baldridge & Burnham, 1975; Tornatzky & Klein, 1982; Avollo & Bass, 1995; Agarwal & Prasad, 2007). In general, the studies cover Innovation characteristics, Individual Characteristics, and Social network characteristics. Looking at the impacting factors, we find that information share and distribution are vital for executing this model. As the continuing accurate and well-tailed information may help increase the observability of the results of innovations to potential adopters, and reduce the complexity to enhance understanding. For the programmes aiming to affect travel behaviour change, planning target population groups together with appropriate messages for different points along a spreading timeline, and projecting a feasible approach are essential but not easy.

Gladwell (2002) attempted to use the 'Tipping Point' to give an explanation on how a change is adopted by a community, characteristically as a social epidemic. He suggested that there is a particular moment when the epidemic explodes from affecting a small proportion of the population to almost everyone, known as the 'Tipping Point'.

In the context of travel behaviour change, how to identify a) what residents feel their community can do to influence their behaviour as well as for that change to propagate to the whole community, and b) what factors could impact their choice or give them positive encouragement (for new transport plans) are vital for pre-project planning. Also, how to approach and evaluate the ‘Tipping point’ main application with these models is also of critical importance.

2.3. Travel Demand Management (TDM)

Travel Demand Management (TDM) was introduced by the United States when making the urban transportation planning at federal and regional levels in the 1970s (Meyer, 1999), aiming in encouraging travellers to use alternatives to driving alone, especially at the era with increasingly severe traffic jam in city centres (Abu-Lebdeh & Benekohal, 2003)

According to Victoria Transport Policy Institute (Victoria Transport Policy Institute, 2008), the term TDM is not one action, but rather a set of actions or strategies encompassing both alternative modes to driving alone and the techniques, or strategies that encourage use of these modes. TDM alternatives include familiar travel options such as:

- Carpools and vanpools
- Public and private transit (including buspools and shuttles)
- Bicycling, walking, and other non-motorized travel

TDM alternatives also can include "alternative work hours," program options that reduce the number of days commuters need to travel to the worksite, or that shift commuting travel to non-peak period times of the day. Alternative work hours include:

- Compressed work weeks, in which employees work a full 40-hour work week in fewer than the typical 5 days;
- Flexible work schedules, which allow employees to shift their work start and end times (and thus travel times) to less congested times of the day; and
- Telecommuting, in which employees work one or more days at home or at a "satellite work centre" closer to their homes.

TDM strategies usually include 1) improvements in alternative modes of transportation; 2) financial and/or time incentives for commuters who use alternative modes, such as preferential parking for rideshares, subsidies for transit riders, and transportation allowances; 3) Priority treatment for rideshares, like high occupancy vehicle (HOV) lanes and freeway ramps; 4) Parking management programs; 5) information dissemination and marketing activities that heighten travellers' awareness of and/or interest in alternatives; 6) supporting services that make the use of alternatives more convenient or that remove psychological impediments to use of alternatives.

Particularly, a primary goal of most TDM programs is to reduce commuter trips in a particular area and/or at a particular time of day effective (Comsis Corporation, 1993).

Similarly, special event transport management encourages the use of alternative travel modes to occasional events that draw large crowds and create temporary transportation problems, aiming in reducing traffic and parking problems, ensuring safety and security, and improving transportation options, particularly for non-car users.

According to Victoria Transport Policy Institute (Victoria Transport Policy Institute, 2008), special Event TDM includes many specific and intensive strategies to improve transportation options, manage transportation resources, and communicate with the travelling public, including:

- Smart Growth land-use management, so major activity centres (e.g. fair grounds and sports arena) are located for convenient access to population centres and public transit services;
- Vehicle Restrictions;
- Special Transit, Shuttle and Ridesharing services, with no extra cost to participants or combined with event ticket;
- Pedestrian and Cycling Improvements;
- Taxi Improvements, such as shared taxis;
- Parking Management and Shared Parking;
- Commuter Trip Reduction programs;
- Priority to emergency, service, freight and High Occupancy vehicles in traffic and parking;
- Cross-train staff to perform critical management and repair services.
- Transportation planning that provides appropriate redundancies and efficiencies to accommodate special and unexpected demands.
- Marketing of alternative transportation options.
- Produce a Multi-Modal Access Guide, which concisely describes how to reach an event, highlighting efficient modes such as cycling, ridesharing and transit. This information can be incorporated into event invitations and publicity.

2.4. Conclusion

The purpose of this review is to summarise current knowledge about travel patterns and travel behaviour changes. It is learnt from review that, factors of Time, Cost, Reliability, Convenience, Comfort, and Security are commonly recognized for describing travel patterns, although time and cost are usually dominant factors and easy to quantify. Some other factors' influences are far from being sufficiently observed. In particular, the review suggested that 'communication and culture', as a 'hidden' factor determining travel pattern, needs to be carefully considered in transport planning and approaches.

The review paid particular attention on the previous work on travel behaviour changes, covering the factors that influence individual travel behaviour and the change models for behaviours. As many Olympic host cities such as Beijing received intensive transportation improvement in anticipation of the Games, local residents experienced unprecedented changes in their life. The socio-demographic and psychosocial factors are very important inside the changes of their daily travel patterns. Besides, the knowledge on the behaviour change process showed the importance of the information design and distribution, which to some extent supported the emphasis of the 'communication and culture' factors. In this respect, the 'influencing message' and the 'influencing approaches' come to be interesting for mega events travel behaviour research, including the role of media.

The review in this chapter gives a fundamental knowledge resource for following research and will be transferred into the later analysis and discussion. However, due to the nature of the existing surveys, there is very limited data and information available on the aspects of influencing approaches and perceived behaviour controls. We can only give limited qualitative analysis on certain possible aspects, but we would like to suggest it for future studies and planers.

Chapter 3

TRANSPORTATION FOR MEGA EVENTS

Though there has always been continuing debate and controversy, hallmark events and mega events, such as the Olympics, the EXPO, mega exhibitions and so on are considered catalysis for cities' regeneration. The Olympic Games, regarded as the world's most prestigious sporting event, with the ability of attracting national and international attention, have been increasingly used as a trigger for a wide range of urban developments, economic growth, transportation and cultural facilities improvements, and global recognition and prestige. It brings not only short-term international participation and attention, but also long-term consequences for the host city (Chalkley & Essex, 1998; Hall, 1987; Ritchie & Smith, 1991; Roche, 2000; Syme et al., 1989).

At a more tangible and down-to-earth level in transportation, the Olympics stimulate intensive investment and construction of supporting transportation infrastructure, such as roads connecting the event venues, public transport systems, accessible facilities, etc., in order to cope with increasing travel demands and special events needs. As congestion and other transport issues are becoming more and more common in major metropolises, the preparation of transportation is one of the most crucial components of event staging.

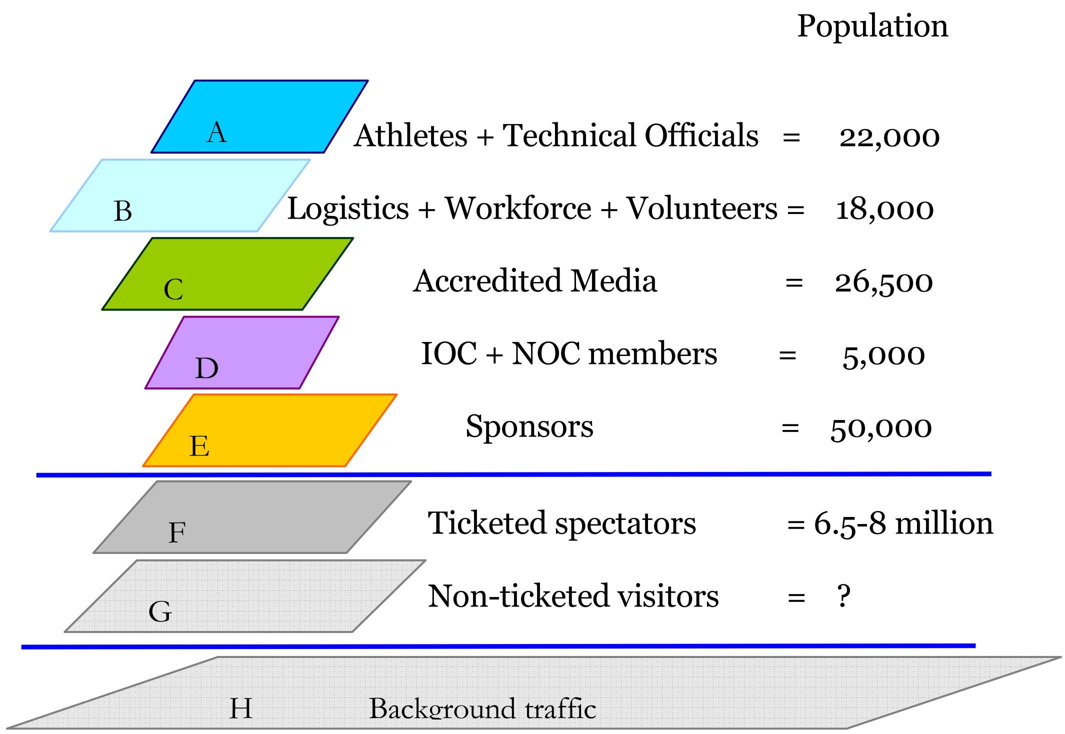
This chapter examines the history of the Olympics from 1896 to 2008 along with other relevant resources for mega events, to understand the short-term and lasting transport impacts of mega events to host cities and to examine what measures have been taken to deal with the impacts and their outcomes. This study will be of paramount importance for understanding and analyzing the behaviours and relative changes in such circumstance, as well as succeeding in future planning and games-time operation. TDM measures applied in mega events and their consequent results have been given specific focus, as they contribute to not only improvements in Games time traffic conditions, but also potential benefit in longer-term scope for the city transport structure. On the other hand, it is very important for future studies to focus on the cost-effective services delivery and lasting benefits for both the event and host cities. This is particularly crucial in light of the present economic recession.

3.1. Transport demands of the Olympics

3.1.1. Who are they

Since the revival of the Olympics at the end of the nineteenth century, the Games have emerged as the world's greatest sporting event, growing from a total of 311 athletes from 13 countries in the first modern Games held in Athens in 1896 (230 of the athletes were Greek) to the Beijing 2008 Olympics with more than 18,000 athletes from 202 countries, 4,000 technical officials, 5,000 Olympic family members, and 26,5000 accredited media. Its scale and significance creates major challenges and opportunities for the organization and infrastructure of the host cities (Official Report of the Games of the 1st Olympiad, 1896; Chalkley & Essex, 1999; Yu, 2008).

Figure 3-1 Population and travel demands during Olympic Games



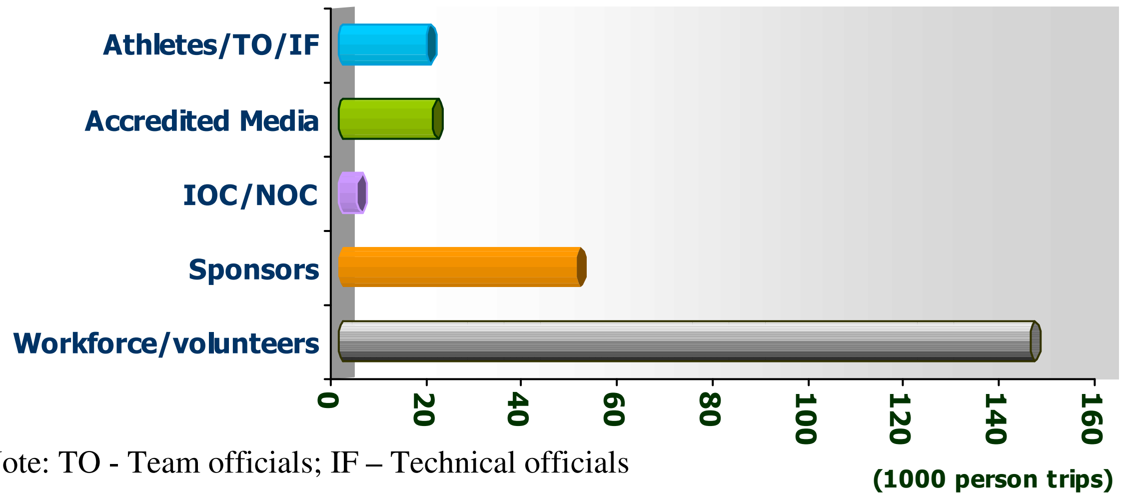
Sources: Bovy (2002a), Yu (2008).

Figure 3-1 shows the population of clients and their estimated travel demands during Olympic Games in the order of service priority according to the IOC. According to their requirement and service levels, travel demands during the Olympic Games could be divided into three categories:

1) Olympic families, including dignitaries, athletes, technical officials, IOC/NOC members, and accredited media, totally up to 70,000, must be provided with dedicated transport services on IOC specific introductions, and the sponsors, workforce and volunteers,

whose numbers vary for different games and whose members are normally entitled to free public transport only during Games time. The average travel demands for the Olympic families are around 240,000 person-trips per day (Bovy, 2002a). In particular, according to International Olympic Committee (2007), the host cities need to include traffic management schemes, such as Olympic lane network, in their host city transport plan to ensure a fast, safe transport for the Olympic families especially for the athletes. The journey time between accommodation and venues for the athletes should not exceed 30 minutes (one way).

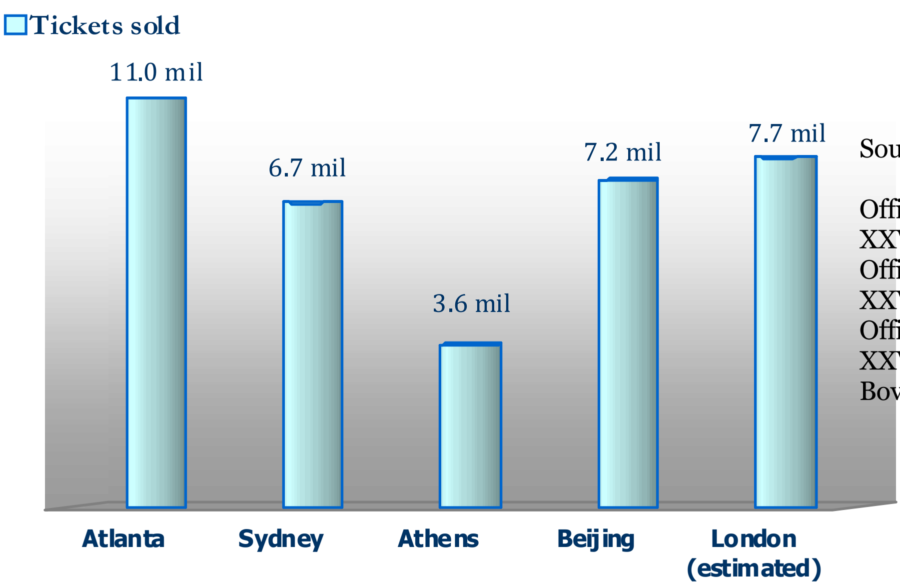
Figure 3-2 Daily travel demands of Games families



Note: TO - Team officials; IF – Technical officials

Source: Bovy (2002a)

Figure 3-3 Population of ticketed spectators



Sources:

Official Report of the Games of the XXVI Olympiad (1996),
Official Report of the Games of the XXVII Olympiad (2000),
Official Report of the Games of the XXVIII Olympiad (2004)
Bovy (2009a), ODA (2007).

2) Ticketed spectators and non-ticketed games-visitors generate the largest demands on the Olympic venue sites, and their demands are concentrated in time and space. According to previous research, there were around 300-600,000 spectators attending the games in addition to 100-250,000 non-ticketed visitors everyday on average, generating over 650,000 trips everyday. This demand has been trending up over the recent few Games. Statistics show that 4.66 million people visited the Sydney Olympic Park while more than 7.2 million ticketed spectators attended the competitions in Beijing, with an additional 1.17 million people visiting the Olympic green without watching events during Games time (Beijing Transportation Research Center, 2008b; Bovy, 2002a, 2007b; Dimitriou et al., 2006; Official Report of the Games of the XXVII Olympiad, 2000).

Table 3-1 Transport demands of the cities

	Atlanta 1996	Sydney 2000	Athens 2004	Beijing 2008	London 2012
Residents	3.4 million	4,067,000	4,500,000	16,330,000	7,512,000 (2006)
Daily trips (normal time)	work-related traffic reduced by 50% in downtown	15.2 million (1998-99)	4,875,000*	34,360,000	27,600,000 (2006)
Daily trips (Games time)			6,825,000	30,900,000	?
Daily passengers by public transport (normal time)	0.48 million (1997)	1.7 million (1998-99)	1,368,420	17,021,800	> 10 million
Daily passengers by public transport (Games time)	1.30 million	2.24 million	2,625,000	17,680,100	?

Note: * Average number of daily trips in Athens was approximately 7,500,000, which decreased by 35% in the summer.

Sources: Amodei et al. (1997), Official Report of the Games of the XXVI Olympiad (1996), Australian Bureau of Statistics (2007), Mclntyre & Lori St John (2002), Official Report of the Games of the XXVII Olympiad (2000), Sydney Statistical Division (1998), Official Report of the Games of the XXVIII Olympiad (2004), Dimitriou et al. (2006), EMTA (2004), Beijing Transportation Research Center (2008a, 2008b), TFL (2007a).

3) Residents, with existing huge background traffic every day, represent the biggest challenge on the transport system for the host cities. As shown in Table 3-1, transport needs from the residents are much greater than from spectators. Residents appeared to have reduced their travel due to higher traffic pressure and proper communication in Beijing. Conversely, numbers in Athens increased significantly during Games time. In the author's view, one reason for that should be because the size of the city was too small to distinguish the declines from the increasing demand of Olympics spectators. However, the base load in Beijing and London are much greater.

3.1.2. What kinds of transport supports are required

Unlike normal transportation services, different categories of passengers attending the games have varying transport needs. Accordingly, requirements for transportation during the Olympic Games could be summarized as below (Bovy, 2009a):

1. Provide reliable, efficient, safe and comfortable transport services to the games families, with the highest priority for the athletes;
2. Manage the concentrated traffic increase for all above groups, especially for the spectators;
3. Keep the city transport system as normal as possible, minimizing the disturbance to the residents and their daily lives;
4. Accessible for disabled passengers, especially for large groups travel in wheelchairs during the Paralympic Games;
5. Adapt to contingencies, program changes;
6. Respect environmental quality as well as sustainable issues, aiming to leave longer lasting legacies for both the games and the host cities.

Transport is always one of the most complicated, critical and sensitive sectors in the hosting of the Olympic Games, regardless of the size and level of development of the host city. It is considered one of the major challenges, especially in those cities with severe existing congestion (*Official Report of the Games of the XXVIII Olympiad-Athens 2004*). In general, transport impacts of the Olympics include short- and long-term impacts.

3.2. Short term transport impacts

As the most famous, popular event in the world, the Olympics brings the host cities enormous immediate impact during Games time, to be discussed in this section:

3.2.1. Increased travel demand

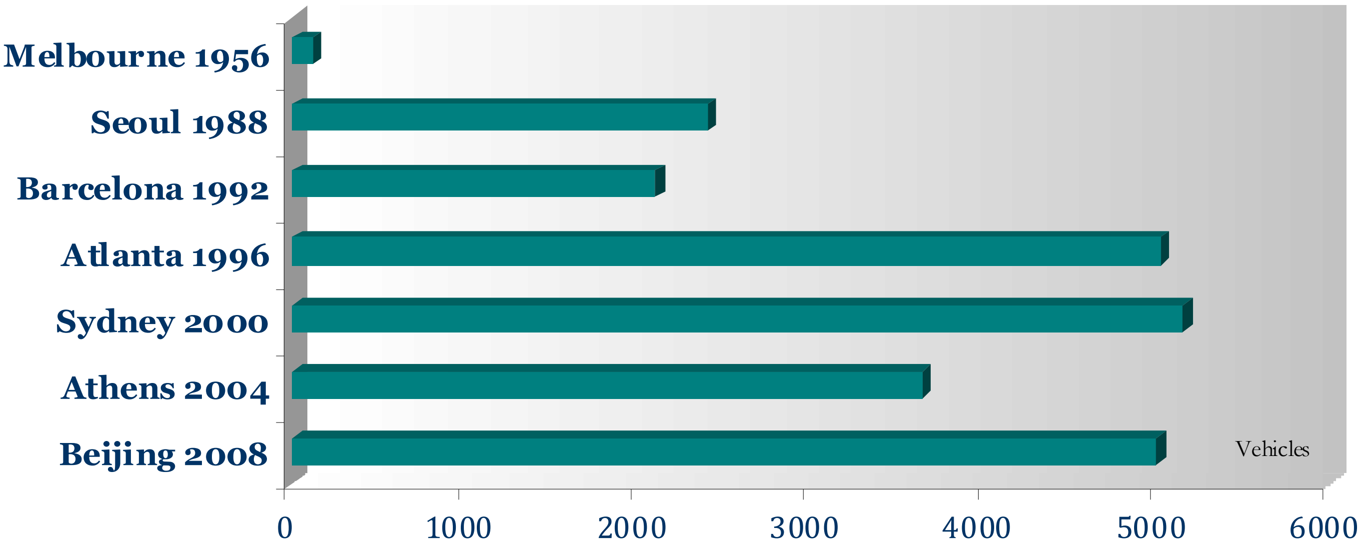
During the Olympics season, hundreds of thousands of athletes, journalists, volunteers and spectators flood to the city and fill every corner inside and outside the venues. A huge burden is brought to the urban transport system. Organizers are charged with providing on-time, safe and comfortable transportation services, especially for athletes and media. Insufficiency and unreliability are the most scary problems for the games, which caused big chaos in Atlanta 1996 during its peak (Bovy, 2007a).

The challenge of increased demand could be primarily described as enormous, concentrated, and mixed with normal traffic of the city.

1) The travel demand during the Olympics are expected to increase enormously.
As discussed in 3.1.1, the Olympics generated traffic is estimated at about 20 millions person trips in 17 days, 1.2 million per day on average. Such a high rate requires large transport supplies as well as facility supports.

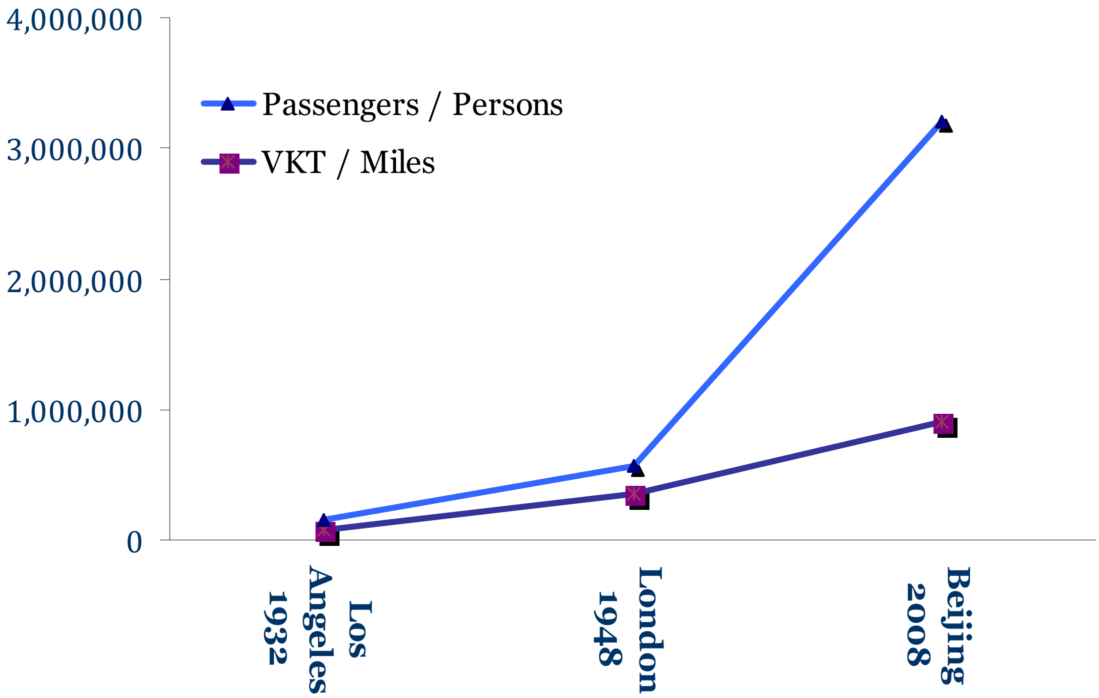
Melbourne 1956 was the first Games that provided a dedicated car fleet for the Olympic families, consisted of 121 donated vehicles from a range of companies. This number grew to approximately 5,025 in Atlanta 1996 and stayed in similar level in Sydney 2000 and Beijing 2008, though Athens 2004 had used less as shown in Figure 3-4.

Figure 3-4 Number of vehicles used for the Olympic families



Sources: Official Report of the Games of the Olympiad (1956, 1988, 1992, 1996, 2000, 2004), Hensher & Brewer (2002), Yu (2008).

Figure 3-5 Travel needs of Olympic families



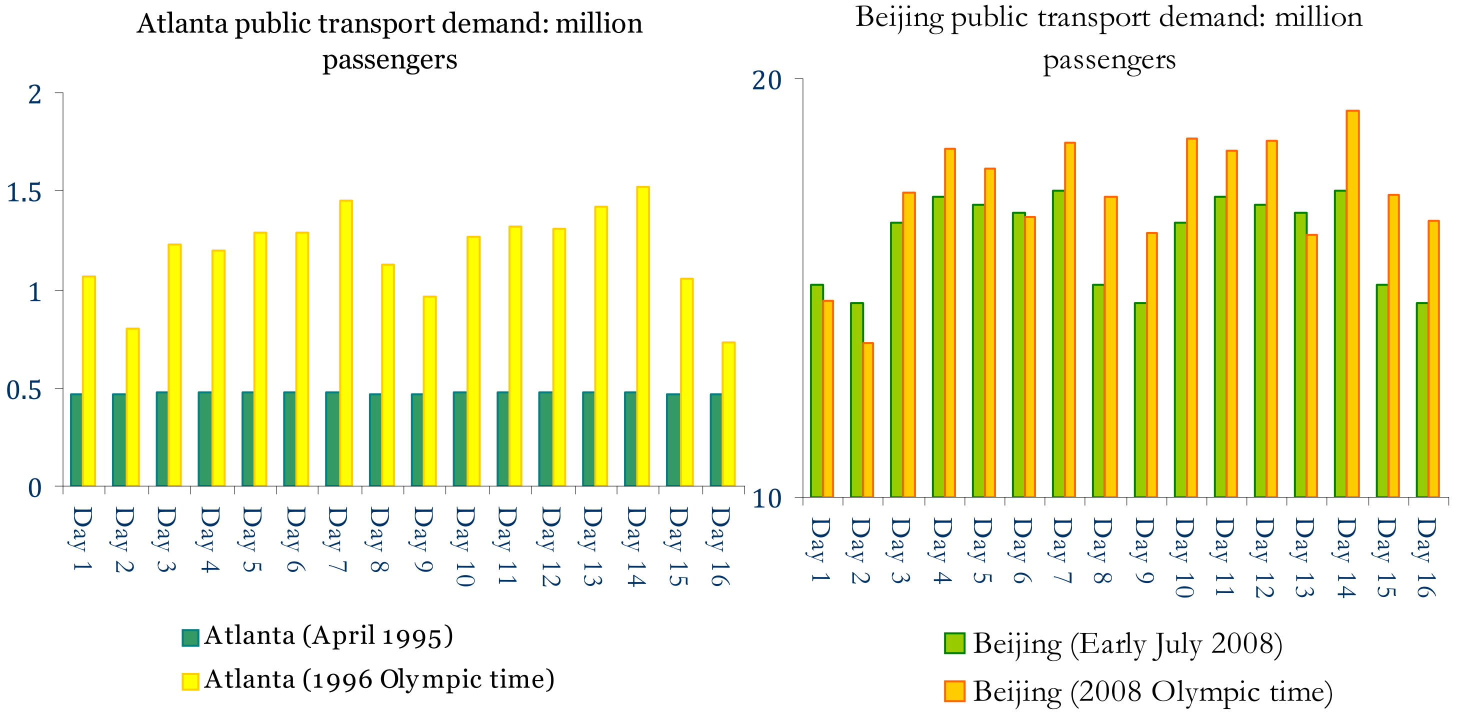
Sources: Official Report of the Games of the XIV Olympiad (1948); Official Report of the Games of the Xth Olympiad (1932), Yu (2008).

As shown in Figure 3-5, the dedicated Olympic transport system operated 83,360 miles, and carried more than 68,000 athletes and officials in Los Angeles 1932, while in Beijing 2008, the organizers provided the games families with the services totalling 14.5 million kilometres and 2.3 million person trips, including more than 570 thousand athletes trips. (Dimitriou et al., 2006; Official Report of the Games of the XV Olympiad-Helsinki 1952; Hensher & Brewer, 2002; Liu et al., 2008; Official Report of the Games of the XIV Olympiad, 1948; Official Report of the Games of the Xth Olympiad, 1932; Mclntyre & Lori St John, 2002; Official Report of the Games of the XVI Olympiad-Melbourne 1956; Official Report of the Games of the XXVII Olympiad-Sydney 2000; Yu, 2008)

Furthermore, areas associated with transporting various user groups, including primarily exterior areas for parking, loading, and queuing to accommodate buses, cars, vans, and any other types of vehicles need to be established (Amodei et al., 1997; Official Report of the Games of the XXVI Olympiad, 1996; Currie, 2008).

In addition, the substantial increase attributed to spectators also pressured public transport greatly. Over two thousand buses were put into the spectator-related services in Athens 2004 and Beijing 2008 respectively. Figure 3-6 shows the increase in public transport patronage from the normal time to Games time, which demonstrates a daliy average growth of 0.72 million during Atlanta 1996 and 1.01 million during Beijing 2008.

Figure 3-6 Pressure on public transport during Olympic time



Sources: Amodei et al. (1997), Beijing Transportation Research Center

With greater demand, and greater variability, the city transport system - especially the public transport system - faces much bigger challenges than the dedicated transport services, in terms of both preparation and operation.

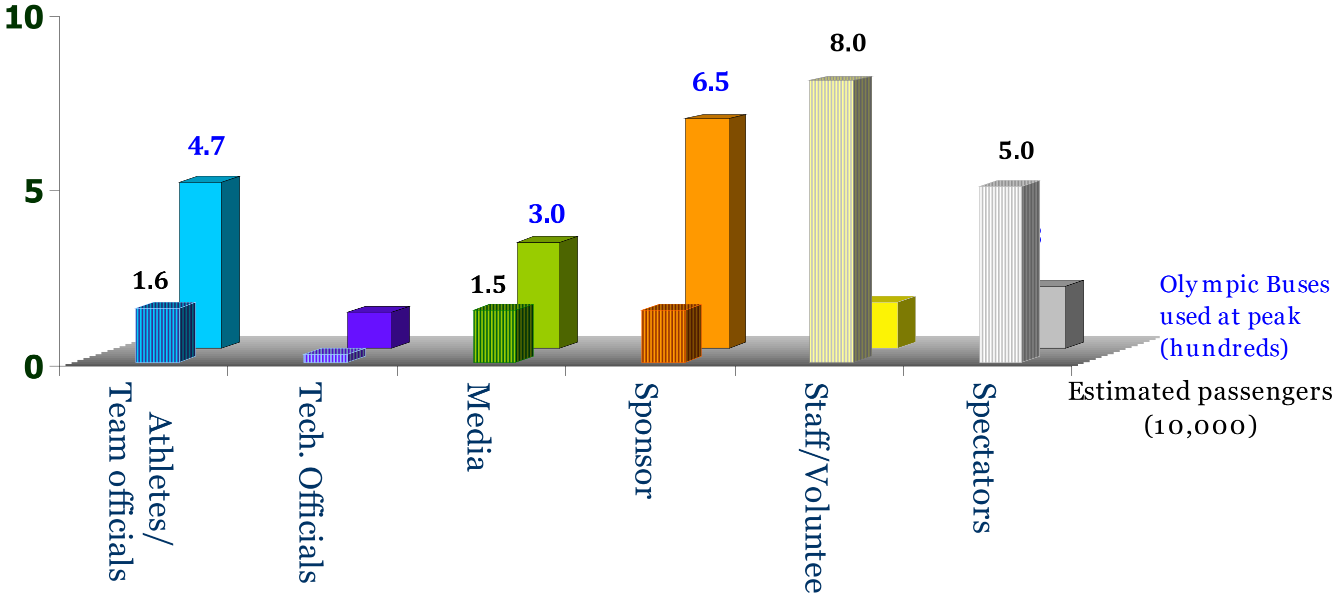
2) The Olympics travel demand is not uniform, with uneven distributions over both geographic and chronological factors.

In recent Olympic Games, more than half of the passengers focused on the Olympic parks, while by contrast, the volume of traffic to the other competition sites was relatively low. As recorded, nearly twenty thousand passengers arrived in the Olympic park station every hour during the Beijing Olympic Games time (Beijing Transportation Research Center, 2008b; Dimitriou et al., 2006; Mclntyre & Lori St John, 2002; Official Report of the Games of the XXth Olympiad, 1972; Yang, 2008).

The rush hours, which were usually related to the tight competition schedules, were found to be during the hour prior to when the competitions started, as well as immediately after they finished. With respect to the day with travel demands, the opening day of athletic and the Closing ceremony days were always the busiest.

On games families' travel demands, services for the Athletes, Technical officials, accredited media and sponsors usually required much more vehicles than others as shown in Figure 3-7, as they usually raised huge demands in very short time together, with different service levels.

Figure 3-7 Travel demands of different client groups in Sydney



Sources: Hensher & Brewer (2002)

On public transport, the concentration has been much more severe but hardly predictable. It was always one of the most challenged and crucial issues for the event organizers as well as the games operators. Take the 1972 Munich and 2000 Sydney Games as examples. One day at Munich, 30,500 passengers left Olympic Park by subway, 13,600 passengers by rapid transit trains, 8,400 by bus and 1,900 by streetcar within one hour between 17:45 and 18:45 P.M, which exceeded the estimated theoretical maximum by more than 12% in the case of the subway, by 17% in the case of the buses, up to 65% in the case of the rapid transit trains and up to 19% in the case of the streetcars. In Sydney, the number of passengers for the Sydney Olympic Park (SOP) was 250,000 every day on average, while on the day the athletics started, the number climbed as high as 400,000 (Mclntyre & Lori St John, 2002; Official Report of the Games of the XXth Olympiad, 1972).

Furthermore, according to studies of Seoul 1988, Atlanta 1996, Sydney 2000, and the data from Beijing 2008, the increase in public transport demsnstrated strong travel mode bias on rail/subway, over buses (Amodei et al., 1997; Beijing Transportation Research Center, 2008b; Official Report of the Games of the XXIV Olympiad, 1988; Official Report of the Games of the XXVII Olympiad, 2000).

2) Huge increasing travel demand added into existing background residents might cause worsening of traffic condition of the host cities.

As people worried Los Angeles 1984 would turn into the largest parking lot in the U.S. with additional 400,000 to 600,000 visitors daily during the Olympic Games, spectators as well as visitors flooded into the city to burden the city transport system, while the peak period of the mega event transport was observed to be much closer to the normal local transport (Beijing Transportation Research Center, 2008b; Bovy, 2009a; 'Eve of a New Olympics', 1983). The substantial increases in the passenger flow of public transport network as well as the traffic volume on the city roadway proved major challenges in the quest to minimize interruptions on citizens' daily lives. During recent games, most host cities attempt to resolve this by applying the demand management measures.

Furthermore, the uncertainties in Olympic travel demand requires an operation compatible with contingencies. Sudden increase in flow, crowd pick up zone, unexpected severe weather and even dangerous cases, which were very hard to predict, were found in previous games. To overcome these requires better understanding of the travellers' needs and likely responses under the game environment, as well as fully-considered and flexible contingency plans.

3.2.2. Event specific needs

The event specific needs on transportation usually include safety, security and accessibility, which required high focus and detailed consideration.

Mega events, especially the Olympics, have been under increasing pressure to ensure safety and security. In addition to all the most outstanding athletes of the present era, nearly one hundred heads of state and government from worldwide made unprecedented challenge to the host cities in securing everyday operations away from the terrorism. Public transport faces such impact as well. The subway has become an important target for terrorist attacks, as demonstrated in a series of international terrorist attacks such as the Tokyo subway gas attack, the explosions in the subways in Paris, Moscow, and London, and the Daegu subway fire in South Korea. The Games in Munich 1972 and Atlanta 1996 were overshadowed by tragedy and all future Games will have to plan and develop facilities with the security of athletes and spectators as a priority (Chalkley & Essex, 1998).

Meanwhile, accessibility is another big issue raised by the Paralympics, which are usually held following the Olympics. The transport facilities, access and egress paths, as well as the vehicles are required to be barrier-free. There were more than 500 passengers travelling by subway with handicapped facilities on average during Beijing Paralympic games day. However, large groups travelling with wheelchairs exert additional pressure on transportation services. As recorded, more than 2,000 athletes and officials using wheelchairs attended the opening ceremony of the Paralympics, using the transit from their accommodation to the stadium in a very short duration. Meanwhile, athletes with other disabilities including the blind and deaf need to be looked after and receive better consideration in all transit planning. (Beijing Transportation Research Center, 2008b; Yang, 2008)

3.2.3. Significant time pressure

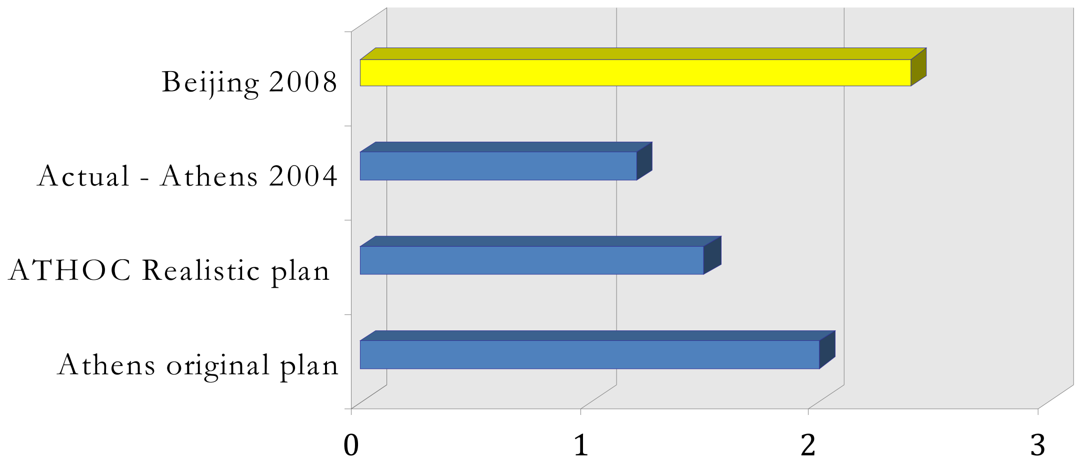
Large-scale transport supporting facilities must to be delivered on time. As will be introduced in the following section, the host cities usually carry out large-scale transport facilities construction and development. Any late delivery of infrastructure lead to knock-on effects and challenges to deliver Games operations.

However, the games-related projects were normally delivered 3 to 12 months prior to the games or even later, the huge number of new transport facilities coming into operation over a short period impacts the adaption, integration and communication with passengers, which also cause difficulties in demand analysis prior to the games. For instance, the subway Line 10, the Olympic extension line and the Airport express opened for trial operation only 18 days ahead of the opening ceremony of the Beijing 2008 Olympics, with very limited time for testing and educating passengers to avoid the risks in games-time operation which might be caused by the unfamiliarity of the passengers or even staff (Yang, 2008). On the other hand, the lack of previous information with the new constructions always caused difficulties in demand analysis (Amodei et al., 1997; Bovy, 2009a; Official Report of the Games of the XVI Olympiad, 1956).

3.2.4. Workforce and technological impacts

As discussed above, the magnitude of transportation operation created anxiety for the organizers, especially when the games services interfere with normal city operation (Official Report of the Games of the XXVIII Olympiad, 2004; Official Report of the Games of the XXVI Olympiad, 1996; Official Report of the Games of the XXV Olympiad, 1992; Official Report of the Games of the XXVII Olympiad, 2000). To ensure the smooth operation of city transport system as well as the games-related services usually require great support from infrastructure facilities workforce, particularly the drivers. There were over 8,000 drivers and dispatchers serving the Beijing Olympic Games. There were on average 2.4 drivers allocated for one bus for each 24 hours of operation during Games time. However, this rate reduced from 2 to 1.5 in planning, but turned out to be 1.2 finally, because of the lack in driver resource. The shortage of well-trained personnel, especially the continuous lots of drivers in both Sydney and Athens caused significant risk in operations (International Olympic Committee, 2001; Kerr & Smith, 2004; Liu, 2008; Official Report of the Games of the XXVII Olympiad, 2000).

Figure 3-8 Targets of driver ratio



Sources: Official Report of the Games of the Olympiad (1956, 1988, 1992, 1996, 2000, 2004), Hensher & Brewer) 2002, Yu (2008).

Also, the large amount of technical equipment, which are required in short period for supporting the command, communication, and information distribution, require a comprehensive plan for gathering and distributing resources correctly and efficiently. How to deal with those after games time were also a headache for some organizers. At the same time, relevant training and adequate testing for ensuring successful deployment and integration of such technical system with a huge number of participants covering the whole games area or even the city also require careful advanced consideration.

3.2.5. High-level information & communication requirements

Clear, reliable, and integrated communication channels providing correct and timely information on Games-time transportation and traffic adjustments and their impact on the local area for each client group are crucial to the success of the whole venture (Amodei et al., 1997; Official Report of the Games of the XXVIII Olympiad, 2004; Official Report of the Games of the XXVI Olympiad, 1996; Liu, 2008; Official Report of the Games of the XXVII Olympiad, 2000; Official Report of the Games of the XVIII Olympiad, 1964), because:

- The services cover large population with different requirements at scattered event sites;
- Information is provided to different agencies on various services;
- There are sorts of 'unexpected cases' expected in different areas, effects and influence of which are hard to estimate.
- Many different authorities, contractors and organizations work together to support the event operation, requiring a highly integrated information exchange system.
- Timely and accurate information is vital for minimizing the negative impacts of the events on the residents' daily life and encouraging the use of public transport.

3.2.6. Integrated coordination & cooperation platform

It has been recognized that the success of Olympic and Paralympic transport planning and operations was primarily built on the cooperative and robust relationships established between the relevant Olympic and transport authorities, agencies, contractors and other participant at different levels. The importance of interagency coordination and cooperation have been mentioned in the planning and operating for most previous Olympics such as Barcelona 1992, Sydney 2000, Athens 2004 as well as Beijing 2008, while Atlanta had suffered particular criticism for its lack of control over spectator transport and poor traffic management procedures (Official Report of the Games of the XXVIII Olympiad, 2004; Brunet, 1995; Mclntyre & Lori St John, 2002; Official Report of the Games of the XXVII Olympiad, 2000). An efficient and effective working relationship will have great positive impact on the Games' operation. However, time for building up the cooperating platform is always crucial for the host organizers.

On the other hand, the interagency coordination is a prerequisite for most information systems especially the ITS deployments that cross institutional boundaries (Amodei et al., 1997).

3.2.7. Others short-term impacts

Besides the above, there are also other impacts concerning transportation, such as economic ones, including budget, labour market, public funds, and sponsorship, which might influence the construction progress of transport facilities or other preparation (Baade & Matheson; Bovy, 2007a; Bovy, 2009a; Brunet, 1995; Chalkley & Essex, 1999; InterVISTAS Consulting Inc., 2002).

As mentioned by the IOC transport advisor (Bovy, 2002a, 2007a), high exposure to media and continuous client criticisms also made organizers nervous and harassed.

3.3. TDM measures and results

Though building transportation infrastructure has been adopted commonly to overcome the expected increasing travel demands during the mega events, Travel Demand Management (TDM), brought up as early as the 1st Olympic Games of 1896 in Athens and popularized somewhat during 1932 Los Angeles Olympics, has taken on a larger role in recent Olympic transportation organization in both literal and practical scopes. as early as the (Official Report of the Games of the 1st Olympiad, 1896). On one hand, the impact on traffic caused by event lasts for a short time, therefore, the traffic problems caused by events may be solved by proper TDM measures rather than the increase of road capacity (Dorsey, 2005). On the other hand, due to the limited space and the development of urban transportation, 'soft' ways towards reducing the traffic volume and providing a wide variety of mobility options instead are seemed to be more favourable to both residents and visitors.

Looking at previous games, TDM measures for the Olympic Games could be summarized into five categories generally:

- Smart land-use
- Vehicle restrictions
- Traffic control
- Travel space creation
- Improve alternative travel options

3.3.1. Smart land-use

Figure 3-9 Olympic transport of Atlanta 1996

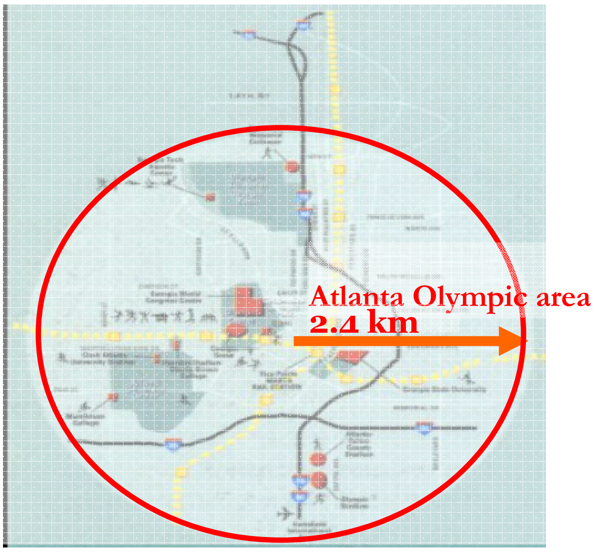
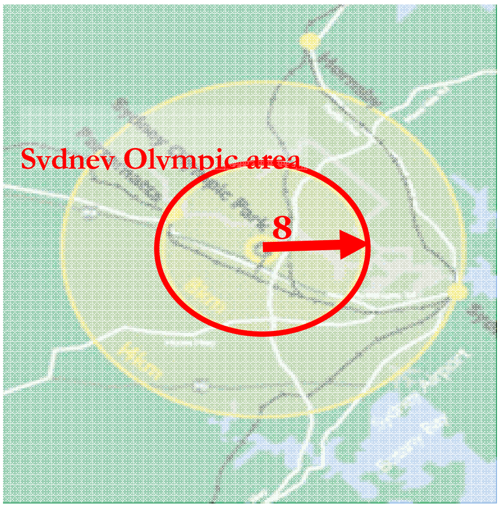


Figure 3-10 Oympic transport of Sydney



Source:
Official report of the Games of the XXVI Olympiad (1996)

Source: www.sydneyolympicpark.com.au/

Figure 3-11 Olympic transport of Athens 2004

Figure 3-12 Olympic transport of Beijing

Source: Media Transport Guide (2004)

Source: Media Transport Guide (2008)

As a basic concept of reducing travel demand, an 'Olympic ring' was usually set up including most competition venues and event sites in recent past games as shown in Figure 3-9, 10, 11 and 12. The concentrated event sites normally facilitated convenient public transport access. In Atlanta 1996, locating the major competition venues as well as the Olympic Village and the Centennial Olympic Park within the 2.4-km radius 'Olympic Ring' around downtown, which was quite different from the Los Angeles Games, was considered as a most significant aspect of that Olympic (Amodei et al., 1997; Official Report of the Games of the XXVI Olympiad, 1996).

Similarly, Sydney grouped all venues into five precincts and built the largest concentration of venues in Olympic history at Sydney Olympic Park, in which people could walk between venues easily (Official Report of the Games of the XXVII Olympiad, 2000).

3.3.2. Vehicle restriction

Opposite to the 'hard' measures in land use, vehicle restriction has been widely taken as a 'semi-soft' measures for controlling the vehicle usage and relieving the congestion in previous games, which appeared in the forms of banning certain vehicles such as non-environment friendly vehicles, shutting down government vehicles, and the odd-even alternate day-off schemes, which has been observed to be the most effective but also impactful measures used for the previous games, resulted in a significant decline in traffic volume during Seoul 1988, Athens 2004 and Beijing 2008. Furthermore, in Beijing 2008, two other schemes were taken for reducing vehicle volume on the road, one was sealing up to 70% government vehicles, and the other one banned the yellow-labelled vehicles, which couldn't meet the emission standard. All these have contributed to the substantial decrease of vehicle usage, which ensured smooth traffic network as well as good air quality for the host cities (Official reports of 1980-2004; Beijing Transportation Research Center, 2008b).

Table 3-2 Vehicle restriction measures taken in previous Olympic Games

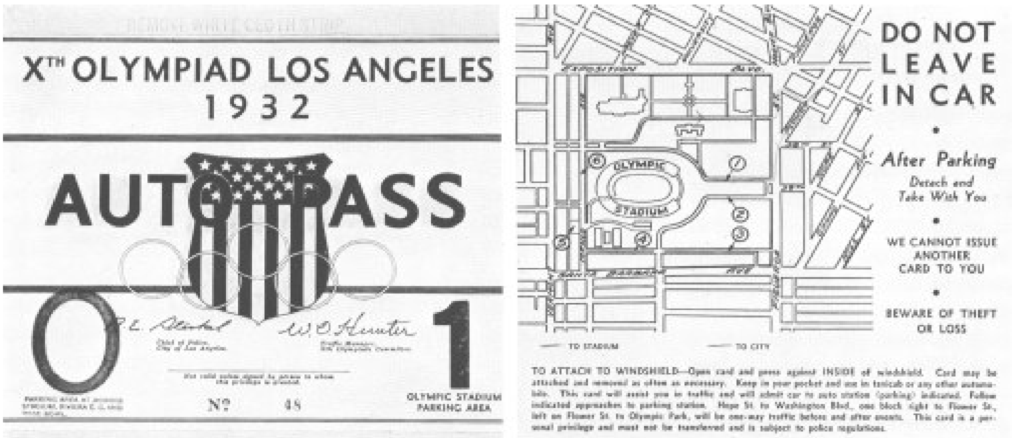
	Beijing 2008	Athens 2004	Sydney 2000	Atlanta 1996	Barcelona 1992	Seoul 1988	Los Angeles 1984
Odd-even alternate day-off	✓	**	Nil	Nil	Nil	✓	Nil
Others (incl. government vehs, yellow-labelled)	✓	N/A		N/A	N/A	N/A	N/A
Decrease in traffic flow / volume [1]	22.5-32.6%	30%	20%	20-25%	15-20%	N/A	Yes
Increase in traffic speed	23-27% (am peak*)	100% (PT)	N/A	N/A	N/A	63.4%	N/A

Note: It is possible some measures taken in some games but not reported.
1 traffic flows calculated for the main streets/roads in city areas.
* am peak: normally during 07:00-08:00; ** - implemented partially. PT: public transport
Sources: Official Reports of the Games of Moscow 1980, Los Angeles 1984, Seoul 1988, Barcelona 1992, Atlanta 1996, Sydney 2000, Athens 2004; Olympic Transport Performance Report (2008b).

3.3.3. Traffic control

Figure 3-13 Facsimile of official auto pass (Los Angeles 1932)

Face side Reverse side



Source: Official Report of the Games of the Xth Olympiad (1932)

Table 3-3 Traffic controls in previous Olympic Games

	Beijing 2008	Athens 2004	Sydney 2000	Atlanta 1996	Barcelona 1992	Seoul 1988	Moscow 1980	Tokyo 1964
Temporary road closure	✓	✓	✓	✓	✓	✓	N/A	✓
Dedicated lanes/ORN	✓	✓	✓	*	*	Nil	Nil	Nil
Parking restriction (event sites)	✓	✓	✓	✓	✓	N/A	✓	✓

Note: It is possible some measures taken in some games but not reported.
* - implemented partially.
Sources: Official Reports of the Games of Tokyo 1964, Moscow 1980, Seoul 1988, Barcelona 1992, Atlanta 1996, Sydney 2000, Athens 2004; Olympic Transport Performance Report (2008b), Amodei et al. (1997).

Traffic control, as the most traditional way of dealing with temporary traffic demands and impacts, dates back to the first games in 1896 (Official Report of the Games of the 1st Olympiad, 1896). It usually included temporary road closure, ramp metering, parking restriction and management, setting up special bans on existing road system such as one-way system, and establishing event special lanes for dedicated use. These measures usually had mixed effects on the system, as the total traffic that must be accommodated is the same. An exception is signal optimization, which augments the capacity of the entire system (Official Report of the Games of the XXVIII Olympiad, 2004; Official Report of the Games of the XXVI Olympiad, 1996; Official Report of the Games of the XXIV Olympiad, 1988;

Official Report of the Games of the XXVII Olympiad, 2000; Official Report of the Games of the XVIII Olympiad, 1964).

3.3.4. Travel space creation

Comparing the above, travel space creation is a among the 'softer' TDM measures in the Olympic practices. It provides appropriate redundancies and efficiencies to accommodate special and unexpected demands by encouraging residents to reduce travel demands, take vacation, as well as adjusting freight deliveries and staggering business hours (Amodei et al., 1997; Official Report of the Games of the XXVI Olympiad, 1996; Official Report of the Games of the XXIV Olympiad, 1988; Official Report of the Games of the XXVII Olympiad, 2000).

Table 3-4 Measures for travel space creation in previous Olympic Games

	Beijing 2008	Athens 2004	Sydney 2000	Atlanta 1996	Barcelona 1992	Seoul 1988	Los Angeles 1984	Tokyo 1964
Encourage holiday	✓	✓	✓	✓	✓	✓	✓	N/A
Alter work /school hours or locations	✓	✓	✓	✓	✓	✓	✓	N/A
Stagger business hours	✓	N/A	✓	✓	N/A	✓	✓	N/A
Rerouting commuter traffic	N/A	N/A	✓	N/A	✓	N/A	✓	✓
Reschedule freight/truck delivery	✓	✓	✓	✓	✓	N/A	✓	N/A

Note: It is possible some measures taken in some games but not reported.
Sources: Official Reports of the Games of Tokyo 1964, Los Angeles 1984, Seoul 1988, Barcelona 1992, Atlanta 1996, Sydney 2000, Athens 2004; Olympic Transport Performance Report (2008b), Amodei et al. (1997), Liu, Guo & Sun (2008).

As a very important part of daily travel, reducing commuter trips and spreading peak demand have been treated particularly in TDM program of several games. Practices include encouraging vacation and flexible work patterns, altering work hours to avoid peak hour travels, staggering business operation hours, and rerouting commuter traffic. (Amodei et al., 1997; Official Report of the Games of the XXVI Olympiad, 1996; Official Report of the Games of the XXIV Olympiad, 1988; Official Report of the Games of the XXVII Olympiad, 2000).

3.3.5. Improve alternative travel options

As early as in the 1964 Tokyo and 1972 Munich games, improving alternative travel options in order to reduce dependence on car driving and to an extent public transportation has been the core concept and widest adopted approaching of TDM for the special events. Examples include providing friendly walking or cycling environments at event sites, enhancing the accessibility and service level of public transport, integrating multi-model travels as well as park & ride, and promoting car-pool or car sharing (Dimitriou et al., 2006; Official Report of the Games of the XXIInd Olympiad, 1984; Official Report of the Games of the XXII Olympiad, 1980; Official Report of the Games of the XXth Olympiad, 1972; Official Report of the Games of the XXIV Olympiad, 1988; Official Report of the Games of the XXVII Olympiad, 2000; Official Report of the Games of the XVIII Olympiad, 1964).

Table 3-5 Alternative option enhancements for the Olympics

	Beijing 2008	Athens 2004	Sydney 2000	Atlanta 1996	Barcelona 1992	Seoul 1988	Los Angeles 1984	Moscow 1980	München 1972	Tokyo 1964
Encourage alternative travel modes and reducing private car usage	✓	✓	✓	✓	✓	✓	✓	N/A	✓	✓
Encourage car pool or car share	✓	N/A	✓	✓	N/A	✓	N/A	N/A	N/A	N/A
Improve public transport services	✓	✓	✓	✓	✓	✓	✓	N/A	✓	N/A
Increase the capacity	✓	✓	✓	✓	✓	✓	✓	N/A	✓	N/A
Integrate multi modal travels	✓	✓	✓	N/A	✓	N/A	N/A	N/A	N/A	N/A
Improve Taxi services	✓	✓	N/A	✓	N/A	✓	N/A	N/A	N/A	N/A
Park & ride	✓	✓	✓	✓	✓	N/A	✓	N/A	✓	✓
Designed bus lines for the events	✓	✓	✓	✓	✓	N/A	✓	N/A	✓	✓
Shuttle between PT and venues	✓	N/A	✓	N/A	N/A	N/A	✓	N/A	N/A	N/A
Free ride for staff, volunteers & spectators	✓	✓	✓	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Improve pedestrian facilities	✓	✓	✓	✓	✓	N/A	N/A	N/A	N/A	N/A

Note: It is possible some measures taken in some games but not reported.
Sources: Official Reports of the Games of Tokyo 1964, Los Angeles 1984, Seoul 1988, Barcelona 1992, Atlanta 1996, Sydney 2000, Athens 2004; Olympic Transport Performance Report (2008b), Amodei et al. (1997); Liu, Guo & Sun (2008).

Particularly on the event-generated travel, 1) free ride on public transport or combined ticket, as well as 2) dedicated transit services have been usually designed for spectators and visitors to the event sites. Besides the Olympic Games mentioned in Table 3-5, the FIFA World Cup also introduced combined ticket (known as 'KombiTicket') since 2006, to encourage public transport for spectators, which resulted in the share of environmentally favourable means of transport reaching 74% to the matches and up to 90% to open-air, public-viewing events (FIFA World Cup Germany 2006, 2006; Theissen, 2008). The special transit designed for event sites has been adopted in most recent past for the Olympic Games is shown in Table 3-5.

3.3.6. Information and Communication

Information provision and communication are vital for the implementation of TDM measures and would influence the performance effectively. Precise and timely information will give travellers confidence on alternatives and encourage residents to travel smarter. Travel guides, venue maps and sign boards were the most used channels for providing information and encouraging people to take the preferred transport modes. Especially, since Atlanta 1996, ITS also played more and more important roles in this real-time communication and guidance. (Amodei et al., 1997; Victoria Transport Policy Institute, 2008)

Evidence showed that the marketing of public transport services to major events was beginning to change the public's perceptions of the use of public transport for a wider range of activities (Battellino & Raimond, 2000). As shown in Table 3-6, Barcelona 1992, Atlanta 1996, Sydney 2000, Athens 2004 as well as Beijing 2008, all placed much focus on marketing sustainable transportation with big organizations, agencies, companies or groups of travellers, aiming to influence behaviour changes. The amount of work-related traffic in downtown Atlanta was reduced by 50 percent on many days during the Games period after more than 4,000 companies were contacted and more than 1,000 presentations were given prior to the 1996 game, while nearly one million people altered their commuting time during the Beijing 2008 games (Amodei et al., 1997; Official Report of the Games of the XXVIII Olympiad, 2004; Official Report of the Games of the XXVI Olympiad, 1996; Beijing Transportation Research Center, 2008b; Official Report of the Games of the XXV Olympiad, 1992; Official Report of the Games of the XXVII Olympiad, 2000).

Besides, Sydney and Beijing using test events to educate residents for altering transport habits to fit the event environment as well as to visit event sites has been demonstrated as a success and provided potential opportunities in longer term benefits on the city transport structure.

Table 3-6 Information & Communication for the Olympics

	Beijing 2008	Athens 2004	Sydney 2000	Atlanta 1996	Barcelona 1992	Seoul 1988	Los Angeles 1984	Moscow 1980
Travel guides for spectators	✓	N/A	✓	N/A	N/A	N/A	N/A	N/A
Travel guides for residents	✓	N/A	✓	N/A	N/A	N/A	N/A	N/A
Real-time information signings	✓	✓	✓	✓	✓	N/A	N/A	N/A
Discourage the residents to travel and congestion warning	✓	✓	✓	✓	N/A	N/A	✓	N/A
Use test events to educate residents	✓	✓	✓	N/A	N/A	N/A	N/A	N/A
Communicate/marketing with large ORGs.	N/A	✓	✓	✓	✓	N/A	✓	N/A

Note: It is possible some measures taken in some games but not reported.
Sources: Official Reports of the Games of Moscow 1980, Los Angeles 1984, Seoul 1988, Barcelona 1992, Atlanta 1996, Sydney 2000, Athens 2004; Olympic Transport Performance Report (2008b), Amodei et al. (1997); Liu, Guo & Sun (2008).

3.3.7. Summary

Table 3-7 summarized the TDM implementation and the transport performance for recent Olympic Games since 1980, showing that the TDM measures have been widely adopted in Olympic Games organizing, greatly emphasized especially since Atlanta 1996. However, the implementation scale varies. It is known from relevant reports that Atlanta focused more on the application of advanced ITS technologies, and Sydney paid a lot of attention to communication and travel behaviour education through an assortment of test events and other large culture events, while Beijing put more emphasis on reducing the background travel demands and cutting down the number of vehicles to make space for supporting the games operation.

In common, putting on TDM measures, which are thought to be an even better way than the increase of road capacity for relieving transport impacts, exerts influence on individual travel behaviours, changes the travellers' travel modes and time-space distribution characteristics, while as time goes by, they will potentially change the city traffic structure gradually with continuous efforts, bringing lasting benefits for the city transport structure.

It could be also noted from the comparison in Table 3-7 that, rail/subway faced much greater challenge than other public transport modes such as buses during Games time. For instance, the increase in patronage of subway was 45.5% and 3% on bus in Beijing, while there were 80% on subway and 37% on bus in Sydney, 316% on subway and 37% on bus in Atlanta.

We also note in Table 3-7 that, the changes in traffic were more noticeable during the Athens 2004 Games than the others. The traffic volume in Athens decreased more significantly, while the travel speed was doubled. It is because the information of changes in travel speed was limited to road-based public transport within the Athens urban zone only, while the information for other cities covered overall travel modes on the ground (Official Report of the Games of the XXIV Olympiad, 1988; Official Report of the Games of the XXVIII Olympiad, 2004; Beijing Transportation Research Center, 2008b). Furthermore, it is found that there is usually a seasonal decrease in travel demand in Athens during the summer which is hardly noticeable in Beijing (Anastasaki et al., 2001). This could be another reason for the significant decrease on urban roads in Athens. By comparing the increase in public transport ridership, we find the increase in Athens was even smaller than in other cities, which can be also due to their difference in the seasonal decrease of travel demand.

As noted in Table 3-7, comparisons of the available information of operational zones, time periods during the day, and travel modes were not consistent between cities, which makes it very difficult to compare the TDM measures and their performance for different Games. A consistent system must be set up for planning, recording, evaluating and transferring of results, which is crucial for improving the events' preparation and relevant research.

Table 3-7 TDM measures and performance during Olympic Games

	Beijing 2008	Athens 2004	Sydney 2000	Atlanta 1996	Barcelona 1992	Seoul 1988	Los Angeles 1984	Moscow 1980
Transport / traffic measures								
Vehicle reduction								
Odd-even alternate day-off	✓	*	Nil	Nil	Nil	✓	Nil	Nil
Others (incl. government vehs, yellow-labelled)	✓	N/A		N/A	N/A	N/A	N/A	N/A
Traffic control								
Temporary road closure	✓	✓	✓	✓	✓	✓	N/A	N/A
Dedicated lanes/ORN	✓	✓	✓	*	*	Nil	Nil	Nil
Parking restriction (event sites)	✓	✓	✓	✓	N/A	N/A	N/A	✓
Travel capacity creation								
Encourage holiday	✓	✓	✓	✓	✓	✓	✓	N/A
Alter work /school hours or locations	✓	✓	✓	✓	✓	✓	✓	N/A
Stagger business hours	✓	N/A	✓	✓	N/A	✓	✓	N/A
Rerouting commuter traffic	N/A	N/A	✓	N/A	✓	N/A	✓	N/A
Reschedule freight/truck delivery	✓	✓	✓	✓	✓	N/A	✓	N/A
Demand dispersing around the city	✓	N/A	✓	N/A	N/A	N/A	N/A	N/A
Reduce other large-scale events	✓	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Public transport enhancement								
Encourage alternative travel modes and reducing private car usage	✓	✓	✓	✓	✓	✓	✓	N/A
Encourage car pool or car share	✓	N/A	✓	✓	N/A	✓	N/A	N/A
Improve public transport services	✓	✓	✓	✓	✓	✓	✓	N/A
Increase the capacity	✓	✓	✓	✓	✓	✓	✓	N/A
Integrate multi modal travels	✓	✓	✓	N/A	✓	N/A	N/A	N/A
Improve Taxi services	✓	✓	N/A	✓	N/A	✓	N/A	N/A
Park & ride	✓	✓	✓	✓	✓	N/A	✓	N/A
Designed bus lines for the events	✓	✓	✓	✓	✓	N/A	✓	N/A
Shuttle between PT and venues	✓	✓	✓	N/A	N/A	N/A	✓	N/A
Free ride for staff, volunteers & spectators	✓	✓	✓	N/A	N/A	N/A	N/A	N/A
Improve pedestrian facilities	✓	✓	✓	✓	✓	N/A	N/A	N/A
Information / Communication								
Travel guides for spectators	✓	✓	✓	N/A	N/A	N/A	N/A	N/A
Travel guides for residents	✓	✓	✓	N/A	N/A	N/A	N/A	N/A
Real-time information signings	✓	✓	✓	✓	✓	N/A	N/A	N/A
Discourage the residents to travel and congestion warning	✓	✓	✓	✓	N/A	N/A	✓	N/A
Use test events to educate residents	✓	✓	✓	N/A	N/A	N/A	N/A	N/A
Communicate/marketing with large ORGs.	✓	✓	✓	✓	✓	N/A	✓	N/A
Transport performances								
Decrease in traffic flow / volume [1]	22.5-32.6%	30%	20%	20-25%	15-20%	N/A	Yes	N/A
Increase in traffic speed	23-27% (am peak)	100% (PT)	N/A	N/A	N/A	63.4%	N/A	N/A
Increase in rail/subway ridership	45.5%	40%	80%*	316%	53%	N/A	N/A	N/A
Increase in public buses ridership	3%		37%+	37%	56%	N/A	N/A	N/A
Travel to venues by public transport	65%+	74%	N/A	N/A	N/A	N/A	N/A	N/A

Note: It is possible some measures taken in some games but not reported.
1 traffic flows calculated for the main streets/roads in city areas.

*- implemented partially; ** - estimated/supposed; N/A: information unavailable.
PT: public transport

Sources: Official Reports of the Games of Moscow 1980 , Los Angeles 1984 , Seoul 1988 , Barcelona 1992 , Atlanta 1996 , Sydney 2000 , Athens 2004; Olympic Transport Performance Report, (2008b), Amodei et al.(1997), Bovy (2001, 2002a, 2002b, 2004, 2007a), Currie (2008), Friedman, Powell, Hutwagner, Graham, & Teague (2001); Liu, Guo & Sun (2008) .

3.4. Behaviour changes found previously

While there is increasing interest in the field of travel behaviour change, relatively little attention has been given to the potential changes under major events. (Rose and Marfurt, 2007) Very limited literature can be found on travel behaviour changes in the context of mega events, especially the Olympic Games which had been held by different cities. It might be because the information of those mega events is usually limited and restricted to academic research to some extent. On the other hand, the organizing committees are dismissed soon after the events finish, making it difficult to track any changes after a period of time. Even though the International Olympic Committee (IOC) has arranged a series of knowledge transfer programmes, most attention has been given to the organizing and operational aspects of the events, rather than the fundamental understanding on travel behaviours. Although available resource were limited, we compare the normal transport pattern of the host cities and find that, as a result of relevant measures and education before and during the games, certain behaviour changes have been observed in previous special events as follows:

- On overall travel demands, the games traffic increased, while general traffic reduced, with peak demands flattening and spreading. It was observed that peak flows were up to 30% less than on normal weekdays. During the first week, traffic volumes were found to be much below normal levels and gradually increased to reach pre-Olympic patterns (Amodei et al., 1997).

- On alternative travels, many people would adopt sustainable travel patterns such as public transport, carpooling, cycling and walking during Games time. Carefully planned trip chains can lead to fast and reliable trips compared to direct access with private vehicles. During the FIFA World Cup Germany 2006, which also exerted significant efforts in promoting 'green travel', the share of public transport turned from 40% at the beginning of its preparation to over 85% in Berlin and at least 60% in other host cities during Games time, including 'park & ride'. Further more, an average of 250 people came by cycling per match at Berlin, while up to 20,000 made their way on foot in Dortmund (Official Report of the Games of the XXVI Olympiad, 1996; FIFA World Cup Germany 2006, 2006; Mclntyre & Lori St John, 2002).

Among the public transport options, rail transit/subway bore much greater patronage than others. For instance, the average weekday ridership on urban rail transit and bus reached 957 thousand and 346 thousand respectively, increasing by 316% and 37% as referred to in April 1995 at Atlanta (Amodei et al., 1997).

Moreover, it was found that the trip chain usage of more than two modes was not preferred, implying that planning for more that one transfer may result in unpredictable transportation patterns. (Dimitriou et al., 2006)

- On work-related travel, it was found that the reduction in work trips contributed greatly to improved traffic conditions, including altering the regular working place or working time, taking vacation, etc. Several simulations showed that the scheduling of major Olympic events to avoid peak commute periods had the single greatest impact on traffic flow, while commuter work trip was found shorter by 14 per cent due to a shift of commute time away from peak congestion and a shift of travel route in Atlanta 1996. Furthermore, a survey also indicated the importance of employer policies in affecting commuter behaviour (Official Report of the Games of the XXVI Olympiad-Atlanta 1996).

- Regarding non-work and non-event related trips, there was apparent reduction in discretionary travel. Evidence showed that activities such as shopping and hospital visits were avoided by many residents, with business travel, such as sales calls and interoffice meetings also reduced during Los Angeles 1984 Olympics (Amodei et al., 1997; Official Report of the Games of the XXIInd Olympiad, 1984).

The travel behaviour changes have been significant during the games, though some of them appeared lower than predictions. However, most of them were removed after games, such as the significant declines on the performance of CityRail ("Aussie train services 'among world's worst'", 2007; CityRail, 2001-2009), as those travel behaviour changes during the Olympics were normally just temporary, adjusted according to the intensive Olympics public information program and other warnings, etc. How to sustain the positive impacts for longer will be a very critical issue for both planners and future operators, while it will be also given most attention in this study.

3.5. Legacies and lasting influences

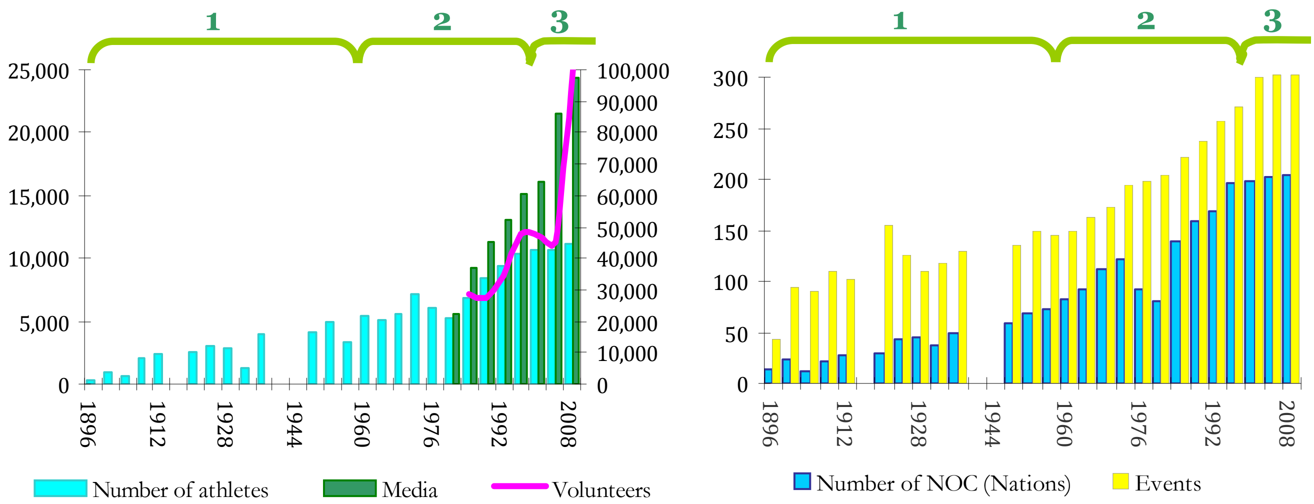
Olympics present unique opportunities and challenges for planning and operating transport services to host cities during the short period, however, as a kind of one-off event, their lasting impact is a matter of continuing debate and controversy. On one hand, they leave immense legacies with large-scale transport facilities constructions as well as public transport developments, which might benefit on the whole city mobility for many years and lead to a sustainable transport future, though it is believed that sustaining the benefits is often difficult and requires more continuous efforts (Harvey, 1989). While on the other hand, lack in integrated planning with local needs bring massive risks, together with tangible and intangible impacts falling on the city in the economic, environmental, and social aspects. In summary, the legacy of the Olympics in many previous host cities has been a mix of good and bad.

This section will give an overview on long-term impacts of Olympic in the context of urban transportation during previous games, many of whom have potentially wider implication and consideration for the planning and operation of coming events.

3.5.1. Infrastructure and urban landscape

As the Eiffel Tower was constructed for Universal Exposition of 1889 and Wembley Stadium was left standing after the 1924-1925 British Empire Exhibition, many mega events had given the host cities great legacies in urban development and constructions. It is well known that Olympics' contribution to urban regeneration has a long history. In 1908 London was the first to build a new stadium for the games, which was known as White City Stadium (originally The Great Stadium) (Official Report of the Games of the IVth Olympiad, 1908), while after the media especially broadcasters joining the events in 1948 (Official Report of the Games of the XIV Olympiad, 1948), Olympics was seen as a trigger for large-scale urban improvements, which consequently had a much more substantial impact on the landscape and urban environment of the host cities.

Figure 3-14 Developments of the Olympics



Note: The 1916, 1940 and 1944 Olympics cancelled because of the First and Second World Wars
Sources: Official website of the Olympic Movement (International Olympic Committee, 2009), Bovy (2009a).

Focusing on transportation, as indicated by Rubalcaba-Bermejo and Cuadrado-Roura (Rubalcaba-Bermejo & Cuadrado-Roura, 1995), mega events have been the planning instrument for clearing congested areas, re-organizing transport systems, promoting parks, relandscaping, and other forms of environmental improvement. The biggest contribution in early years was found to be the Universal Exhibition in Madrid in 1929 which led to major improvements in the city's public transport system (Chalkley & Essex, 1999). However, in the author's view, the development of Olympics could be identified in three stages as described below by looking at the Olympic impacts on transportation infrastructures:

1) <u>1896-1956</u>, when the events were not big, when none or few facilities were constructed or upgraded for games purpose.

2) <u>1960-1996</u>, the games began to have much more far reaching consequences on urban structure, and started representing a trigger for large-scale urban improvements, especially after the worldwide media began covering them. Host cities constructed outstanding facilities for the development of urban transport, with emphasis on the public transport.

   Rome appeared as the first city on record to build a new road named 'Olympic Way' in 1960, new airport facilities and public transport were also improved for that Olympics, while in 1964, eight subway lines extending a distance of 177.5 kilometres as well as eight 16-meter wide roads covering a distance of 69.6 kilometres were built for the Tokyo games. Following that, Montreal also built a new airport, new roads and constructed 20 km subway extension, including direct service to the Olympic Park for the 1972 Olympics, which left the city a debt of CAN $1.5 billion. In Moscow 1980, 12 new sports centres were constructed, together with the upgrade of 13 existing facilities and the renovation of the urban transport system. Seoul (1988) and Barcelona (1992) saw similar improvements. The city of Seoul constructed three new subway lines and extended 47 bus routes as well as the international airport for their first Olympics, while Barcelona restructured the rail network, built a new coastal ring road as well as other supporting facilities, which changed the city into an international business and administrative centre. (Chalkley & Essex, 1999; Official Report of the Games of the XXV Olympiad, 1992; Official Report of the Games of the XXI Olympiad, 1976; Official Report of the Games of the XXII Olympiad, 1980; Official Report of the Games of the XXth Olympiad, 1972; Official Report of the Games of the XXIV Olympiad, 1988; Official Report of the Games of the XVIII Olympiad, 1964)

3) <u>2000-present</u>, after being adopted by the IOC Session in 1999, sustainable development became the fundamental concept for both bidding and preparation (International Olympic Committee, 2008). As a result, the Olympic Games stepped into a new age with more systemic planning and highlighted the 'Sustainability' as never before. All of Sydney (2000), Athens (2004) and Beijing (2008), as well as London (2012) call on sustainable transport for the Olympic or even post-games period by building all venues to be accessible by public transport, bringing unprecedented opportunities in developing the city public transport system. In Athens, a considerable development "boost" to the metropolitan transport system 25 year delayed has been in progress in 7 years, which bought changes on the city for years to come (Official Report of the Games of the XXVIII Olympiad, 2004; Bovy, 2007a).

Undoubtedly, the Olympic Games created unique impact on the city transport system on a whole and left substantial legacies to the host cities, with much more media attention and larger funding available than other hallmark events and exhibitions (Chalkley & Essex, 1999). On the other side, as the Olympics differ from many other mega events with its special demand on providing facilities, which are unlikely to be used repeatedly and frequently. For such a 'one-off' event, host cities have needed to pay particular attention to funding issues and to ensuring that investments prove worthwhile in the longer term, against the potential huge burden brought by the large-scale infrastructure construction before and after the games. History shows that inappropriate, economically unviable, and environmentally and socially harmful projects have been carried out in the name of Olympic preparations (Dwyer et al., 2000). Integrating the event plans with the local needs for a long-term benefit, which is the most important way of minimizing the negative impacts after the games, has yet to be implemented properly by any host city thus far.

3.5.2. Sustainability

As mentioned above, sustainability is another important legacy left behind by the Olympic Games to the city transport, in both concept and facilities, particularly in promoting the city public transport and reducing emissions. Sustainability has been presented as a fundamental concept for the games in Sydney, Athens, Beijing as well as London and all future host cities (Official Report of the Games of the XXVIII Olympiad, 2004; Beijing Transportation Research Center, 2008b; Carmichael et al., 2009; International Olympic Committee, 2008; Official Report of the Games of the XXVII Olympiad, 2000). It is widely recognized that the Olympic Games, with its ability to ignite passion and emotion like no other major event on earth, not only brings opportunities to improve the environmentally friendly transportation systems in the cities, but also encourages 'green' travel patterns to visitors and residents widely, which is believed to have far-reaching meaning for the city transport structure.

3.5.3. Public awareness on public transport

Following the pre-games planning and improvements of public transport, together with educational information provided to residents about the benefits of being, and ways to be, environmentally conscious, public awareness on sustainable urban transport has been significantly highlighted (Official Report of the Games of the XXVI Olympiad, 1996; Official Report of the Games of the XXIV Olympiad, 1988). The emphasis on sustainable development and raising global awareness of environmental and resource issues are considered one of the most positive points for the host cities on their long-term developments.

Moreover, a perceived success of the public transport operations during major events may positively influence a shift towards public transport usage in the post–event era. (Dimitriou et al., 2006; Official Report of the Games of the XXVII Olympiad, 2000)

Additionally, since sports have particular access to young people and the Olympic Games are connected to environmental recommendations, the Games were believed to provide an awareness opportunity for a large number of young people, who may in turn act as "multipliers" of these values and go with improved lifestyle in the future (Official Report of the Games of the XXVIII Olympiad, 2004).

3.5.4. Improvements on transport services

Information provisioning, communication systems, accessibility and safety management for transportation were given highest focus, which had a positive impact on incident and crowd management, accessible designs, and real-time information communication, offering the potential for future improvement in the area of traffic, transit management, and traveller information at the host cities.

Moreover, the demand-oriented policy of the Olympic Games has been emphasized in the city transport planning and operation, and brought more researchers working on the demands studies, which obviously helped with the improvements of the public transport services.

3.5.5. Event transport operations

The events also helped the host cities as well as non-host cities gain great knowledge in event and urban transport operations, such as integrated coordination, which was more critical during Games time than ever. Atlanta, Sydney, Athens, and Beijing recognized their learning of upgraded skills to manage transport and delivery for events, as well as the legacy for traffic monitoring, interagency coordination, and communication after the games (Amodei et al., 1997; Official Report of the Games of the XXVIII Olympiad, 2004; Liu, Guo & Sun, 2008; Mclntyre & Lori St John, 2002; , Official Report of the Games of the XXVI Olympiad-Atlanta 1996; , Volume One - Preparing for the Games, 2001)

3.5.6. Inter-city competition and knowledge transfer

The increasing number of bidding cities set up a global urban competition between each bidder, on urban transport investment, planning, as well as the operation aspects (Chalkley & Essex, 1999), while the Olympic movements encouraged the knowledge transfer between cities, which was also supported by the IOC. Undoubtedly, the experience gained through the games is a priceless treasure for transport development in the modern era, bringing worldwide researchers and engineers to work together for better transport prospective.

3.5.7. Transfer between short-term and long-term impacts

The success of Olympic transport should not be simply relegated to the past. On one hand, the large-scale investments and improvements achieved during Games time are considered as a one-in-a-lifetime opportunity for the host cities, better post-game usage requires the needs of the games being balanced and integrated with the needs of the City, during and after Games time (Official Report of the Games of the XXVII Olympiad-Sydney 2000). On the other hand, the most ambitious Olympic hosts have seen the Games as a chance to bring forward long-term plans to change the way in which the city operates, the residents behave, and the perception of the rest of the world towards the city (Brindley et al., 1996). For example, with the sustainable concepts and careful transport planning, many people discarded cars and changed to more sustainable transport patterns with all kinds of supports and coordinating policies during the Olympic period. How to get such changes to positively influence a shift towards public transport usage in the post-event era has far-reaching meaning to the host cities for further sustainable transport development. Thus, understanding the real travel demands from the city itself and from outside under normal circumstance and during the event period, the potential changes in the city transport patterns after the events, and the way of extend the instant benefits into longer term is crucial for the planning and future movements of host cities as well as the Olympic movement.

3.6. Previous research

From previous research, many authors investigated and evaluated the performance of transportation systems during such a large event, examined the increased importance of event-led development to wider transformations in tourism and economy, while the unique characteristics and complex issues in planning and operating a transportation system for large scale demand have been also addressed in related studies. The impacts resulting from the infrastructure construction and consequent economic pressure has received most interest previously (Amodei et al., 1997; Chalkley & Essex, 1999; Dimitriou et al., 2006; Duffy, 2003; Giuliano et al., 1987; Hensher & Brewer, 2002; Mathis, 2003).

3.7. Conclusion

This chapter overviewed the challenges and impacts of mega events to the urban transport system, especially in the context of Olympic Games. It is widely acknowledged that transportation planning and operation for mega events is a comprehensive and complicated project. With significant impact on city infrastructure and sustainable urban transport development, the mega events are believed to potentially offer the host city considerable advantages. On the other hand, mega events provide a great opportunity of creating an environment where the public accepts the need for change which might be positive for sustainable future of transport. Creating a legacy on bringing the regional travel pattern towards smarter travel will continually benefit the city even further.

However, the challenges of hosting mega events are just as severe (Amodei et al., 1997; Chalkley & Essex, 1999). Looking back at past Olympic Games, adapting the Olympics tasks to the local background travel needs appropriately is crucial for a smooth operation during Games time and building positive legacies in the years to come. Comparing the Games-time public transport to everyday transport, the daily patronage increased by 171% during Atlanta 1996 and 3.7% during Beijing 2008. So it was much more difficult for Atlanta to handle the immediate increase in travel demands during Games time, which was described as a 'disaster' by media. The travel patterns such as the travel mode also influenced the Games-time operation and the effects of relevant TDM measures.

On the other hand, the Games' longer-term legacy effects on local daily lives have gained increasing concerns, and become a focal point of criticism. How the host cities could maintain 'Olympic' with its positive impacts after the Games is considered crucial for the future of host cities as well as the Olympic movements. This requires the events' bidders and planners to consider and identify the balance between Games' requirements and background transport development as well as residents' travel patterns alteration, which is vital for building a lasting legacy. Take Sydney as an example, whose Games' operation was thought to be a big success. Due to lack of integrated planning with local residents' demands, the railway line built for the Games to Homebush Bay turned empty after the Games (Bovy, 2001; Hensher & Brewer 2002). There were also a lot of similar evidence of empty venues and infrastructure left from other Games. Thus, the Planning-Match on improving public transport and altering the travel patterns of residents is suggested here, on the basis of comparisons and analysis.

As discussed above, there have also been a lot of discussions emphasizing the challenges for hosting mega events, while the available information and details are still far from enough for evaluating and supporting future decisions (Amodei et al., 1997; Chalkley & Essex, 1999). In particular, there have been significant difficulties in predicting the travel demands and making correct assumptions. According to the IOC's Technical Manual on Transport (2007), the organizing committees are required to pass their experiences in planning the Games, the operational data in the forms of knowledge transfer or workshop. There are also a series of monitoring procedures, aiming at reducing Olympic Games operational risks and ensuring efficient incorporation between transport authorities and relative stakeholders. But by reviewing the post-games reports as well as workshop notes of previous Games available to the author, we found that there were certain limitations on the data and information. First of all, little is known about the facilities' immediate impact on the local travel patterns or the overall long-term impacts (Amodei et al., 1997; Chalkley & Essex, 1999; Frantzeskakis, 2007). Most of the information and data described the travel demands for Games families (as mentioned in Section 3.1), rather than those changes in daily travel of the residents. It is because people focused on the extra demands coming from Games families and visitors, which brought worries to planners and organizers. As compared in Figure 3-1 and Table 3-1, we can find that the base travel demands of residents are much bigger than those of the Games' families. As discussed in Section 3.4, previous research suggested that the mega events might bring significant changes to residents' behaviours. The information on residents' behaviour change, which is vital for improving fundamental understanding on travel demands of mega events as well as their planning, is valuable for the host city itself and other following hosts. Secondly, rare continuing information, which provided opportunities in comparing the situations of 'Before' 'During' and 'After' for the events, has been found from previous research. It is because most organizing committees dismissed soon after the events finished and people moved to other projects. Few people or resource was available to continue collecting relevant information. Thus, it is suggested that IOC or relevant academic research associations should consider some continuous assignments of in-depth comparative studies between different periods and different cities to help improve the planning and demand management for future games, which also bring opportunities in building legacies for the local public.

Chapter 4

CASE STUDY OF BEIJING

The purpose of this part of the study is to review the evolutional journey as well as the status quo for urban transport in Beijing. It is not only the vital knowledge for understanding the travel pattern of this latest Olympic host city, but also provides opportunities in parallel comparisons with other cities, both of which are solid foundation for investigating the travel behaviour changes as well as the analysis on their differences from the circumstance with Games' interrupts in the following study.

Since the award of the Olympic Games to Beijing in 2001, the preparation of the games has been introduced into the concept of building a new Beijing. The catalysis of Olympic Games performed effectively ever in the urbanization of this city, especially on its urban transport system's improvement. Such unprecedented enormous and intensive transportation improvement, which has been never experienced in most cities including Beijing, indeed influenced on most aspects in daily life of the city. Thereby, this part of the study starts with the overview and longitudinal comparison of Beijing transport system, with the following approaches:

- Brief introduction to the city of Beijing
- Demographic characteristics of Beijing
- Evolution and revolution in transport supplies of Beijing
- Travel patterns and their developing trends in Beijing
- 2008 Beijing Olympic Games
- Post-games prospective

4.1. Introduction

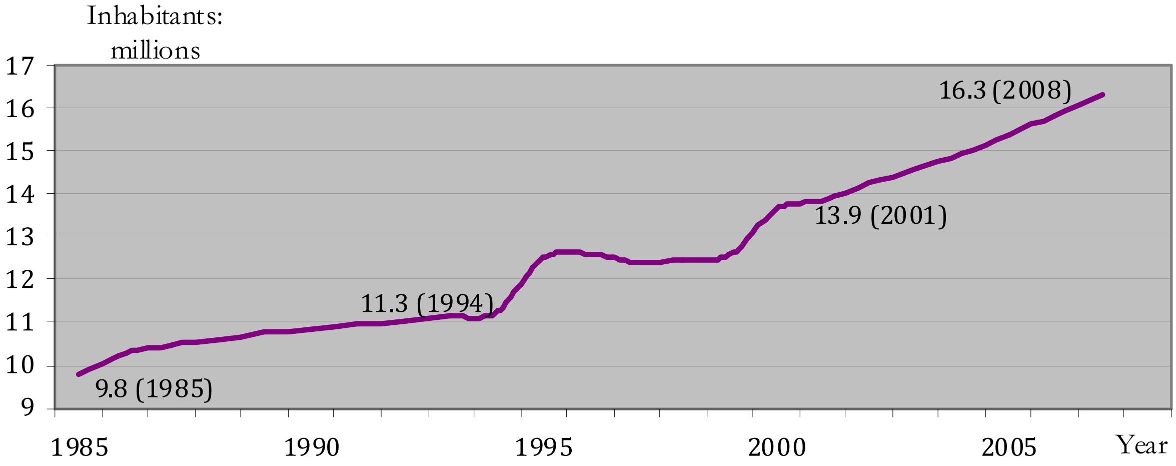
As the capital of China, Beijing is one of the world's most imposing cities, with more than 3,000-year history and 16.33 million people. This 16,808-square-kilometre area is the political, cultural and economic centre of China, with the rich cultural heritage and modern buildings together. Similar to other major metropolises in the world, the crisscrossing road network becomes another icon of Beijing for its complexity and serious congestion during rush hours or even off-peak. The 2008 Olympic Games made Beijing the focus of the world, with unprecedented opportunities and challenges in the city development and operations.

4.2. Demographic characteristics

1) Population

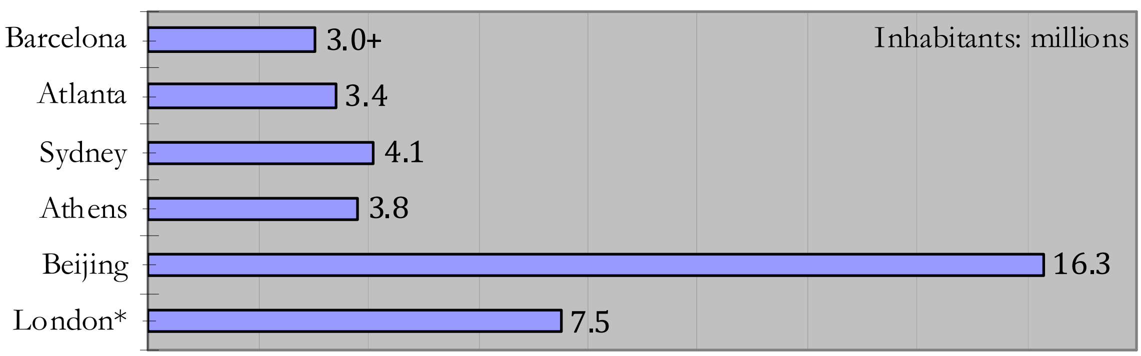
Beijing, the capital city of China for more than seven centuries, is one of the biggest cities in the world with 16.33 million permanent residents distributing in the sixteen administrative districts plus two counties. Additionally, over 4 million temporary residents live and work in the city on average (Beijing Municipal Bureau of Statistics, 2007).

Figure 4-1 Resident population in Beijing



Source: Beijing Statistical Yearbook

Figure 4-2 Resident populations of host cities in the year of the Games



* data in 2006
Sources: Official Report of the Games of the XXV Olympiad-Barcelona 1992,
Official Report of the Games of the XXVI Olympiad-Atlanta 1996,
Official Report of the Games of the XXVII Olympiad-Sydney 2000,
Official Report of the Games of the XXVIII Olympiad-Athens 2004,
Beijing Statistical Yearbook (2007),
Regional Trends: 40 (UK National Statistics, 2008)

The resident populations of Games year of Olympic host cities are compared in Figure 4-2, significantly showing that Beijing has far more people than others, while London holds the second place with the population even less than a half of that in Beijing.

2) Density and Distribution

Concentrated, widely distributed, and geographically unbalanced characterize the population density of Beijing.

Beijing is a large metropolis city with huge population of all over the world. As its urbanization stepped into the 21st century, the population density of the city reached an unprecedented height, especially within the central area. As shown in Table 4-1, the average density was close to a thousand people per km² for the whole area, while the population density in Chaoyang district was as high as 6,594 people per km², where nearly half of the Olympic competition venues were located.

Table 4-1 Population and densities in Beijing

Zone	2001			2007			No. of Olympic Comp. venues
	Area (km²)	Population (000)	Density (people/km²)	Area (km²)	Population (000)	Density (people/km²)	
Central region	87.1	2,793	32,067	92.4	2,069	22,394	1
1. Dongcheng	24.7	758	30,688	25.3	552	21,784	1
2. Xicheng	30.0	900	30,000	31.6	665	21,031	0
3. Chongwen	15.9	480	30,189	16.5	299	18,099	0
4. Xuanwu	16.5	655	39,697	18.9	553	29,244	0
Expanding	1,282.8	5,896	4,596	1,275.9	8,054	6,312	27
5. Chaoyang	470.8	2,088	4,435	455.1	3,001	6,594	13
6. Fengtai	304.2	1,198	3,938	305.8	1,693	5,536	1
7. Shijingshan	81.8	430	5,257	84.3	546	6,475	5
8. Haidian	426.0	2,180	5,117	430.7	2,814	6,533	8
Beijing (whole)	**16,807.8**	**13,851**	**824**	**16,410.5**	**16,330**	**995**	**28**

Sources: Beijing Municipal Bureau of Statistics (2008), Media Transport Guide (2008), Beijing Transportation Research Center (2001).

The high-density area in Beijing is significantly wider than the previous Olympic host cities, and most other metropolises in the world. Table 4-2 lists the population and densities of some Olympic host cities, showing all these host cities with certain high population density. In the comparison, Beijing is distinguished in the scale of the area as well as the population, but its overall average density at 995.1 people per km² is much lower than London's, while close to Athens and a little higher than Sydney. However, investigating these cities at a density level of 7,000 people per km², the high-density area is more than 1,350 km² in Beijing, comparing around 900 km² in London, less than 100 km² only in Athens and Sydney (Athens Organizing Committee for the Games of the XXVIII Olympiad; Beijing Municipal Bureau of Statistics, 2008; Sydney Organizing Committee for the Games of the XXVII Olympiad; TFL, 2007a).

Table 4-2 Population and densities in Beijing and other Olympic host cities

	Area (km²)	Population (thousands)	Density (people/km²)	Year of the records	No. of Olympic Competition venues	Note
Beijing[1]	16,410.54	16,330	995.1	2007	31	Districts 1~16 & Counties 1~2
Beijing[2]	1,368.32	10,123	7,398.1	2007	28	Districts 1~8
Sydney	12,144	4,086	336.5	2000	29	Statistical Division
Athens	3,808	3,895	1,022.7	2001	33	Attiki
London	1,572	7,512.4	4,779	2006	29*	Inner & Outer London

*updated in 2008

Sources: Beijing Municipal Bureau of Statistics (2008), Australian Bureau of Statistics (2001c, 2006d), Media Transport Guide (2000), Official Report of the Games of the XXVII Olympiad-Sydney 2000, NSSG (2007), Media Transport Guide (2004), Mayor of London (2008a), ODA (2007).

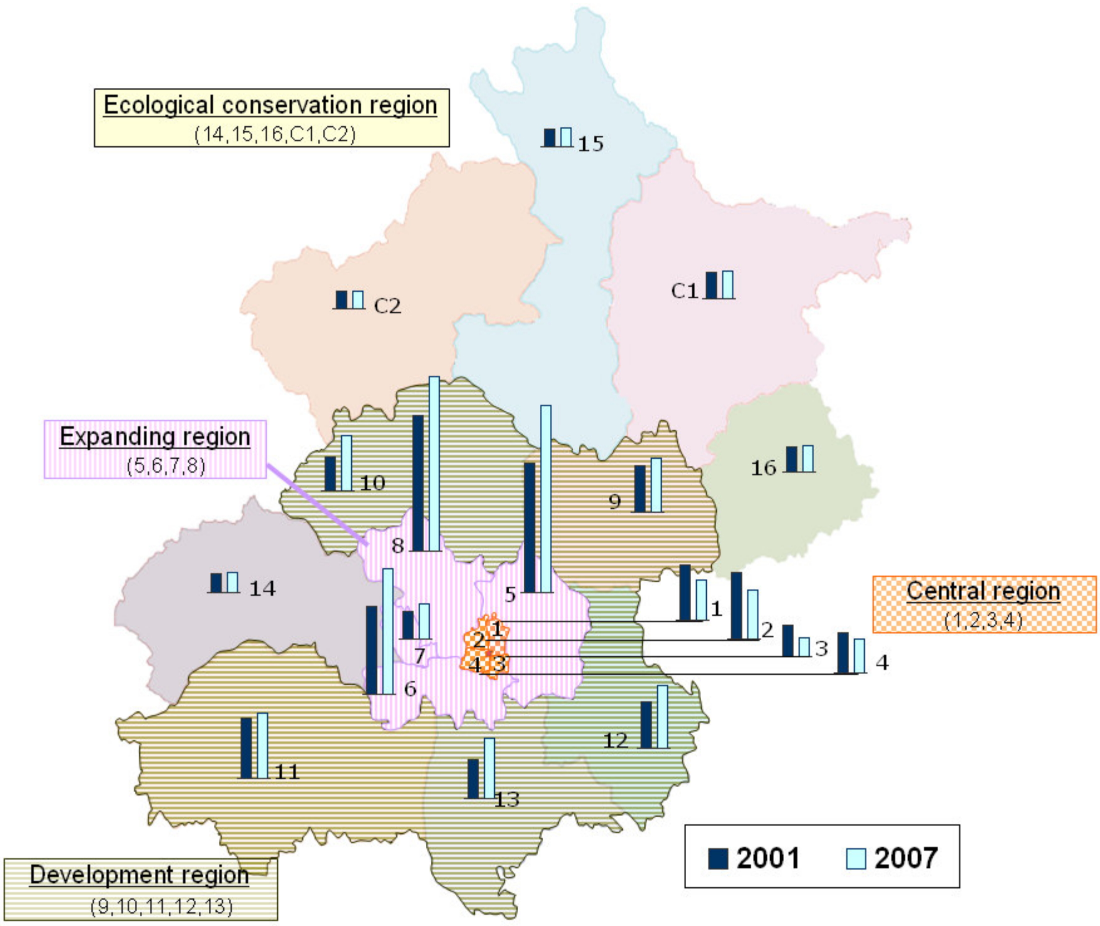
As most other metropolis, the population distribution in Beijing appears greatly unbalanced in geographic aspect. According to the Municipality regional statistics system, the City of Beijing is divided into four sub-regions as following, covering 16,808-square-kilometres in total (Beijing Municipal Bureau of Statistics, 2008).

- Central region, contains Dongcheng, Xicheng, Chongwen, Xuanwu districts;
- Expanding region, contains Chaoyang, Fengtai, Shijingshan, Haidian districts;
- Development region, contains Fangshan, Tongzhou, Shunyi, Changping, Daxing districts;
- Ecological conservation region, comprises the districts of Mentougou, Huairou and the counties of Pinggu, Miyun.

The distribution of population in Beijing appears unbalanced with the vast majority of people living within the inner area of the city. As shown in Table 4-1 and Figure 4-3, the density of the Central region (Dist. 1-4), a 92.39 square-kilometre area, is extremely high, at an average level of 22,394 people/km2, while the average density of Expanding region (Dist. 5-8) is only 6,312 people/km2 and the 15,042-square-kilometre suburb area including the

Development region and Ecological conservation region was (Dist. 9-16 & C1, C2) only with 413 people per square kilometre on average (Beijing Municipal Bureau of Statistics, 2002, 2008). However, observing the city development in recent years, people have gradually moved out of the city centre, and the bulk increase in the population happened in the Expanding region surrounding the city centre as shown in Figure 4-3. In contrast to the notable increase in district of Chaoyang (Dist. 5), Fengtai (Dist. 6) and Haidian (Dist. 8) of the Expanding region, the population dropped significantly within the central region in past 6 years from 2001 to 2007. These migrations were due to the relative population relocation and suburbanization programs of the city. However, the lack of parallel development of city functions and correlative arrangement for working place, entertainment sites, etc. has stimulated the travel demands in an unbalance trend, impacting on the urban transportation system greatly.

Figure 4-3 Municipality Regional population of Beijing



Sources: Beijing Municipal Bureau of Statistics (2002, 2008)

In most previous research, the 16.33 million population of Beijing was used for case study or compared with other cities. However, the area described above in Figure 4-3 as well as Table 4-1 and 4-2 is far bigger than the games actually impacted. As a result, weak comparability prevented such comparative researches from carrying out helpful implication for future planning or decision-making. It is worth thinking over the characteristics of cities themselves as well as the hiding resemblances. Regarding this, selection of the investigated areas is carefully re-considered in this study and preferred for comparative research afterwards wherever the corresponding data is available, aiming in better understanding 1) the demographic and development characteristics of Beijing and its comparing cities, 2) the linkage between the background transport and games operation, 3) the impacts of games' temporary interrupt on the local transportation, and 4) their possible implication on travel patterns and relevant future planning. By reviewing the investigated cities in social, economic, historical and geographic aspects as well as the situation of local majority public transport, the **Urban area**s are identified with the criteria below,

The **Urban area** should be

1. The basic urban area in the context of the city functions or traditional development;
2. Covering most or all Olympic competition venues;
3. Able to reach by mass transport systems such as subway system;
4. Statistics data is available.

Accordingly, the definition of **Urban Area** and relevant parameters for selected Olympic hosting cities are provided in Table 4-3, which will be used for comparative studies hereafter on certain issues in this report.

Table 4-3 Parameters for the **Urban** areas

City	Area (km^2)	Population (thousands)	Density (people/km^2)	Statistics Year	No. of Olympic Comp. venues	Note
Beijing	1,368.32	10,123	7,398.1	2007	28	Districts 1~8
Sydney	1,687.4	3,502.3	2,075.6	2001	29	Urban centre/Locality (171400)
Athens	362	2,805.3	7,749.4	2001	33	Athens Prefecture
London	585	3,667.0	6,268.4	2006	29*	Central & East

*Updated in 2007.

Sources: Beijing Municipal Bureau of Statistics (2008), Media Transport Guide (2008), Australian Bureau of Statistics (2001d, 2003a, 2006d),,EMTA (2004), NSSG (2007), Media Transport Guide (2004), Mayor of London (2008a, 2008b, 2008c), ODA (2007), TFL (2007b), 'Travelcard Zone', 'London Borough' (Wikipedia, 2009b, 2009d), London 2012 (2009).

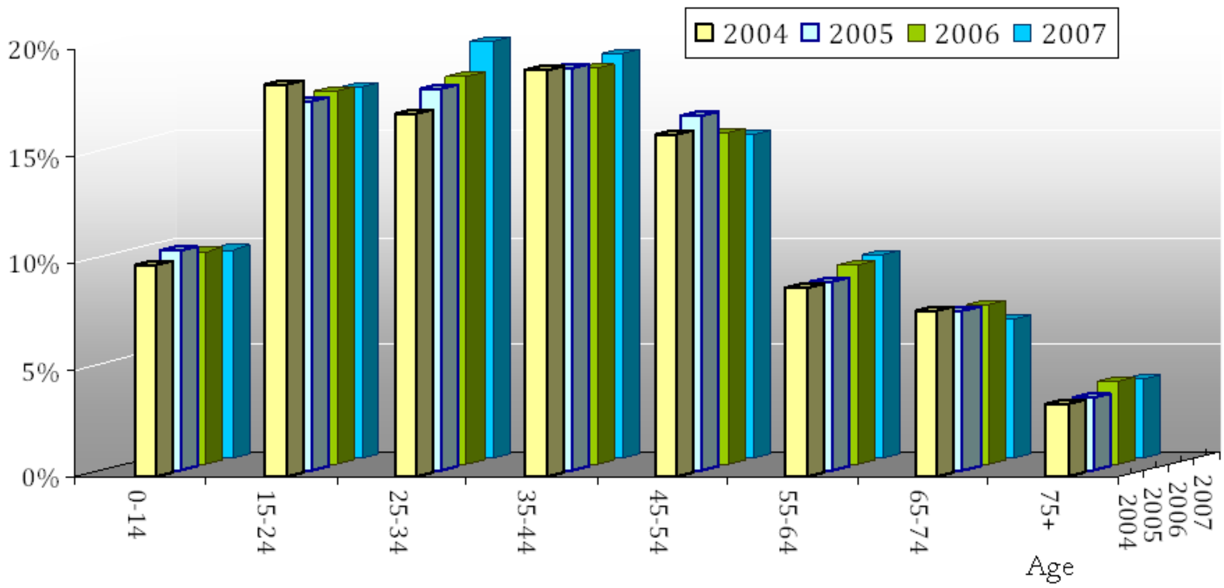
It is illustrated in Table 4-3 that, the urban areas of these cities are extremely high in population density in common, while the city centres or CBDs are even more crowd. According to the Annual statistic records, the population density was 8,400 at central Sydney (2001), 9,509 within London Zone 1 & 2 (2006), while reached 22,394 people per km^2 in the central region of Beijing (2007) (Australian Bureau of Statistics, 2003b; Beijing Municipal Bureau of Statistics, 2008; NSSG, 2007; UK National Statistics, 2008).

3) Gender and Age structure of population

Beijing is an old city with a long history, but also a dynamic city full of young people. It could be read out from Figure 4-4 that the age groups of 15-24, 25-34, and 35-44 were the biggest groups in the age structure of Beijing, accounting for more than half of the population of the city.

Observing the movement of age structure between 2004 and 2007, the population at working ages kept increasing significantly, with the proportion of 25-44 age groups grew from 35.9% in 2004 to 38.3% in 2007, while older group such as 65-74 continuously decreased from 7.7% to 6.5% during recent four years.

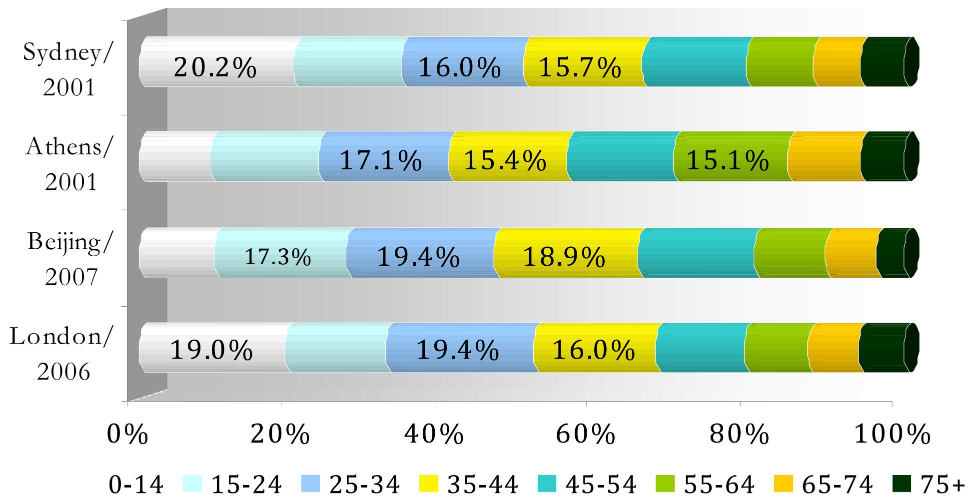
Figure 4-4 Age structure of population in Beijing



Sources: Beijing Municipal Bureau of Statistics (2005, 2006, 2007, 2008)

As shown in Figure 4-5, the top three age groups in Beijing are 15-24, 25-34, 35-44, all of which are working-aged people, while at least one teenage group is of the largest in London and Sydney, and the group of 55-64 is ranking the 3rd in Athens' age structure.

Figure 4-5 Age structure of population of host cities



Sources: Australian Bureau of Statistics (2006a), Beijing Municipal Bureau of Statistics (2008), ONS (2001).

The share of male and female in the population of Beijing is growing closer, which was 52.1 % (M) and 47.9 % (F) in 2001, while 50.8% (M) and 49.2% (F) in 2007 (Beijing Municipal Bureau of Statistics, 2002, 2008).

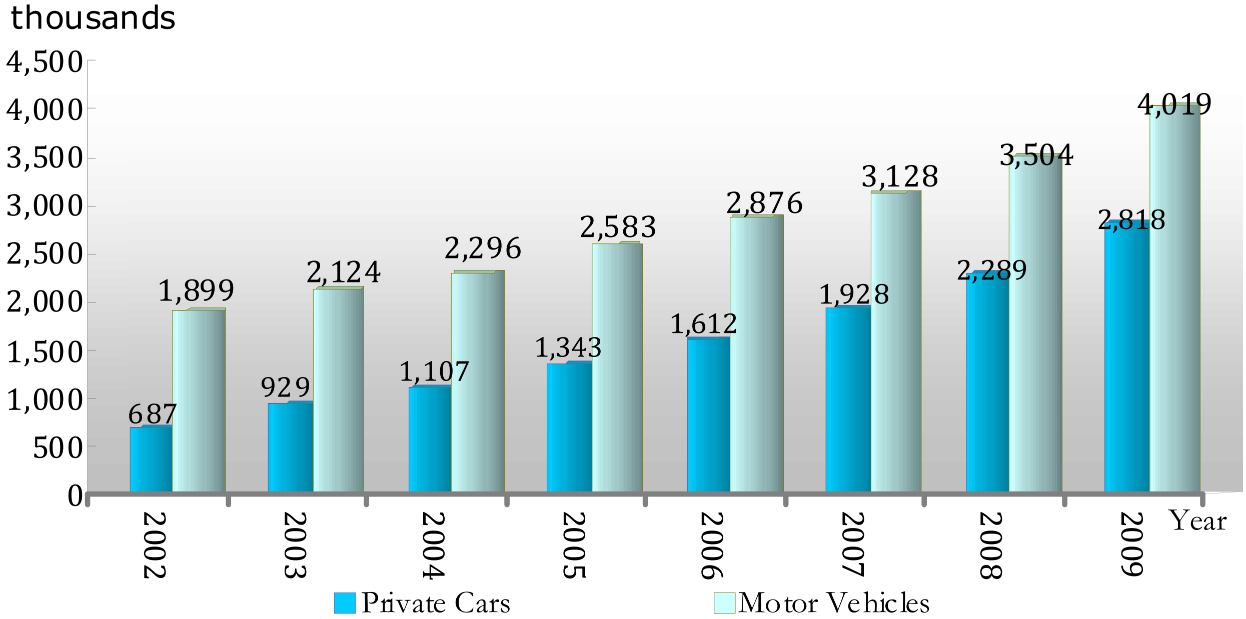
4) Increase of cars and car ownership

The number of motor vehicles in Beijing has been growing explosively in recent years, especially since 2004. The yearly increase of motor vehicles reached about 250,000 or more, while 316,000 private cars added onto the Beijing roadways in 2007, giving continuous increase of the share of private cars in overall motor vehicles.

On the other hand, the increase of car ownership in Beijing is also remarkable. According to the local statistics records (Beijing Transportation Research Center, 2002, 2008, 2009), the private car ownership in 2007 was 118 private cars per 1,000 inhabitants, with 145.83% increase from 2002 when 1,000 people only owned 48 cars on average[1].

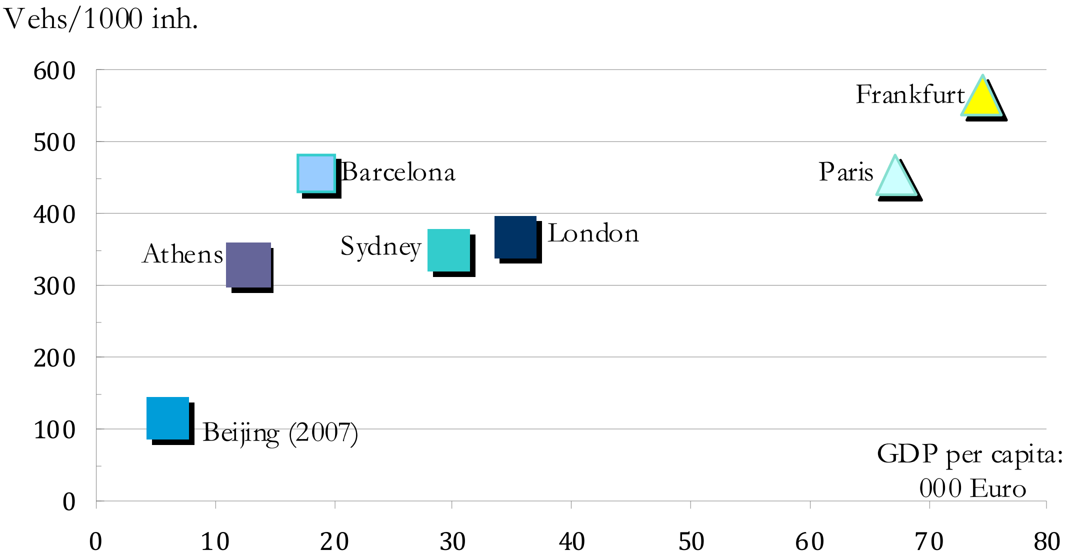
[1] The ownership rate is calculated with the population of permanent residents.

Figure 4-6 Vehicle increase in Beijing



Sources: Beijing Transportation Research Center (2003, 2004, 2005, 2006, 2007, 2008a, 2009)

Figure 4-7 Car ownership by Gross domestic product (GDP) per capita2



Sources: Australian Bureau of Statistics (2008), Barclays Bank (2001), Beijing Municipal Bureau of Statistics (2008), Beijing Transportation Research Center (2008a), EMTA (2002, 2004, 2007), TFL (2005).

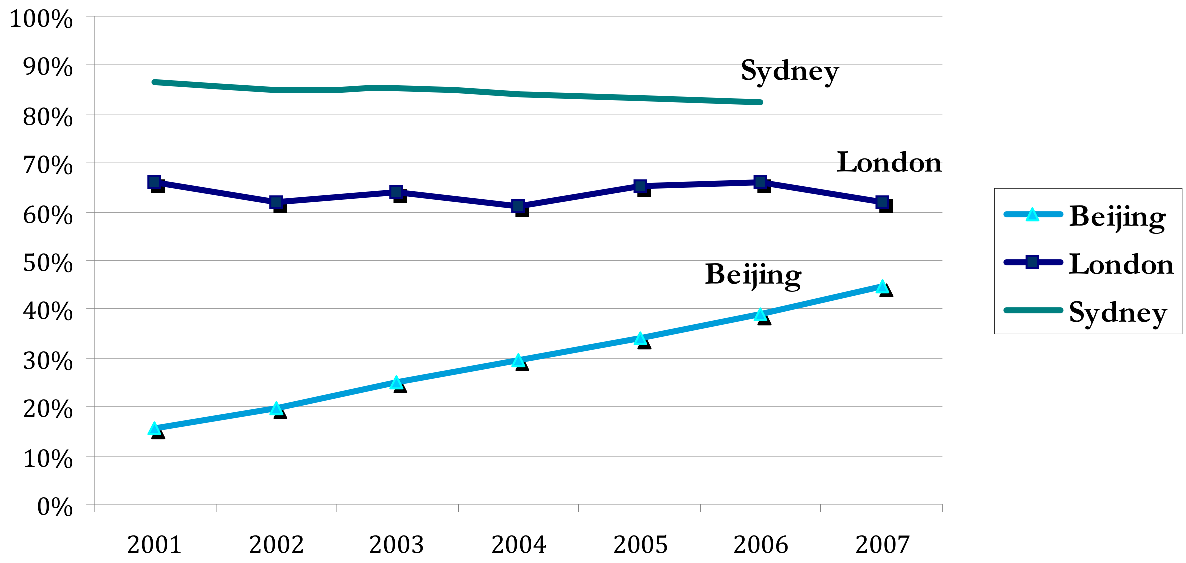
The average car ownership of Beijing is still far behind other metropolises over the world, but considering the economic development status such as GDP per capita, the ownership is quite high. In Figure 4-7, comparison of the car ownership of selected metropolises is provided together with their corresponding GDP per capita situation in the same year, showing the private car ownership of Beijing in 2007 was 118 for 1000 inhabitants

[2] Records for comparing cities were in 2001, while that for Beijing was in 2007.

comparing that of 350 in Sydney in 2001, while the comparing rate of GDP per capita was 30 to 6. More significantly, the vehicle ownership in Beijing was about a quarter of that in Frankfurt (Germany), when the GDP per capita in Beijing was even 90% less.

There is no denial that, Beijing has undergone a period of rapid motorization, especially since 2001. The growth of car ownership by household rose from around 15% in 2001 to nearly 45% in 2007, even greater than that change in the car ownership per head. It is quite different from those metropolises which have already finished or almost finished the motorization process as shown in Figure 4-8, such as Sydney, the household car ownership moved from 86.94% to 86.81% (Statistical Division) or from 86.41% to 82.36% (Urban centre/Locality) from 2001 to 2006, while it floated between 61% and 66% in London between 2001 and 2007. According to EMTA (2004), the household car ownership hasn't been much different from 50% in Paris recent years as well (Australian Bureau of Statistics, 2001a, 2001b, 2006b, 2006c; Beijing Transportation Research Center, 2008a; EMTA, 2004; TFL, 2007a).

Figure 4-8 Household car ownership in Beijing and London

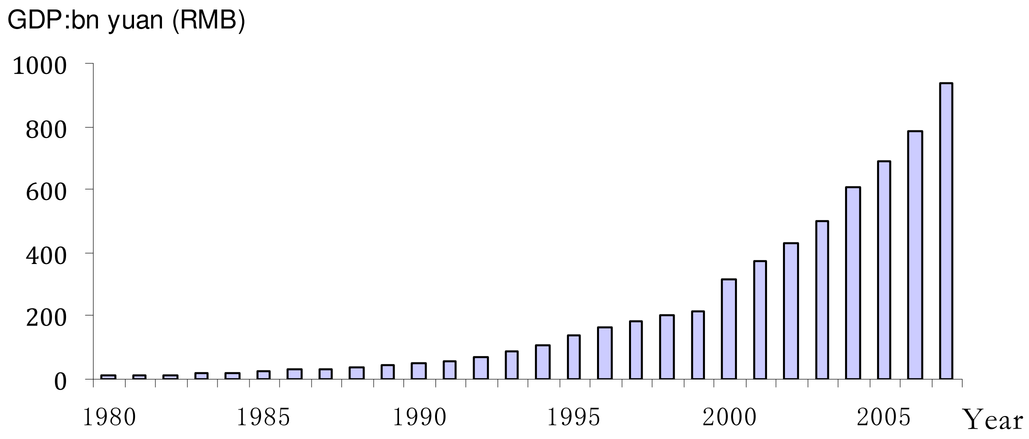


Sources: Australian Bureau of Statistics (2001b, 2006c), Beijing Transportation Research Center (2008a), TFL (2007a).

4.3. Urban transport development

The period from 2001 to 2008 was the games-staging and preparing period in Beijing, but also an unprecedented developing era for this city. The Olympics, as the catalyst, accelerated the city regeneration in both tangible and intangible aspects, including economy, infrastructure, environment, culture, appearance of the city, etc., as well as the urban transportation system. The unbelievable developing speed has attracted worldwide attention.

Figure 4-9 Yearly GDP of Beijing



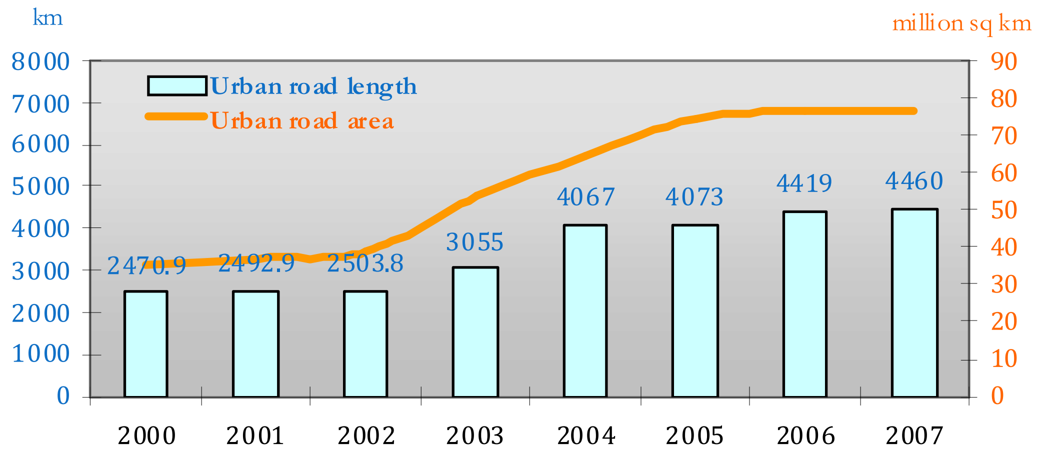
Sources: Beijing Municipal Bureau of Statistics (2000, 2002, 2003, 2004, 2005, 2006, 2007, 2008)

Since 2002, the developing has been further accelerated. More than 170 billion Yuan (RMB) was invested on transport infrastructure and facilities during 2002 to 2008, making widely remarkable achievement in surface road network, public transport, facilities including the airport and stations, clean energy technology, ITS, as well as the transport command & coordinate system, particularly in the following areas:

1) The surface road network has been doubled

The urban roadway network in Beijing has increased 2,000 km in length during the past 7 years, while the road built area is more than twice than that in 2000.

Figure 4-10 Development of transport facilities

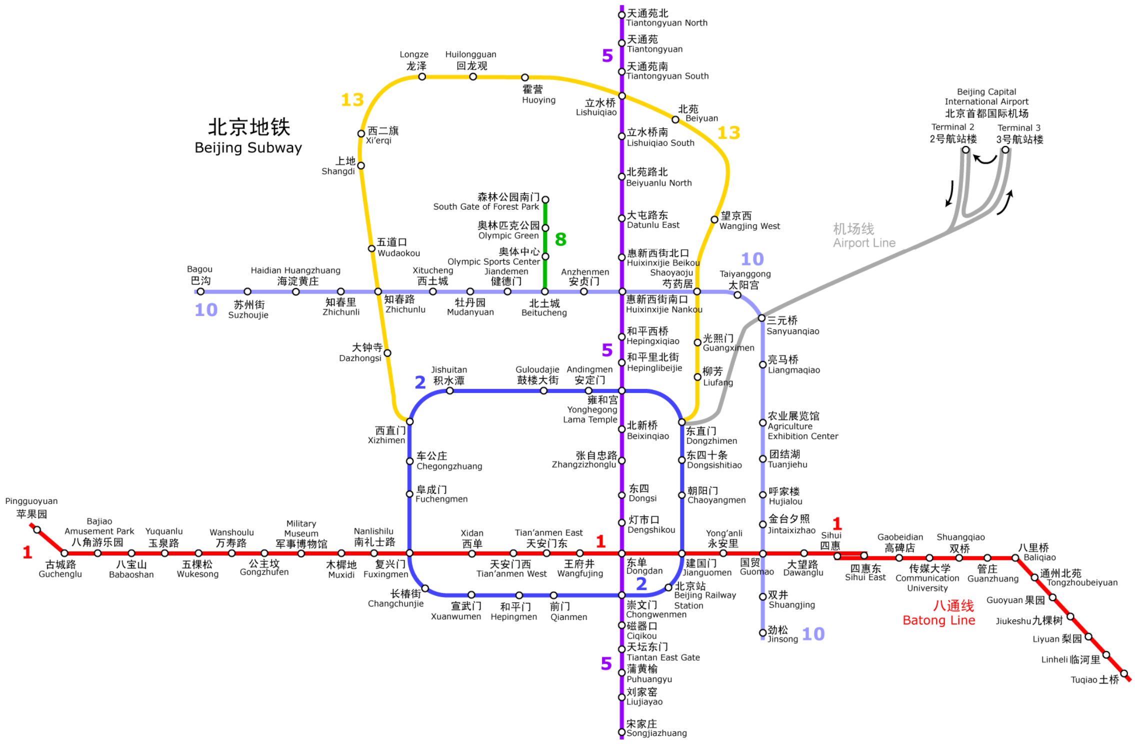


Sources: Beijing Municipal Roadway Administration Bureau,
Beijing Transportation Research Center.

2) The subway system reached much more areas

The subway system in operation at Beijing reached 200 km in 2008, while it remained at 54 km for 30 years before 2001. Currently, there are eight lines with 123 stations in Beijing subway system, with more than 300 km under construction (An, 2008). Overall, the subway system in Beijing is expected to come up to 561 km in length by 2015 (Beijing Transportation Research Center, 2008a).

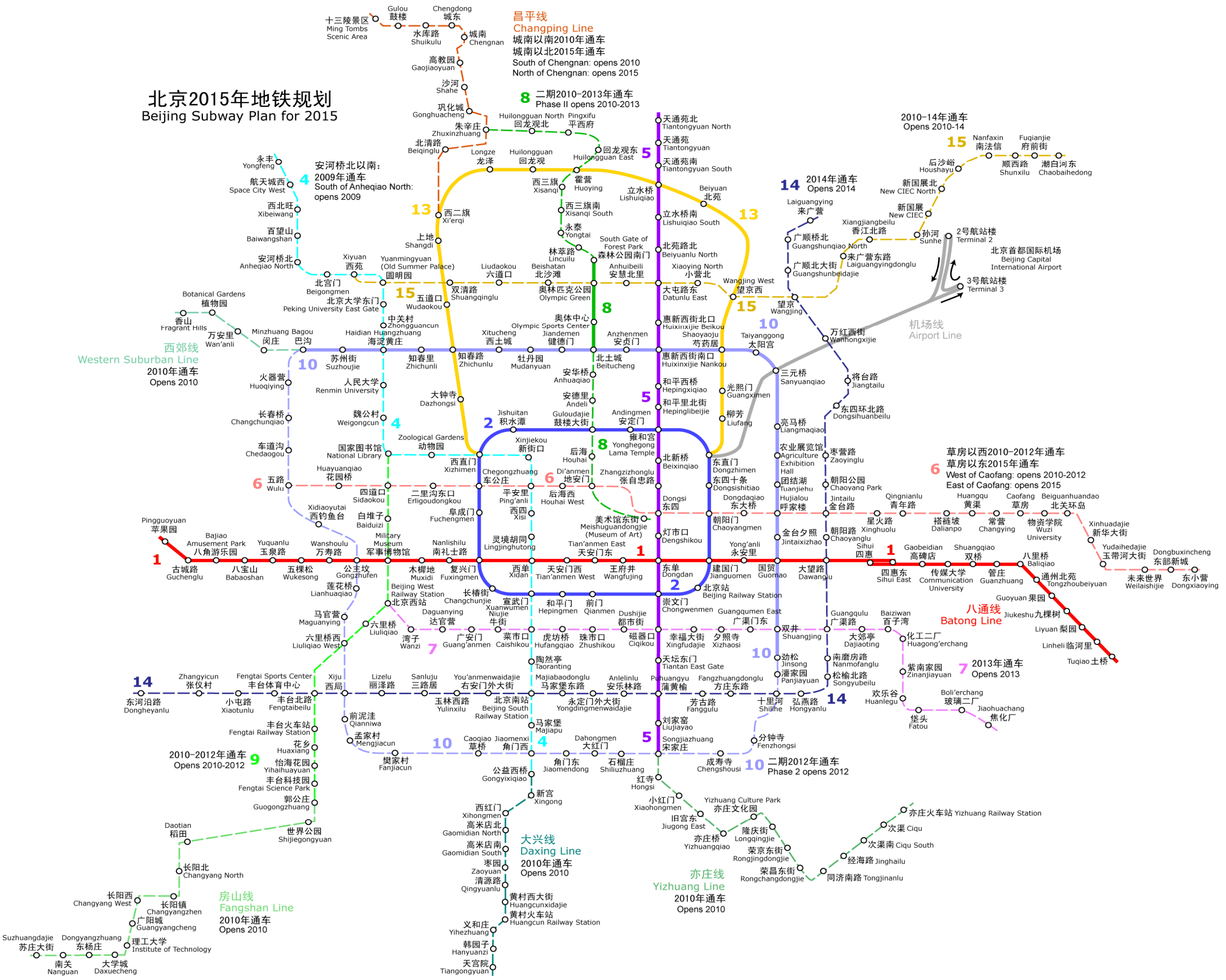
Figure 4-11 Present subway system in Beijing



Source: Beijing Transportation Research Center

Figure 4-11 presents the current subway system in operation at Beijing, of which Line 8 and 10 as well as the Airport express were opened in 2008 while Line 5 opened in October, 2007. During the games staging period, 86 km new subway track has been built, together with 501 new trains/coaches replaced or added into operation (Beijing Transportation Research Center, 2008b). The expanded system didn't only well serve the huge amount of people during the Olympic Games, but also greatly improved the daily transport for Beijing residents and visitors, even though the supply is still far away from the existing and potential travel demands of the city. However, the Beijing subway in recent years is considered as the most rapid growth ever in subway development, becoming one of the focuses of world attention in Beijing (Beijing Transportation Research Center, 2008a).

Figure 4-12 Subway plan in Beijing



Source: Beijing Transportation Research Center

In Figure 4-12, the blueprint of Beijing subway in next seven years is given, comprising with 19 lines over all. By then, the mass transit network in Beijing will be set up to cover most regions of Beijing city and support the 'green' urban mobility.

3) The public transport services in Beijing have been comprehensively improved.

Besides the remarkable progress on subway system, 13.8 thousand buses and 62 thousand taxis have been upgraded or replaced or increased into services, together with a number of bus routes modified and optimized within the seven years while the vehicle increase of public buses was only 8.5% every year (Beijing Transportation Research Center).

In Table 4-4, the development of the public transport supplies in Beijing during recent years have been summarized, showing the substantial progresses and changes in context of daily transport of Beijing citizens and visitors.

Table 4-4 Developments of public transport supplies in Beijing

	2001	2002	2003	2004	2005	2006	2007	2008
Public buses								
Lines	553	589	616	596	622	648	644	932
Lines length (km)	13,126	15,760	17,908	16,823	19,206	19,360	17,353	18,468
Number of Vehicles	15,420	17,580	18,667	20,014	19,101	19,522	19,395	>20,000
Subway								
Lines	2	3	4	4	4	4	5	8
Lines length (km)	54	75	114	114	114	114	142	200
Stations	43	57	70	70	70	70	93	123
Number of Vehicles	617	641	692	892	958	967	1130	
Peak capacity (people/hr)	37,000	47,730	24,000	67,840	69,068	72,540	110,794	add 1.5-4.5 mil per day
Taxi								
Number of Vehicles	63,649	63,805	62,283	52,346	66,660	66,660	66,646	66,646

*Updated in 2007.
Sources: Beijing Municipal Bureau of Statistics (2008), Media Transport Guide (2008), Liu (2008), 'Sydney' (Wikipedia, 2009c), Australian Bureau of Statistics (2001d, 2003a, 2006d), EMTA (2004), NSSG (2007), Media Transport Guide (2004), Mayor of London (2008a, 2008b, 2008c), ODA (2007), TFL (2007b), 'Travelcard Zone', 'London Borough' (Wikipedia, 2009b, 2009d), London 2012 (2009)

4.4. Urban Travel Pattern

4.4.1. Overview

The continuous Household Travel Surveys conducted by Beijing Transportation Research Center since 2004 are the most important source of travel data in Beijing, comparably, there were two other relative surveys available, one was conducted by Beijing government together with Beijing Municipal Science & Technology Commission in 1986 (The Beijing Government, 1986) and the other was worked out by Beijing Municipal Commission of Urban Planning and Beijing Municipal Science & Technology Commission in 2000 (Wu, 2000).

According to the data resource, Table 4-5 summarises the overall picture of travel patterns in the urban area of Beijing during 1986 to 2007, demonstrating the demands and patterns of the urban travel in Beijing have changed significantly, accompanying with the great improvement on infrastructure constructions and transport supplies. When comparing the period I from 1986 to 2000 and the period II from 2000 to 2007, it is apparent from the information that much stronger growth of the impacted on urban transportation since Beijing was awarded as Olympic host city in 2001, measured both in terms of the population and the number of trips as well as the share of car travels.

Table 4-5 Summary of the travel pattern in Beijing

	1986	2000	2005	2007
General demand				
Population (millions)	9.712	11.075	11.807	12.133
No. of households (millions)	2.85	3.98	4.57	4.73
Employment (millions)	3.98	4.34	4.48	4.79
Number of trips (millions)	10.8	20.5	29.6	30.7
Purpose share*				
Commuting	30.2%	22.2%	21.8%	22.2%
Education	7.9%	6.7%	5.1%	5.3%
Return home	46.1%	42.8%	46.1%	46.6%
Shopping/Recreation/Hospital/Serve passenger	10.1%	16.4%	24.0%	22.6%
Business	3.3%	3.5%	2.6%	1.7%
Other	2.4%	8.4%	0.4%	1.6%
Mode share				
Walk only	13.8%	32.6%	31.7%	26.0%
Bicycle	54.0%	25.8%	26.5%	17.0%
Bus & Subway	24.3%	17.8%	20.6%	25.5%
Car	4.4%	15.8%	16.8%	25.8%
Taxi	0.3%	5.9%	1.9%	5.7%
Other modes	3.3%	2.1%	2.5%	0%
Avg. travel distance per trip (kilometres)	-	-	5.6	-
Avg. trip duration at peak hours (minutes)				
By walk	-	-	17	15
By bicycle	-	-	22	22
By bus	-	-	70	67
By subway	-	-	73	68
By car	-	-	42	35

* Due to data availability, information on 'Purpose share' in 2005 was instead of that of 2006.

Sources: Beijing Municipal Bureau of Statistics, Beijing Transportation Research Center.

From comparisons, travel patterns of the city of Beijing are well observed in the following aspects,

1) **Demands increased sharply.** All aspects have shown great increases since 2000. During 2000-2007, the population and volume of trips in Beijing have increased by 1.09 million and 10.2 million in seven years, while only 0.36 million people and 9.7 million trips increased in the fourteen years between 1986 and 2000.

2) **Greater growth in trip volume especially car trips than that of population**. During the recent seven years, the increasing rate for trip volume was about 1.5 and was less than 1.1 for the population, while the car travel has increased by nearly two and a half times.

3) **The use of car has had significant changes.** Considering the reported decreasing travel speed on the road (Beijing Transportation Research Center, 2008a), the decreasing trend in average trip duration showed people making more frequent trips by car with shorter distance, especially considering the reported continuous reduction on road traffic speed.

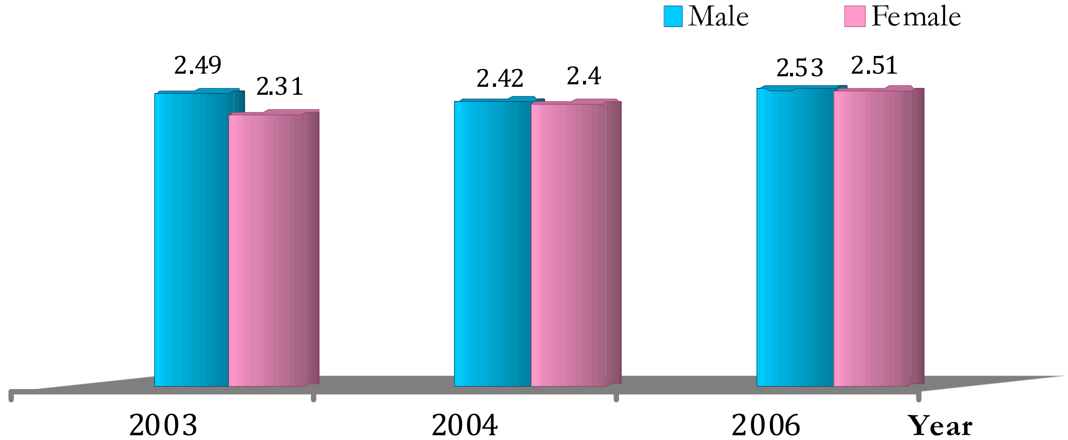
4.4.2. Urban travel patterns in Beijing

1) Who is travelling?

Further to the above information on population growth during these periods in Beijing, some interesting patterns were revealed as looking at traveller characteristics, such as trip rate by gender and age.

Previous research demonstrated diversities in travel patterns by genders e.g. women share greater proportion of domestic responsibilities with shorter work-related trips in developed countries, while public transport is considered not providing an acceptable alternative to the car for the women with young children, etc. (Dowling & Gollner, 1997; Law, 1999).

Figure 4-13 Trip rates by gender (trips per person/ day)



Sources: Beijing Transportation Research Center (2004, 2005, 2006, 2007, 2008a)

However, the comparison of the trip rates by gender in 2003, 2004 and 2006 presented in Figure 4-13, showing difference was not significant between genders on trip rates in Beijing, though male citizens with slightly higher trip rate than female. The gap kept shrinking in these years and came to very close in 2006. Further investigations such as trip distance and mode share by gender might be interested in future research.

Comparing travellers by age using the survey information in 2006, average trip rate per person was 2.08-2.18 per day for ages below 25, while 2.43-2.66 for ages of 25-60 and 2.74-2.90 for the above 60 years age groups. It demonstrated that the trip rates increased by ages, with notable increase when people stepping into working ages. The older people (>60) travelled even more than younger, although they don't travel by car as much as the working-aged (25-60).

It is also noticed that, population increased by 24.9% from 1986 to 2007, while the number of household increased by 66.0% in the same duration. It indicated that the size of household became smaller and human being appeared more individual, which might promote travel demands in certain aspects.

2) Why people travel?

The growth in travel is usually considered as a mirror to the urbanization concerning the population increase, economic development and the promoting of human life standards, etc, which has been even exaggeratedly demonstrated during the fast growing of Beijing.

Commute however, is the main reason for travel as shown in Table 4-5, occupying about one third to a half proportion of all travel purpose. The volume of commuting trips has increased by 109% while employment population only increased 20% in the past 20 years. Of all purposes for travel, the share of commuting travel decreased 10.3% between 2000 and 2005. Though it is noticed that there might be certain statistical bias due to the category of 'Return home', which was calculated in 'Commuting' category or others in some years, the overall trend for the commuting travel is going down.

In contrast, travelling for recreation, shopping, as well as other social activities has kept increasing every year, with nearly 8% growth in five years between 2000 and 2005. It contributed most in the increase of travel demands.

Look at other cities, the shares of work-related travel and non-work related travel situations are quite in common except Sydney as shown in Table 4-6, where 'Commuting' trip only represented about 15% while the 'recreation and social activity' trip occupies the most proportion of all travel.

Table 4-6 Comparison of travel to work (% of all trips)

	Beijing		Sydney	Athens	London
Proportion (%)	42.7	38.1	15.0	43.0	30.5
Statistical year	2000	2005	2002	1996	2006/2007

Sources: Beijing Transportation Research Center,
TPDC report 2004/02 (Transport & population data centre, 2004),
Travel Demand Forecasting for the Olympic Games Athens 2004 (Anastasaki, etc., 2001)
LTDS 2006/07 Household Survey (Transport for London, 2007)

3) How people travel?

The choice of mode used for travel kept shifting towards the private car has attributed the most changes in travel pattern of Beijing residents. Beijing has been stepping quickly and steadily from non-motorised into motorised era within a short period, though it is still with a pretty high level in bicycle use compared with the cities in developed countries. As indicated in Table 4-5, the share of bicycle usage turned from more than half in 1986 to as low as 17% in 2007, while the car share rose from 4.4% to 25.8% in the same duration. The turning speed also showed strong growth in recent years, the car usage increased 11.4% between 1986 and 2000 in all mode shares, while 10% during 2000-2007. Particularly, with the proportion in excess of that of public transport including buses and subway, the car use became the most popular of all motorized travel modes in 2007.

It could be also found out in Table 4-5 that the public transport retrieved popularities after a period of neglect during 1990s to the beginning of this century, as a result of the development of urban transportation facilities and public transport services. In 2007, before the new lines starting, the share had come up to 25.5%, expecting much higher share of sustainable travel patterns during the Olympic Games with sorts of relative measures, operational supports and communications.

The seasonal changes in travel patterns in Beijing has been hardly noticed previously, considering some cities such as Athens always with notable decrease in transport demands in summer (Anastasaki et al., 2001).

4) Cars and car use

Table 4-7 Summaries of car ownership and car use in Beijing

	1988	1994	2002	2006
Number of motor vehicles (million)	0.3*	0.82	1.90	2.88
Car ownership (cars per 1000 inhabitants)	-	-	167	240
Car ownership (% household with car access)	-	-	19	39
Number of car trips (million/day)	0.76*	1.63	3.50	6.54
Avg. vehicle travelled length (km/trip)	18.12	17.25	-	-
Avg. vehicle travelled length (km/year)	-	-	26,750	23,041
Avg. duration at peak hour by car (minutes/trip)	47.9	48.3	50.0	36.8
Occupants per car/trip	-	-	1.52	1.26

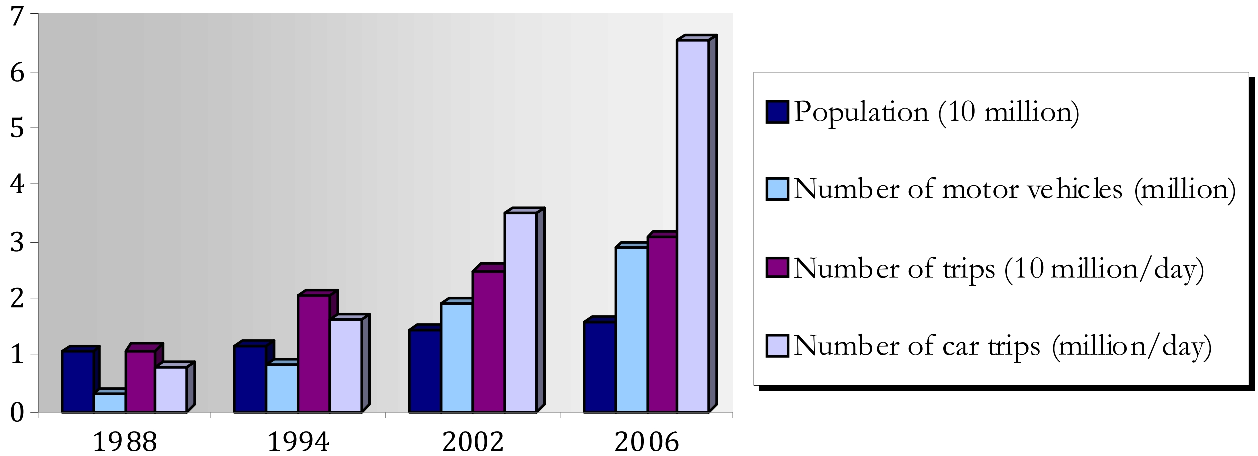
Sources: Beijing Municipal Bureau of Statistics, Beijing Transportation Research Center

The dramatic increase of the number of cars has become an icon of the transportation development in Beijing. Table 4-7 summarizes the increase of vehicle ownership and car use in Beijing from 1986 to 2006, according to relative yearly records. It shows from the information above that the duration of 1988 to 1994 had increases of about 87 thousand per year of vehicles, while the following eight years from 1994 to 2002 had a yearly growth of 135 thousands, while between 2002 and 2006, average 245 thousand motor vehicles (namely one thousand every weekday) were adding onto the urban roads in Beijing every year.

As the increase in the number of cars has been much greater than that of the population, the car ownership per inhabitant grew by 43.7% during 2002 to 2006, while one-fifth households became motorized newly. However, considering car ownership of cities in developed countries ranged from 420-510 cars per 1000 inhabitants or 520-800 vehicles per 1000 inhabitants (Banister, 2000), the potential increase of car ownership accompanying the economic development will continue threatening the limited roadway in Beijing.

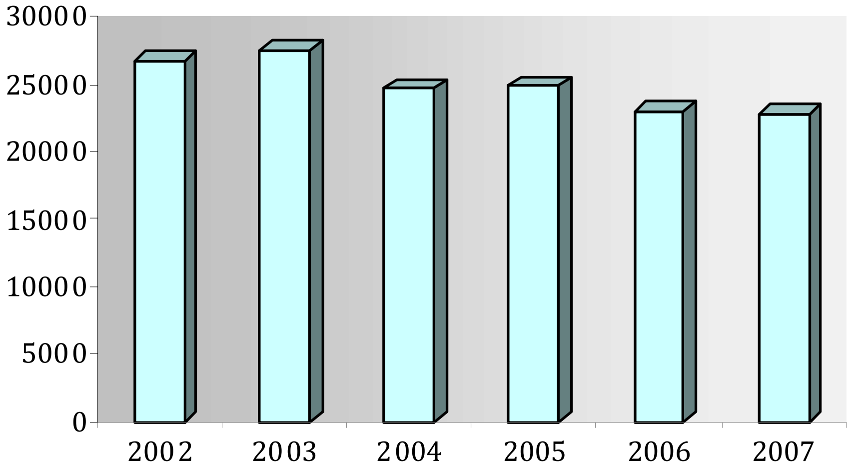
Consequently, the number of car trips has largely increased, explaining most increase in overall urban travel of the city, which is similar to other global megacities (Banister, 2002; Battellino & Raimond, 2000). During 2006, residents in Beijing made about 6.54 million car trips per day, while the number of trips was only 3.50 million per day in 2002 and 0.76 million per day in 1988. In Figure 4-14, number of overall trips as well as car trips is compared together with the increase of population and number of motor vehicles in Beijing from the end of 1980s till 2006, demonstrating the much stronger growth in car trips and number of motor vehicles, comparing that of similar level growth in overall travels and population.

Figure 4-14 Comparison of several travel related indexes



Sources: Beijing Municipal Bureau of Statistics, Beijing Transportation Research Center

Figure 4-15 Average private vehicle travelled distance per day in Beijing (kilometres)



Sources: Beijing Transportation Research Center

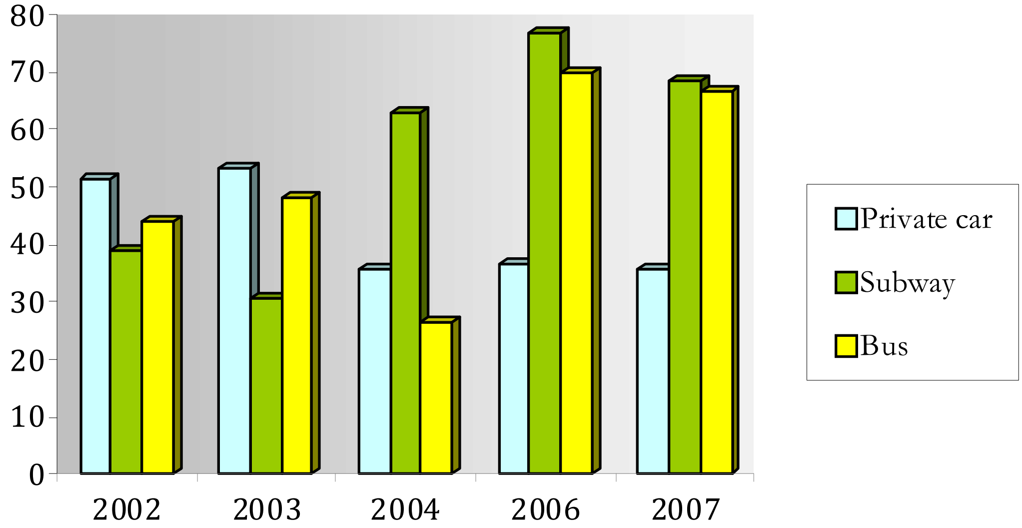
Looking at the vehicle travelled distance, the average vehicle travel distance in Beijing is around 20-30k kilometres per year, with a decreasing trend in recent past as shown below in Figure 4-15, while the personal daily travel distance goes in a reverse trend, increasing by 16.3% from 2001 to 2005 ("Beijing residents travel survey", 2005).

When comparing by mode, the average travelled distance by car is similar to that by subway, but slightly longer than that by bus in Beijing ("Beijing residents travel survey", 2005).

On the other hand, the average trip duration in peak hour by car is normally within one hour, ranged from 35 to 50 minutes. However, the average travelling duration of subway turned to more than one hour in recent years.

Figure 4-16 Average duration of trips by selected mode at peak hours in Beijing

(minutes)



Source: Beijing Transportation Research Center

Comparing the trip duration and distance, it is noted that for similar distance, travelling with public transport requires longer time than with car. This situation has become more rigorous in recent years, which obviously caused public transport losing its attractiveness further.

The travel distance and duration per person are usually considered as a simple and readily indicator for transport (Stead, 1999), the factors behind the generation of the travelled distance as well as duration in Beijing will be interesting in future analysis of this research for better understanding how travel demand could be more effectively managed.

Furthermore, viewing on car sharing, the travel impact in Beijing comes more severe, with average number of passengers for each car decreasing. It indicates that more and more people prefer using private travel means other than sharing, bringing the efficiency of road usage down and the limited road capacity more congested.

5) Time of day of travel

Similar to other cities, significant portion travel volume happens in rush hours at Beijing, normally between 07:00 and 08:30 in the morning and 17:00-19:00 in the evening. According to recent report from Beijing Transportation Research Center, the peak hours moved slightly earlier and spread longer, while the difference between peak and off-peak became smaller. As shown in Figure 4-16, the percentage of trips were taken during the am rush hour between 07:00 and 08:00 in the morning ranged 16%-20% of all trips in Beijing, including nearly one-fifth car trips and more than 20% subway. The percentages were slightly lower in pm rush hour between 17:00 and 18:00 (source: Beijing Transportation Research Center).

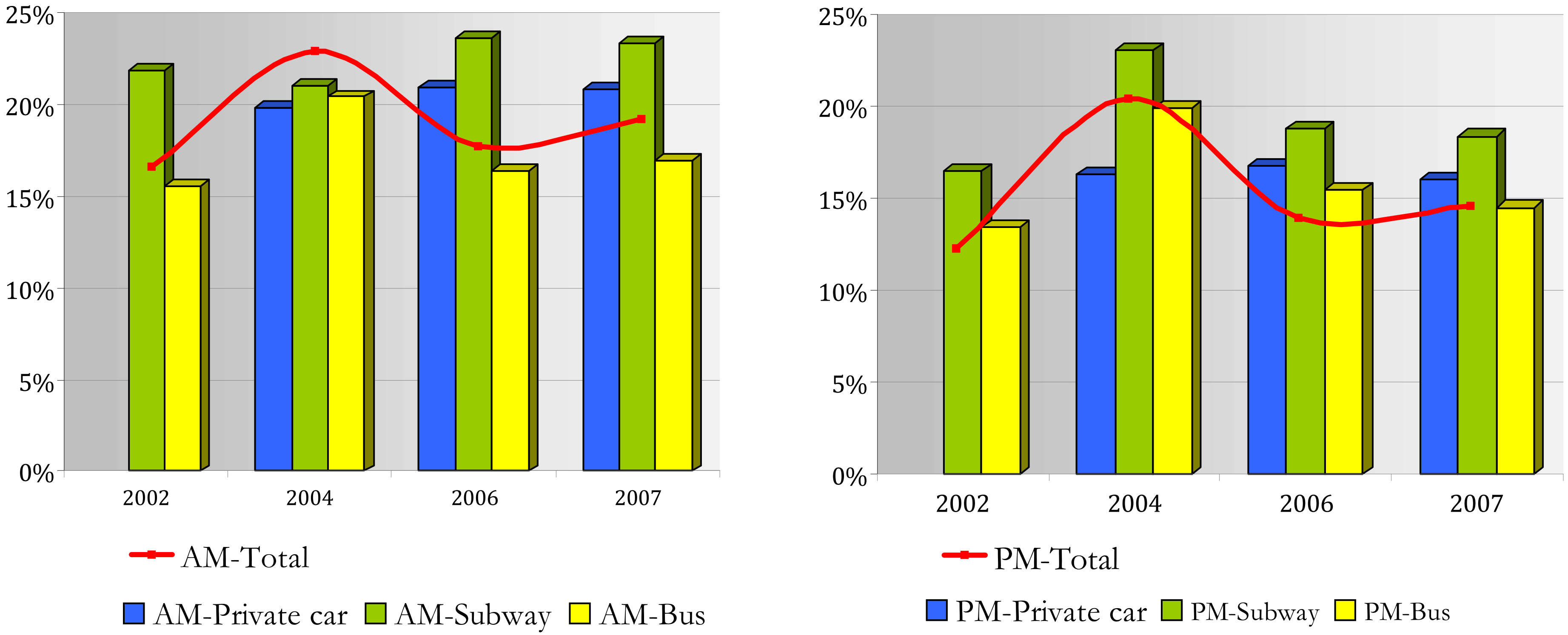
6) Summary

Section 4.4 described the travel patterns in Beijing, together with longitudinal comparison within similar level as well as crossing comparison with global cities or Olympic host cities for better understanding of what the situation actually is and looks likely to be.

Comprehensive understanding on the city travel patterns is substantial and important for the subsequent research on travel behaviours as well as further exploration on the mobility forms. Particularly, their internal-connections in the city, as well as linkages to demographic or other possible influence factors might be interesting for the opportunities of improving transport performance and efficiencies, which benefit the mega events like Olympic Games in the short term and the city in the longer term.

The analysis and comparison above shows that travel demands in Beijing have had significant increase during the recent past, with the travel patterns changed greatly in terms of mode use, purpose, travel distance and time of travel etc. Traditional means like adding transport facilities and supplies can hardly meet present requirements of urban transport in Beijing. How to make travel demand management more effective and helpful for sustainable urban transport development are important for current and future steps.

Figure 4-17　Trip shares in peak hours during the whole day



Source: Beijing Transportation Research Center

4.5. Previous TDM measures carried for events in Beijing

As the capital city and the cultural centre of China, Beijing holds various kinds of events every year. Transport and traffic measures are always considered as the essential part of the event preparing and organizing, ensuring the special mobility needs met as well as the transport system of the whole city going smoothly during the event periods. Temporary traffic control or set closure on selected roads was the most popular way for managing special events in Beijing previously. Concerning the limitation of resources including road capacity and operational efficiencies as well as the quick increase on the number of vehicles and background travel demand, Travel Demand Management (TDM) attracted unprecedented attentions and performed in practical use at more and more areas.

The most used TDM measures in Beijing currently include a) temporary traffic control on selected roads, b) sealing government-owned vehicles usage, c) encourage public transport d) staggering work hours, e) restriction on freight traffic, f) reducing other events, g) setting areas prohibiting vacant taxis and h) timely information communication. In recent years, campaigns for reducing private car usage are also used frequently (Guo et al., 2008).

Especially during the Beijing summit & Third Ministerial Conference of Forum on China-Africa Cooperation, November 1– November 6, 2006, a special event with more than forty Chiefs of State and Heads of Government of African countries and the principal of Commission of Africa, the leader for African Affairs of the United Nations, as well as the representatives and journalists worldwide, various TDM measures were taken to support the event transport needs and city transportation operation (Guo et al., 2008). As the most recent special event before the Olympic Games in Beijing, TDM measures were tested crossing the event, while a wide range of knowledge and experiences on TDM practices were provided thought that together with following games test events at Beijing. These practical trials have greatly supported the subsequent Beijing 2008 Olympic Games' transport operation.

4.6. Beijing 2008

The Beijing 2008 Olympic Games, took place from 8th August until 24th August 2008 and was followed by the Paralympics between 6th and 17th in September, were widely acclaimed as one of the most spectacular sporting events ever held, not only for '*the sumptuous and dazzling opening and closing ceremonies showing the amazing oriental history and cultures and the high standards of competition from athletics*', but also for the smooth operation crossing the games and the whole city (International Olympic Committee, 2009).

The mainly impacts on transportation for the Beijing Olympics were in common with previous as described in Chapter 3, while particularly, Beijing faced challenges in: 1) the status quo of transportation in Beijing; 2) enormous travel demands from the domestic and international spectators and visitors; 3) the large-scale constructions bringing number of new transport facilities, which were difficult to test, integrate and introduce very well before the games; 4) communication in different languages and cultures; 5) accessibility requirements on transport system.

4.6.1. Travel demands

The population of Olympic family attending Beijing 2008 Olympics, including the athletes, technical officials, accredited media, IOC / NOC members, as well as the sponsors, staff and volunteers was larger than ever, especially the number of volunteers reached 100,000, which was double compared to previous Olympics (Bovy, 2009b; SOCOG, 2000).

As reported, 5,000 vehicles have been put in use to transport the 18,000 athletes & officials, 4,000 technical officials, 5,000 Olympic family members and 26,500 credited media between 31 competition venues, 44 individual training venues and the Olympic village, International broadcast centre, Main press centre, Olympic family hotels, and more than one hundred official accommodation sites, etc. The vehicle kilometres travelled (VKT) was nearly 1,450 kilometres while the patronage reached 2.30 million in total (Yu, 2008).

Refer to the requirements on safety and environment, special standards were set out for Olympic vehicles, which require all buses with good air-conditioning system, be low noise and comfortable, aged not exceed three years, etc.

At the same time for the public transport, spectators made additional 7 million person trips, with an average daily number over of 400,000 – 600,000+ person trips into the normal transport system of Beijing. On the busiest day, the Olympic Green received about 300,000 spectators, with most of them accumulating in the central park area (Liu, Guo & Sun, 2008). Though the daily travel demands of the residents appeared decreased, from 34.4 million trips per day at normal time to 30.9 million trips per day during Games time, the daily passengers by public transport increased from 18.8 million at normal to 20.1 million during Games time, including more than 13 million on public buses, 4.68 million on subway and 2.4 million by taxi. The growth on patronages of public buses, subway and taxi were 2.8 million, 1.1 million, and 0.6 million respectively (Source: Beijing Transportation Research Center).

On the other hand, the Olympic travel demands appeared extremely in time and space. Area around the Olympic Green experienced much more congestion as traffic of people going to the events was added into peak hour's traffic. Also, crowding came up to the subway station at the Olympic Green before events start. It is reported that the peak daily traffic demand to Olympic park by public transport was above one million person trips and the daily patronage for the Olympic subway line was nearly 462 thousand, while during the busiest hour, the demand reached 62.6 thousand person trips (Source: Beijing Transportation Research Center).

The Opening and Closing ceremonies were of the most challenges of the transport organizing during Games time, for the extremely high population concentration in time and space. For the event itself, according to related record, 160.000 people were evacuated within 75 minutes after the Olympic Opening ceremony in Beijing (Beijing Transportation Research Center), while referring to the background travel needs, the challenges were risen much higher.

Table 4-8 Patronage of public transport on Opening and Closing ceremony days

(Thousands persons)

	Olympic Games		Paralympic Games	
	Opening ceremony day	Closing ceremony day	Opening ceremony day	Closing ceremony day
Public bus				
Overall	11,920	13,170	14,390	14,990
Olympic lines	75	205.4	101.2	113.5
Subway				
Overall	3,120	3,420	3,210	3,990
Olympic line	129.8	183	79	161

Source: Beijing Transportation Research Center

In Table 4-8, patronages of public transport including bus and subway are compared, from which we could found the most pressure for the Olympic lines (for both subway and bus) was on the Olympic Closing ceremony day. However, it is noticed that, for the overall public transport system of the city, patronage was much higher during Paralympics than Olympics. The students, who use public transport as their main daily travel mode, coming back to school in September might be a main reason for this.

4.6.2. Games related preparation and supplies

The Olympics brought Beijing unprecedented opportunities in advanced transport management, sustainable travel concepts and functional integration crossing the whole city and achieved great changes on transport facilities, along with the tremendous impacts. An integrated pattern of the urban, suburban, and inter-city traffic has been formed (Liu, Guo & Sun, 2008).

Numbers of improvements described in Section 4.3 were put for supporting Games time transport operation. Focus on public transport, high frequency was extended from around 8:00 a.m. to 6:30 a.m. to 9:00 a.m. for morning peaks. The operating bus trips increased from 152 thousand to 167 thousand per day. To make the public transport more convenient for both spectators and visitors, 34 special bus lines to Olympic venues as well as 28 special lines for the opening and closing ceremonies with 1,600 buses were planned and designed in addition to existing bus system, including 16 lines operated for the Olympic green, which was the most concentrated area during Games time. Furthermore, 28 special bus lines operated for the Olympic opening and closing ceremonies. These special bus lines were operated related to the competition schedule, at high frequencies. During 8^{th} to 24^{th} August, 142,803 bus trips had transported about 11.42 million passengers to and from the Olympic sites on the Olympic bus lines.

On the other hand, a remarkable achievement was on accessibility. Except for the 408 accessible ramps, 85 signage for the blind in both Chinese and English, 144 lower signage for wheelchair users installed at load/unload zone of Olympic sites, there were 183 accessible access/egress entrances designed in 64 subway, and 1,541 kilometres blind paths on 880 urban road as well as 14 dedicated parking lots plus nearly one thousand parking spaces designed to improve the accessible condition. Meanwhile, 2,835 accessible buses were put into use on Olympic bus lines. In total, more than 40 thousand disabled passengers used the accessible facilities on subway and public buses during the Paralympic Games time (Beijing Transportation Research Center, 2008b).

4.6.3. TDM measures for the Olympic Games

TDM measures have contributed greatly to the smooth operation of the overall transport system in Beijing, leaving significant legacy on mega event transportation management for both Beijing and the Olympic movements. The TDM measures carried in Games time of the Beijing Olympic could be summarized in following four programs:

1) Reduction for the number of motor vehicles.

Olympic vehicle reduction programs were considered to have contributed most to release the urban traffic with reducing nearly two million vehicles from the roadways in Beijing everyday during Games time, including:

- The 'Odd-even alternate day-off rule', which stipulated vehicles with odd numbered license plates could only be driven on odd numbered days only, and vice versa for number plates ending in an even number. Except the 136.2 thousand city-supporting vehicles (e.g.: fire trucks, ambulances, police cars and engineering service vehicles), 53 thousand games-supporting, as well as buses and taxis, this rule cut down around 1.95 million motor vehicles everyday and saved the road capacity for the significantly increasing demands (Source: Beijing Transportation Research Center);
- Seal up to 70% government-owned vehicles;
- Prohibit 400,000 yellow-labelled[3] vehicles within urban area and the motorbike within 4th ring road;

2) Establishment of Olympic special lane

A network of 285 km of Olympic lanes was established from 20 July to 20 September 2008 to facilitate the transport needs of athletes, other Olympic family members, and the accredited media between venues and accommodation sites, ensuring the athletes arrive for the competitions on time.

3) Staggering work hours and business hours for department stores

From a survey report, 48% companies including nearly one million employers took part in the campaign of staggering work hours, with 12% brought forward the work hour and 36% postponed from 8:30-9:00 to 9:00-10:00. Meanwhile, flexible working hours and working from Internet were widely encouraged.

Major department stores were also suggested to postpone their opening hour till 10:00 am or even later.

[3] Yellow-labelled vehicle: the vehicle failed to meet the Ev01 standard for exhaust emissions.

4) Adjust freight delivery in urban area to night time.

4.6.4. Performance

As a result of the preparation work, measures and all kinds of supports, the road network as well as the transport system had been greatly improved during Games time and facilitated the games transport services very well.

On road traffic, the recorded vehicle flow had been reduced by 22.5%-32.6%. According to relevant report, the average speed during peak hours had increased by 28.5% to reach 30.2 km/hour (a.m.), and increased by 24.1% to reach 25.2 km/hour (p.m.), while on the Olympic opening ceremony day, it achieved 35.4 km/hour (a.m.) and 31.0 km/hour (p.m.) during rush hours. It is reported that, average speed of the whole day in urban district reached 43 km/hour (Liu, Guo & Sun, 2008; Beijing Transportation Research Center, 2008b).

On bus operation, the average bus speed in the urban area increased by 9.4%-31.8% for whole day, with 2.1-5.1 km/hour increases during peak hours. (Source: Beijing Transportation Research Center)

In Table 4-9, the TDM measures implemented and performance during the Beijing Olympic and the Beijing summit & Third Ministerial Conference of Forum on China-Africa Cooperation, one of the most recent events held in Beijing with advanced TDM measures supporting, are compared. It shows that the transport system in Beijing had received much greater changes on transport system during the Olympic Games, including the decrease of traffic volume as well as the increase of travel speed, etc., which were believed to result from the larger scale measures implemented. One of the most significant differences between these two was that the Olympic Games last for much longer period than the other, requiring the policies and measures fitting longer period than the other, which made the changes penetrating into various corners of the daily life of the citizens in Beijing and effecting on the city travel pattern from the concepts to behaviours.

Table 4-9 Comparison of the TDM measures and performance (Beijing)

	The Beijing Summit of FOCAC	The 29th Olympic Games
Year held	2006	2008
Scope	> 3,500 persons, including: • Chiefs of State of 37 African counties, • Heads of Government of 6 African countries, • Officials of several international org. e.g.: UN	• 86 heads of state/gov., • 18,000+ athletes & officials, • 4,000 technical officials, • 5,000 Olympic family members • 26,500 credited media • 36,000+ sponsors • 81,500 staff & 100,000 volunteers • over 7 million spectators
Duration	6 days	17 days
Transport / traffic measures		
Vehicle reduction		
Odd-even alternate day-off	Nil	✓
Government vehicles seal	✓ (50%-80%, 900k vehicles/day)	✓ (up to 70%)
Other (yellow-labelled vehs. etc.)	N/A	✓
Traffic control		
Temporary road closure	✓	✓
Dedicated lanes/ORN	Nil	✓
Parking restriction (event sites)	✓	✓
Travel capacity creation		
Encourage holiday	Nil	✓
Alter work /school hours or locations	✓	✓
Stagger business hours	Nil	✓
Rerouting commuter traffic	✓	✓
Reschedule freight/truck delivery	✓ (6:00-23:00, within 4th ring rd.)	✓
Demand dispersing around the city	Nil	✓
Reduce other large-scale events	N/A	✓
Public transport enhancement		
Encourage alternative travel modes and reducing private car usage	✓	✓
Encourage car pool or car share	✓	✓
Improve public transport services	✓	✓
Increase the capacity	✓ (bus:10%; subway: 21.4%)	✓
Integrate multi modal travels	N/A	✓
Improve Taxi services	N/A	✓
Park & ride	N/A	✓
Designed bus lines for the events	Nil	✓
Improve pedestrian facilities	N/A	✓
Information / Communication		
Travel guides for residents	✓	✓
Real-time information signings	✓	✓
Discourage the residents to travel and congestion warning	✓	✓
Communicate/marketing with large org.	✓ jointly by 180 orgs	✓
Transport performances		
Decrease in traffic flow / volume	5.8% (am peak), 5.3% (pm peak)*	23%
Increase in traffic speed	7.4% (am peak), 15.6% (pm peak)*	28.5% (am peak)*
Patronage growth on public transport	Bus: 2.94%–5.83% (300k - 590k); Subway:15.7%–28.3% (270k –510k)	Subway: 19.7%; Taxi: 18%

*In Beijing, am peak is 07:00-08:00 in the morning, while pm peak is 17:00-18:00 in the afternoon in normal days.

Sources: (Bovy, 2009b; Guo et al., 2008; Liu et al., 2008; Liu, Guo & Sun, 2008)

4.6.5. Olympic legacies on transport of Beijing

As stated by IOC when they summarized the Beijing 2008 Olympics, the Beijing games left the city, and the entire country, with an undeniable legacy in the areas of infrastructure and transport. The great success and splendid legacies shall have far-reaching effects on the history of both China and the Olympic movements, which could be summarized into five scopes:

1) **Unprecedented developments on urban transport system, including constructions, technologies, and accessible facilities, etc.**

Same as previous games, the Olympic brought Beijing great opportunity and left the legacies afterwards in the urban development, especially in the transport facilities. As staging the Olympics, Beijing made historic developments on transport in the past seven years, in roadways, airport, subway and public transport services, which will obviously improve the daily travel of Beijing city after the games and have laid very good foundation of the developing trend of public transport for the whole city.

2) Build up the cooperation, coordination and integrated communication between transportation authority and other city operation function areas.

One of the most important legacies is considered to be the coordination and communication for the transport management, together with other city functions. The games gave great a chance to integrate different city functions together, to ensure smooth operation of the games. The experience gained from the games is believed to very valuable for future events' organizing.

3) Integrated information provision and communication strategies

As described in Section 4.6, various TDM measures were implemented for Beijing 2008 Olympics, including providing kinds of information and launching several communication campaigns, which contributed greatly to the success in reduction of local travel demands and the scheme of promoting smart travel for both citizens and spectators. The channels and methodologies used had been approved to be effective and efficient, which will be very helpful for the 'green travel' promotion in the future.

4) Concepts of 'Green travel' for travellers in Beijing and even the whole country.

Through the largest and longest propagations ever, the public of Beijing even the whole country have been educated with the 'Green travel' concept, as those with previous Olympic Games. The considering of choosing greener travel modes, ways of travelling smarter have shown their effects on changing the travel behaviours of the public, which were believed to last longer. It is expected to be a greatest legacy left from the Olympic Games to the transport of the city, with further efforts and lasting inputs. How to transfer such changes to longer term travel patterns is consequently a most interest of this research.

5) Knowledge of mega-events organizing for Beijing and other cities.

There is no question that the knowledge transferring for the city itself as well as between cities for future mega events' organizing will be of invaluable treasure. Particularly on transportation, the experience, including the success and disadvantages will be of great legacies for the sustainable transport development in Beijing as well as future Olympic host cities.

4.7. Discussion

Beijing, as a world-famous old city with an incredibly rapid growth rate, is facing unprecedentedly severe challenges in its urban transport development with hectic growth of motor vehicle usage. The concentration of population and significant travel demands lead the city into a congested era and the transport issue has become one of the most focused problems for the city in its recent history. The 2008 Olympic Games were not only considered as a great success, which undoubtedly gave the city especially the city transportation tremendous legacies in tangible and intangible ways, but also awarded the city great opportunities in thinking about the future development for transportation. As the IOC Olympic transport expert Philippe Bovy said, "Olympic Summer Games are one of the most unique 'transport and advanced mobility management laboratories in the world' and a significant contribution towards more sustainable mobility development. Presenting findings and insights on how a transportation system performed during such a mega event and the potential changes to the urban transport patterns could be particularly useful for both the city itself as well as future hosts, especially on the development of sustainable urban transport.

The success of the Beijing Olympic transport planning and operations merits serious attention. The expansion of the subway networks, the upgraded public transport services and the improvement in accessibility have not only supported the Games' successful operations, but also continuously influenced the local travel patterns. On one hand, a good balance between the Games' requirements and local transport demand is crucial for the success of the Games time operation and lasting legacies. Different from Atlanta, the usual daily demands of public transport for Beijing is huge. It was much easier for Beijing to handle the immediate increase during Games time and avoid an out-of-control situation. Viewing the longer term, an integrated plan matching the Games requirements to local travel demand is well worth our while. Taking Beijing and Sydney as examples, the former had a huge potential demand on public transport and got a continuous growth in daily patronage on the upgraded public transport system, while the railway line built for the Sydney 2000 Games turned empty after the Games because of its weak connection to the local residents' demands (Bovy, 2001; Hensher & Brewer 2002). On the other hand, we can see that hosting the Olympic Games in such a fast developing environment of local transport would have big advantages. Similar to the case of Athens, the Olympic Games had shortened the delay of transport development in Beijing. Some aspects of transport system such as subway system and accessibility had been greatly improved. The parallel progress for urban transport and Games transport has given the planners a very good opportunity to match the demands and popularize the new/upgraded services. We also find from the Beijing case that, even though the Olympic Games' effects on encouraging sustainable travel patterns such as reducing private car usage, car pooling, and travelling by public transport were observed subsequently to be weakened gradually or even vanished, they still gained some time to develop public transport which had long been considered to lag far behind need.

However, we need to be careful when doing comparative analysis for the case of the Beijing Olympic Games with other planning. Some conditions of the 'experiment' of the Beijing Olympics were special, without parallel elsewhere.

For the city itself, Beijing was in a very unique stage with a rapid growing trend in motorization and intensive transport development during the few years before the 2008 Olympic Games as discussed earlier in this chapter. The powerful underlying trends in Beijing transport, which was related to the dramatic growth in economy and car ownership, perhaps overshadowed the influencing factors coming with the Games themselves. Take the number of vehicles in Beijing as an example, it took 48 years (1949-1997) to reach the first million, six and a half years (1997-2003) to get to the 2^{nd} million, and three years and nine months (2003-2007) to increase from 2 to 3 million (Source: Beijing transport research centre). The growth was faster than ever and it is very difficult to tell the influences between the underlying factors such as the increasing car ownership and the measures taken for Olympics separately. Understanding the characteristics of this unique developing stage for Beijing transport is very crucial for the related comparisons and future planning for the city.

Compared with other Olympic host cities, we can also see that Beijing was a unique case with its significant development in infrastructure, road network, public transport services, ITS; as well as policies. As the capital of China, Beijing has been given plentiful resources for its urban development, which bring great opportunities and attract people to work and live there. For the residents, their incomes and life qualities have been significantly improved, reflecting in the average annual increase of 15% or even more in local GDP (Figure 4-9) and the growth of household car ownership: from 15% to nearly 45% between 2001 and 2007. Considering the growth of household car ownership in London (from 61% to 66% between 2001 and 2007) and Sydney (from 86.94% to 86.81% between 2001 and 2006), Beijing was in a much more dynamic state in urban transport development. On one hand, the residents had an increasing travel demand especially for entertainment and leisure, while the structure of their travel purposes became more complicated. There were scenarios that were hard to expect and forecast. On the other hand, the residents were observed to have an increasing interest in purchasing and using a car. The increasing trend was unstable and easy to be influenced. The travel pattern of the potential car users and new car users were more changeable and unpredictable, and different from the residents in the traditional motorized cities. It was reported by the Beijing Transport Research Center that Beijing residents, particularly new car users were observed to be more likely to travel by car within the urban area and use car for short-distance trips (<5km). Due to the low cost of using and parking cars, the Beijing residents used car more frequently to travel within the urban area. The mode share of car in the central area of Beijing was above 25%, which was more than double of that in central London. Of overall car trips in Beijing, more than 40% were only 5 km or less (Source: Beijing Transport Research Center). Furthermore, Beijing has some traditional transport-related issues which were not common in other cities, such as government-owned cars, etc. With such pressures and developing opportunities in travel demand management, the ‘experiment’ of behaviour change and travel demand management that the 2008 Olympics provided was far from ‘controlled’. We need to clearly understand these differences when doing comparisons between these host cities and referring to future planning.

Chapter 5

SURVEY

In order to capture and understand the travel behaviour changes of the residents living in Beijing in the circumstance of such a special event as the Olympics, this research is taking investigation with large household and in-street surveys in Beijing, which were carried pre- and during the 2008 Olympic Games. The information will be compared and analyzed with the normal situations longitudinally, aiming for better understanding the immediate responses of travellers to the transport measures and the potential travel behaviour in future. The results may have strategic implications for future planning and evaluating of mega events, for long-term benefits and further destinations. This chapter will give an introduction of surveys to be used in this research, followed by the validation of the collected database for future research.

5.1. Introduction

The Beijing transport survey is a continuous survey of the travel patterns of Beijing citizens, which is the most comprehensive source of information on residents' daily travel and best way of understanding their behaviour changes. In order to help with understanding the actual travel patterns in the circumstance of the Olympics as well as the relative behaviour changes, Beijing Municipal Committee of Communications designed a series of surveys to the Beijing residents, while the most recent one before the games was carried in 2005. The 2008 transport surveys were designed in the same level as previous with specific timeline according to different games stages as shown in Table 5-1. According to the Beijing Transport Research Center, which was authorized by Beijing Municipal Committee of Communications to bring out these surveys and relevant research, the purposes of these surveys were:

1. To give quantitative analysis on the impacts of Olympic Games to local residents' travel behaviours, and make recommendations for future events;
2. To understand the public attitudes towards Olympic related TDM measures;
3. To evaluate the performance and effectiveness of Olympic related measures to the urban transport system;
4. To evaluate lasting effects of Olympic related transport measures, and support post-Games' planning for urban transport.

In each wave of the household survey, about seven thousand residents' trip details are recorded together with their demographic information. The data is primarily collected by face-to-face interviews at homes. The first survey took between mid-May and beginning of June in 2008, which was to identify the 'pre-Games' for the basic travel patterns of Beijing citizens. The second one 'Games-time' was carried when the actual games were there, with the most exciting competitions and hundreds of thousands of cheering people everywhere and enormous challenged on the city operation, and different TDM measures were implemented, which brought unprecedented experience to not only the spectators and visitors, but also the residents of Beijing. The third one was launched in June 2009, the year following the Beijing Olympic Games.

Table 5-1 Beijing Household Transport Surveys

Survey	Clients	Survey date (period)	Number of Samples	
			Inhabitants	Number of trips (After process)
Phase 1 (Pre-Games)	Residents of the city of Beijing	June, 2008	7,648	17,919
Phase 2 (Games-time)		August, 2008	7,763	18,205
Phase 3 (Post-Games)		June, 2009	6,928	15,764

A supplementary survey was carried out by Beijing Municipal Committee of Communications in 2008 as described in Table 5-2, which investigated on specific issues or targeted client groups. These surveys with focus on the car use, attitudes towards relative policies, etc., will be used for exploring travel behaviours changes of particular client groups.

Table 5-2 Supplementary surveys for Beijing Transport (2008)

Category	Clients	Survey date (period)	Num. of Samples
Attitudes on transport policies	Public Transport Passengers	2/9-5/9 (Games-time)	3,460
	Car Users	2/9-5/9 (Games-time)	1,864

With information gained from these surveys, the Beijing Transport Research Center produced a series of reports on Beijing transport developments and the Olympic transport performance. Due to the main purpose of these surveys, the output focused on the overall evaluation of the whole city's transport operation and performance with various collective descriptions, rather than a detailed analysis on individual behaviour or behaviour changes. We feel that much further studies can be made and more information can be extracted from the data, which is very valuable and contains a great amount of information on the residents' travel patterns and changes. Thus, the author tried to get access to the database, which is impossible to collect for individual researchers without government assistance, to facilitate further research on travel behaviours and behaviour changes. However, there were some limitations or shortages in the survey design for behaviour changes studies, particularly in the following three aspects:

- The changes in surrounding travel circumstance. The surveys, in particular the second wave, didn't provide sufficient information about how the interviewees' surrounding travel circumstance changed. It was difficult to identify how the interviewees' daily travels were actually impacted by the Olympic TDM measures and whether they were provided with alternatives and upgraded public transport services. Such information is crucial to make the research is pertinent and targeted.
- Perceived behavioural controls. The surveys didn't include the questions about the interviewees' perceived behavioural controls. It may be because the main purpose of these surveys was for a collective analysis. Due to the shortage, it is impossible to apply the Theory of Planned Behaviour in this research with the database.
- The consistency of interviewees. Comparing the three waves in the main household survey, we found that the interviewees were not completely the same across different waves. Only 2,450 of the 7,000 interviewees attended all the waves, who can be used to track the individual changes in travel behaviour. Also, the supplementary survey for attitudes towards TDM measures was not consistent with the main household surveys (for example, it was based on surveys at parking lots and at public transport stops), which brought a big challenge for a comparative study.

5.2. Methodologies

There were three kinds of ways for taking the surveys: household visit, in-street interview and online surveys.

Main part of the survey was carried by household visiting. With the supports from government and local authorities, the residents were reached to be recorded their travel diaries on the day of visiting or the previous day. They were also asked to provide their attitudes towards to the games and relative measures, which were used to help understanding the overall intentions and propensities of the changes. No different from before, the survey areas were selected in keeping with the geographic characteristic of demographic.

As shown in Table 5-2, there were two other supplementary surveys taken, one was in-street interview, which mainly located in car parking and bus/subway stations, aiming in the car users and public transport passengers specifically. However, an online survey was also launched during the same period, investigating the car users' about the changes on their daily travel as well as their opinions on the relevant TDM measures.

5.3. Questionnaire

The questionnaire of Beijing Household Transport Survey which attached in Appendix I includes following sections:

- Demographic
- Traveller diary record
- Daily vehicle parking information
- Drive route
- Games-related attitudes

Demographics

To get the accordance of identification of grouping decision makers, the demographics part made up of basic personal information and household information which includes geographic location, household type, accommodation condition, car ownership, etc. This part is to investigate the characteristics of social and economic situations, as well as car ownership. Refer to aggregate model, the data collected in the demographic survey will be aggregated in certain parts according to the travellers' demand as well as the attributes of choice set. It will be the basis of the relationship analysis between decision makers and their corresponding and preference in further research and analysis.

Traveller diary record

As one of the most important part of the survey, this part records the trips taken by the interviewee on the day of investigation or the day prior, including the information on travel modes, trip purpose, the origin and destination, and time of travel, etc. The information provides substantial data resource for understanding why people travel and how they travel in this city. Compare the information from similar surveys but taken in different period of 'normal', 'pre-Games' and 'Games time' provided the opportunities in observing the mobility changes in this city.

Daily vehicle parking information & Drive route

These two parts were about the car parking and driving route during daily travel, including the information on walking distance for the parking, the parking fee, etc. The most interesting issue on this part might be the number of passengers sharing a car for travelling.

Games-related attitudes

This part is designed specifically for games relative studying, which includes the travel behaviours and alternative travel options under the games circumstance, as well as certain changes on the daily life of the residents, especially on work-related aspects. People were asked about their activities towards to the games, and the changes concerning with commuting travels. This information didn't only provide the opportunities in demand forecasting, but also give the knowledge on propensity of changes in travel patterns, which is essential and invaluable for strategies and policies making for the games and even after.

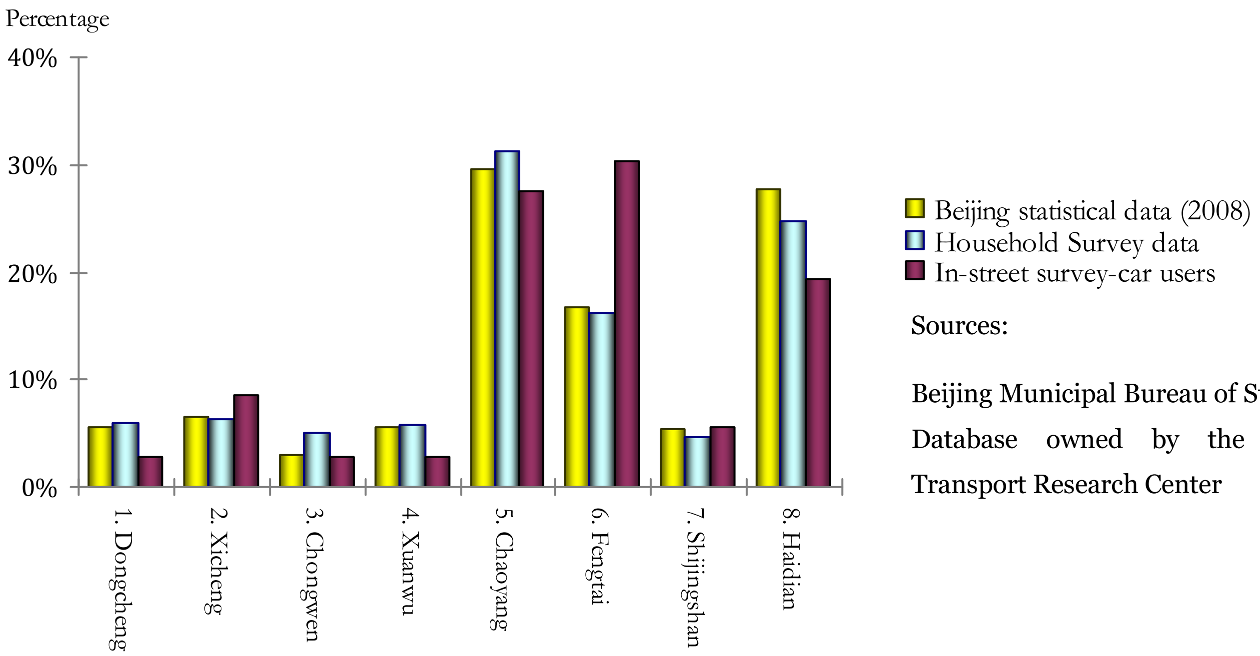
Open comments

As compensation of other parts, the open comment is supposed to get latent psychometric influence on people's choice that is not covered by above questions, especially in environmental and cultural relevant.

5.4. Data validation

In preliminary study, data validation has been processed by comparing the demographic information collected in the surveys together with the background statistics information of the city of Beijing as shown in Figure 5-1, 5-2 and 5-3.

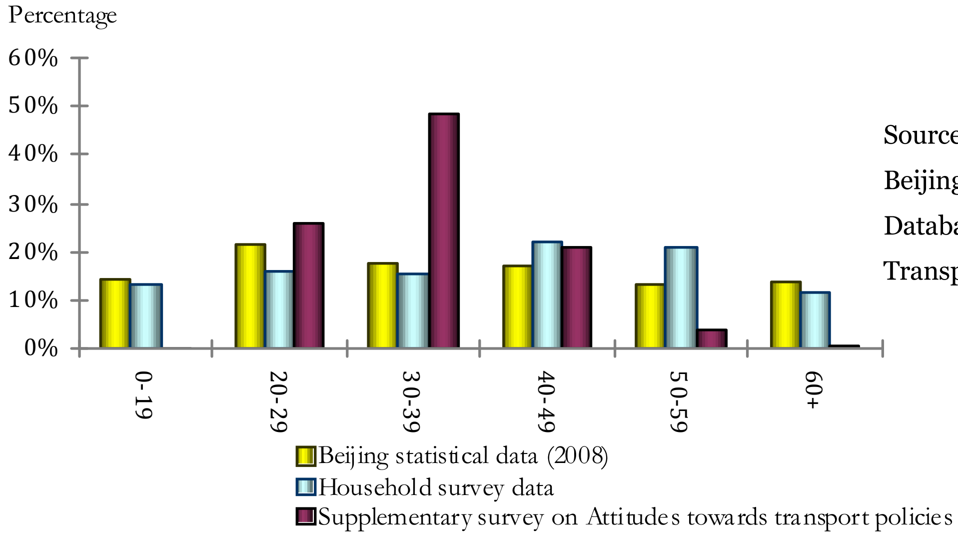
Figure 5-1 Population by residential area



Sources:

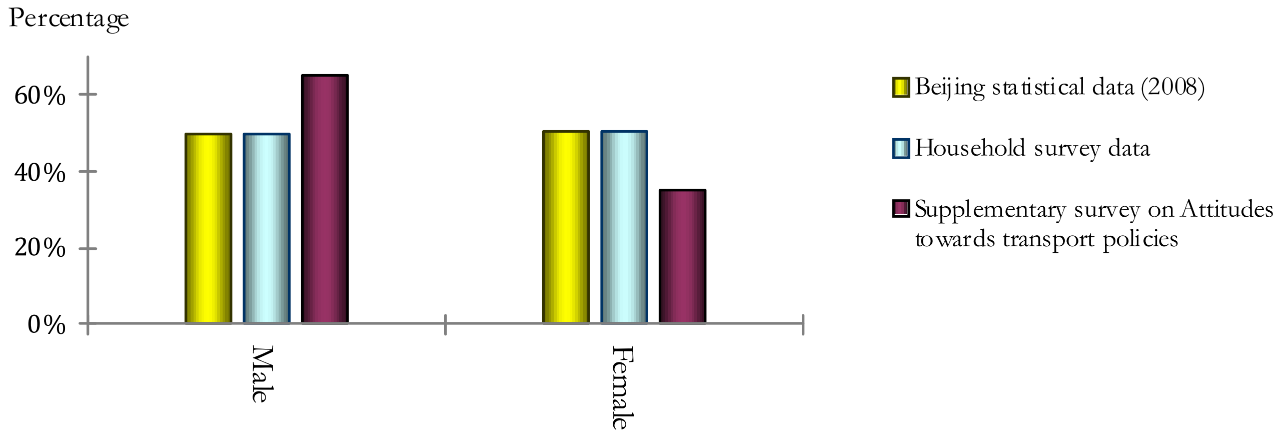
Beijing Municipal Bureau of Statistics, Database owned by the Beijing Transport Research Center

Figure 5-2 Population by age



Sources:
Beijing Municipal Bureau of Statistics, Database owned by the Beijing Transport Research Center

Figure 5-3 Population by gender



Sources: Beijing Municipal Bureau of Statistics, database owned by the Beijing Transport Research Center.

5.5. Data pre-processing

As this research will adapt the definition of trip as 'a travel with a specific purpose', there is some redundant information in the database confused the research, due to the questionnaire design. Following items stated in 'Trip purpose' made it difficult to count the number of trips by purpose.

4. to station,
5. for transferring,
15. fetch car,
16. parking

To reduce the redundant information, the author developed a programme to rewrite the trip records by changing the original trips into trip sections, then integrating the relevant trip sections which went for a same final purpose and destination into a complete trip record. In this way, the trips with 'transfer' purpose (refer to the four purposes above) only were not an independent trip any more, while the information was still kept for further research on access and egress condition, integration between travel modes etc. Figure 5-4 shows the logic of the programme, and Figure 5-5 gives the example of this pre-processing of data.

Figure 5-4 Pre-processing for the survey data

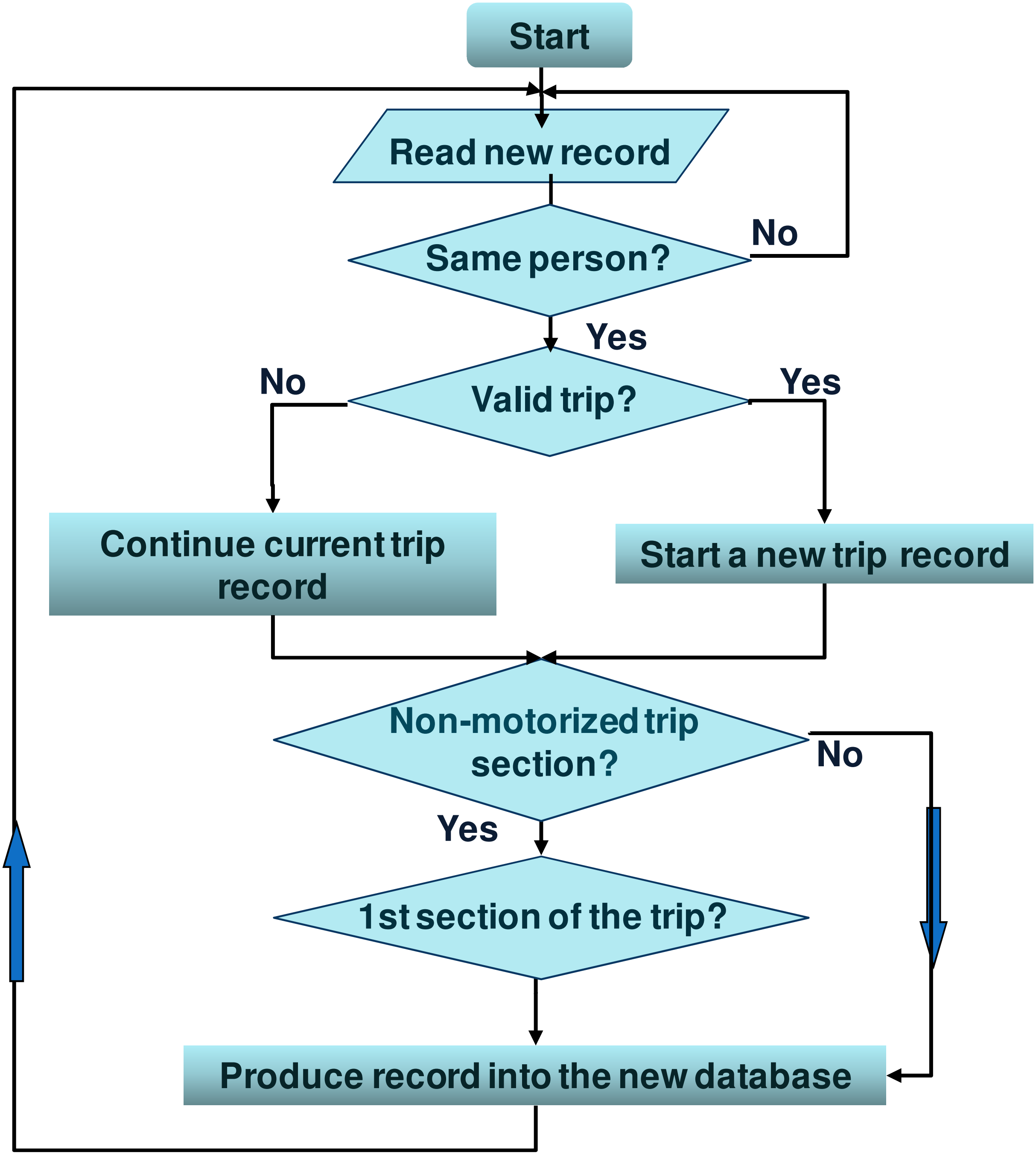


Figure 5-5 Example of data pre-processing

The original data

Family ID	Member ID	Trip Ref. No.	Origin Code	Dep. Time	Travel mode	Destination-code	Arr. Time	Travel distance	Bus line	Journey purpose	Journey time
01010417015	1	1	1	05:30	1	10104	05:40	500	0	4	10
01010417015	1	2	1	05:45	5	10401	06:00	2000	22	5	15
01010417015	1	3	1	06:10	5	91600	07:15	20000	345	5	65
01010417015	1	4	1	07:20	5	91000	08:00	8000	22s	4	40
01010417015	1	5	1	08:00	1	91000	08:30	1000	0	8	30
01010417015	1	6	1	15:30	1	91000	16:00	1000	0	4	30
01010417015	1	7	1	16:00	5	10401	17:00	20000	345	5	60
01010417015	1	8	1	17:00	5	10401	17:30	2000	22	4	30
01010417015	1	9	1	17:10	1	10401	17:40	500	0	3	30

Results

Family ID	Member ID	Journey purpose	Travel mode	Bus lines	Journey Time_min	Travel Dist_m	Transf _No	Transf_ min	Ingress W	Egress W	Ingress T_min	Egress T_min	Trip _t1	Trip _t2	Trip _t3	Dep Time	Arr Time
01010417015	1	8	@5@5@5	@22@345 @22s	180	31500	2	20	1	1	10	30	15	65	40	05:30	08:30
01010417015	1	3	@5@5	@345@22	130	23500	1	0	1	1	30	10	60	30	0	15:30	17:40

5.6. Sample data set

In order to track the changes in individual travelling methods, the database were carefully compared and matched, finding 2,450 residents (the same person) who took all of the three waves of survey: Pre-Games, Games time and Post-Games, and didn't move house during these periods. Thus, following research will take the information of these 2,450 residents as sample data set for further comparison and cluster analysis as well. Through the validating comparisons in Figure 5-6~10 below, the sample data set matches and represents the original whole set of data very well.

Table 5-3 Whole data set and Sample data set

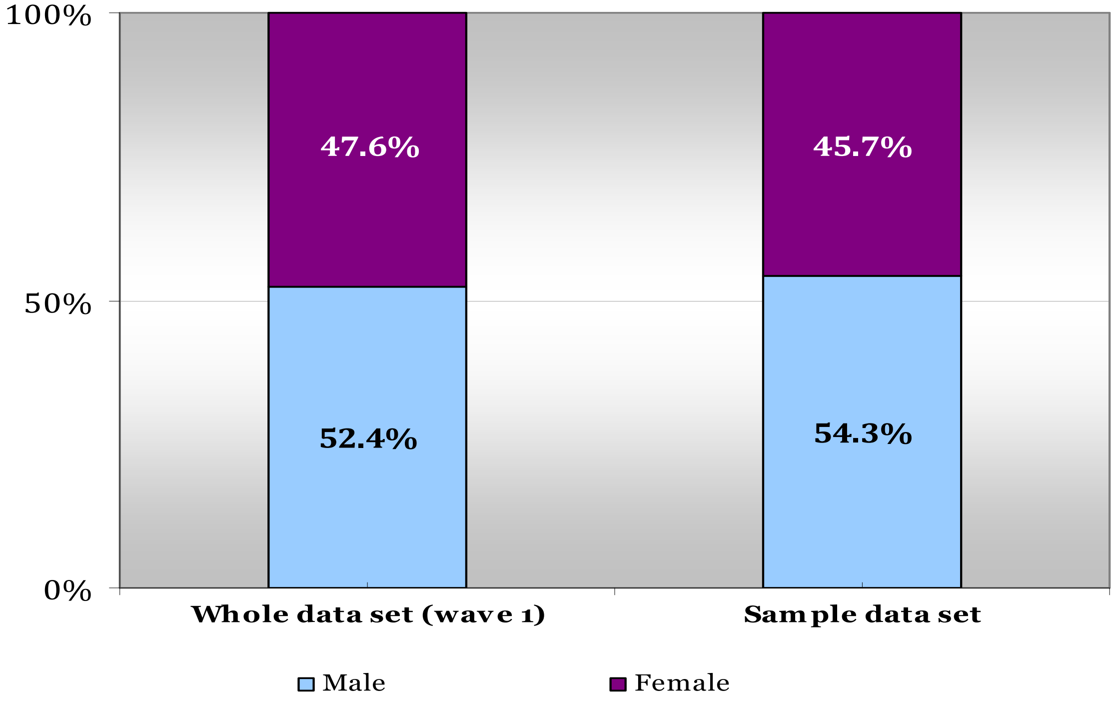
	Survey date	Survey area	Num. of Samples	
			Inhabitants	Num. of Trips[1]
Whole data set				
Wave 1 (Pre-Games)	June, 2008	Beijing urban areas[2] (Districts 1~8)	7,648	17,919
Wave 2 (Games time)	August, 2008		7,763	18,205
Wave 3 (Post-Games)	June, 2009		6,928	15,764
Sample data set for cluster analysis				
Wave 1 (Pre-Games)	June, 2008	Beijing urban areas[2] (Districts 1~8)	2,450	6,137
Wave 2 (Games time)	August, 2008		2,450	5,705
Wave 3 (Post-Games)	June, 2009		2,450	5,724

Source: database owned by Beijing Transportation Research Center
Note: 1. including walking trips only.
2. Refer to Table 4-3.

5.6.1. Data validation

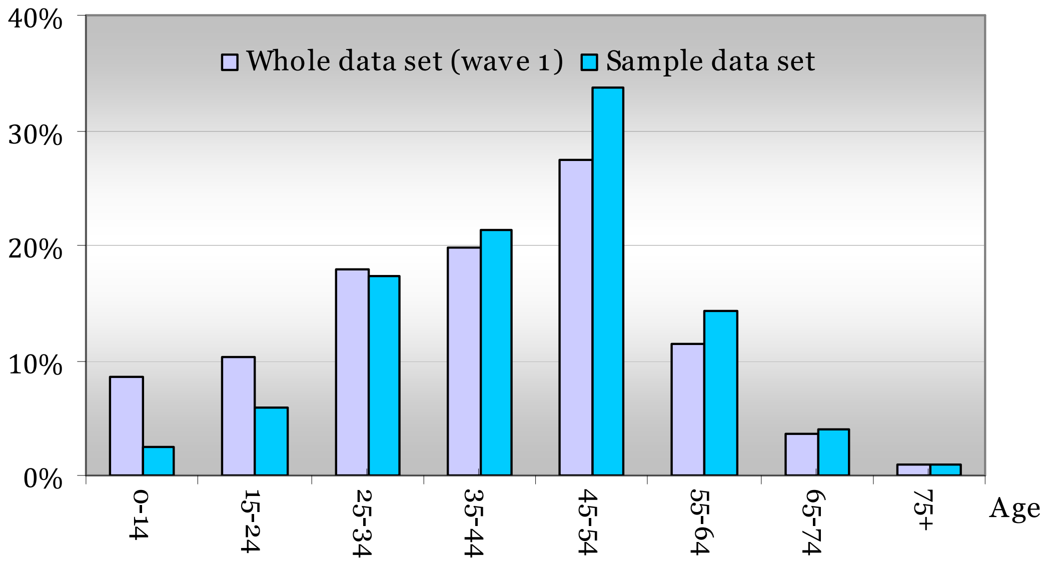
By comparing the demographic information between the whole data set and the sample data set in Figure 5-6~10, it could be learnt that, the background statistics information of sample data set fits that of whole data set very well. They were very close in most aspects especially the population by gender and residential areas. However, there was certain bias in ages due to the nature of the survey and its responders.

Figure 5-6 Population by Gender



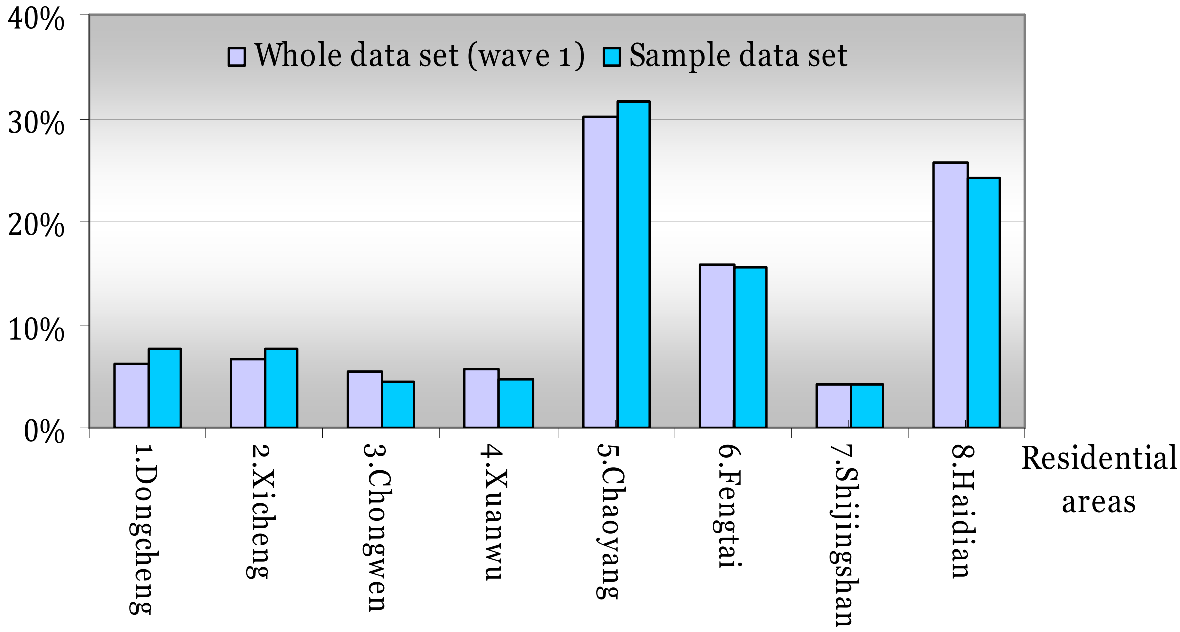
Source: database owned by Beijing Transportation Research Center

Figure 5-7 Population by Age



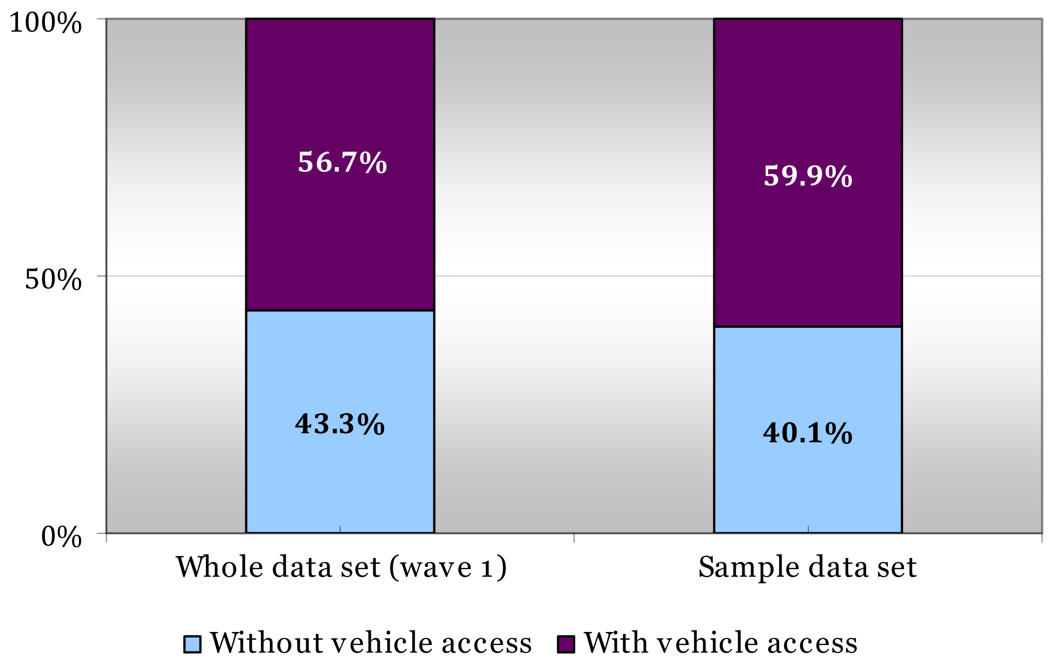
Source: database owned by Beijing Transportation Research Center

Figure 5-8 Population by Residential area



Source: database owned by Beijing Transportation Research Center

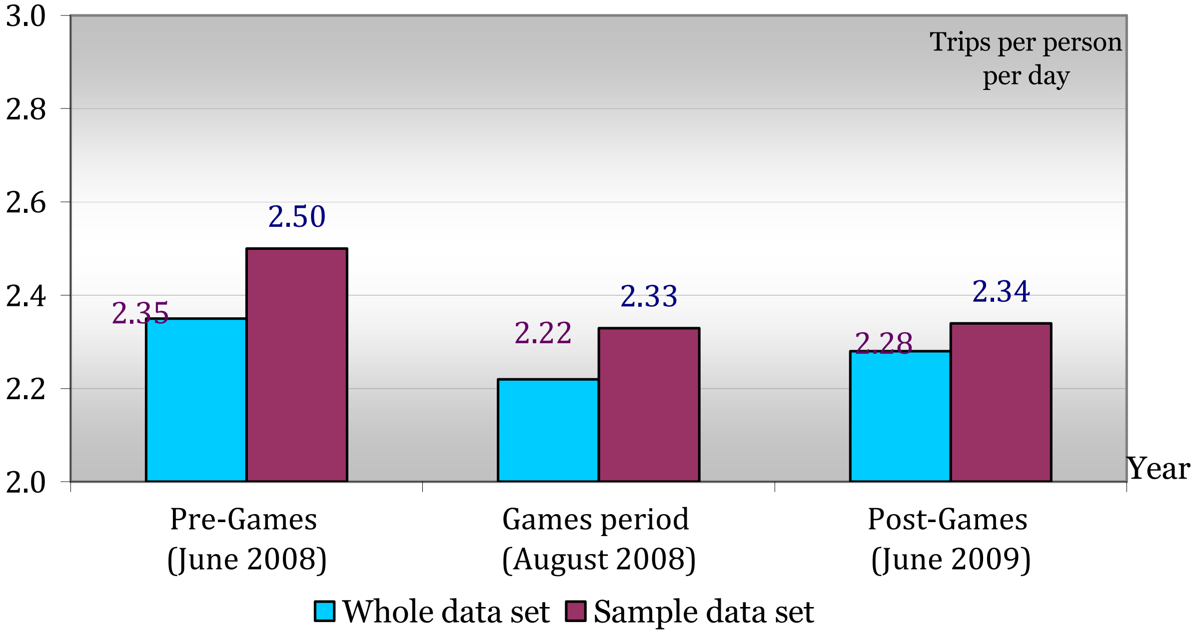
Figure 5-9 Population by Accessibility of vehicles



Source: database owned by Beijing Transportation Research Center

Calculating the trip rates for both data sets, the curves of sample data set appear consistent with that of whole data set as in Figure 5-10. The trip rates of sample data set are slightly higher than whole data set, which was due to the bias in ages. As found in Figure 5-7, the sample data set includes significantly bigger groups of age between 35~44, 45~54 and 55~64, who actually travelled the most of all residents.

Figure 5-10 Trip rates of both data sets



Source: database owned by Beijing Transportation Research Center

5.6.2. Data standardization

In order to calculate the movement in travel modes of residents, as well as categorize samples into groups for investigating changes, standardization was applied to the sample data sets. This process aimed to define one primary travel mode for each person and was progressed as following rules:

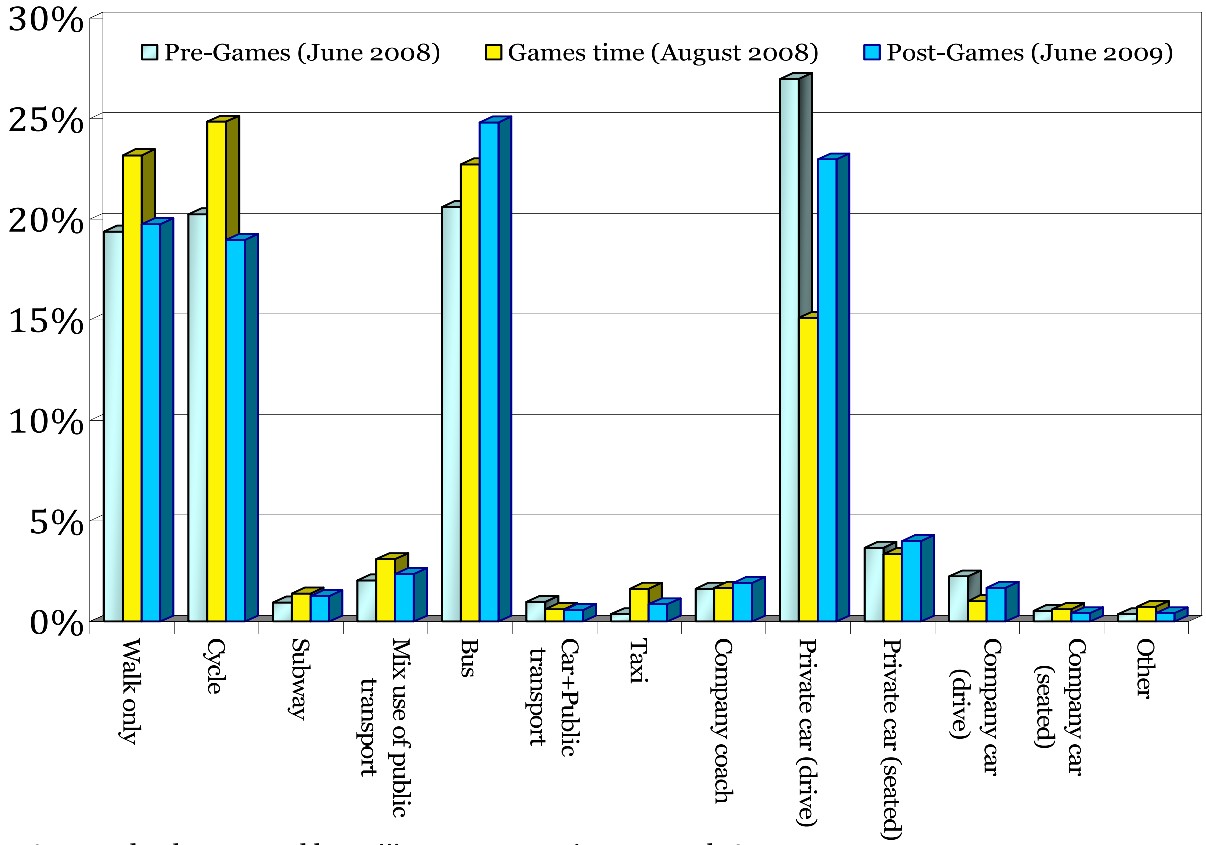
1. If the person used just one kind of method for all trips, set the travel mode as his/her primary travel mode.

2. If the person used more than one travel mode, set the mode he used for work as his/her primary travel mode.

3. If the person used both motorized and non-motorized travel modes for trips, e.g. used bicycle then buses for work, set the motorized one as his primary travel mode.

After standardization, the share of primary travel modes in sample data sets is as shown in Figure 5-11. It needs to note that the share of primary travel modes is based on travellers, rather than trips as before.

Figure 5-11 Share of primary travel modes (by person) in sample data sets



Source: database owned by Beijing Transportation Research Center

We need to notice that this data standardization may bring bias to the analysis. A main issue is the primary travel mode may be identified inappropriately for the interviewees who didn't travel as usual on the interview day, because each wave of survey only took one-day records. As the first and third surveys were carried out on weekdays in June, we assume that there was no seasonal difference between these two surveys. But the second survey was carried out in August. Although there was no significant seasonal difference in travel demands recorded in Beijing, most students and teachers were enjoying their summer vacations when the Games took place. Thus, the standardization process of primary travel modes for the students and teachers, as well as the interviewees who were employed but didn't make any commuter trips on the interview day may bring bias to the analysis. Considering this point, we add specific comparisons by purpose (e.g. commuting trips) across the three-wave surveys for a better and more accurate result.

5.7. Discussion

This chapter introduced the continuous survey on Beijing transport as well as the supplementary surveys. Compared with the original purpose and report of these surveys, which focused on evaluating the performance and studying the travel behaviour changes in aggregate, this research will emphasize the individuals' travel patterns and changes to improve the understanding of Olympic impacts on residents' travel behaviours. According to the research objectives and the nature of the dataset, there were some shortages in questionnaire design. A pre-processing is undertaken here for the travel records from the household survey. It combines the stages belonging to a same trips together, to provide the opportunity of getting accurate information on daily travel patterns of residents, such as trip rate (number of trips per person per day), time of travel, journey purposes, etc. The other purpose of the pre-processing is to eliminate or revert the redundant journey stages during the trips such as 'fetch car'.

Particularly, a sample data set was selected from the three-wave surveys to form a true panel data to track the travel behaviour changes of residents across the pre-Games, Games time and post-Games periods. By studying the sample data set, it is possible to investigate the travel records of the same persons, and compare their behaviour changes during the examined periods. Because there were interviewees observed to not travel as usual on the interview days and most students and teachers were on summer vacation during the second wave of surveys, extra comparisons by travel purpose are considered in this research.

Data validation is also given in this chapter for both data sets: whole data set and sample data set. The results show that the data sets are well fitted to the background demographic characteristics of Beijing residents, and are considered as a valuable and reliable resource for the study in travel behaviour changes, especially in the context of the Olympic Games.

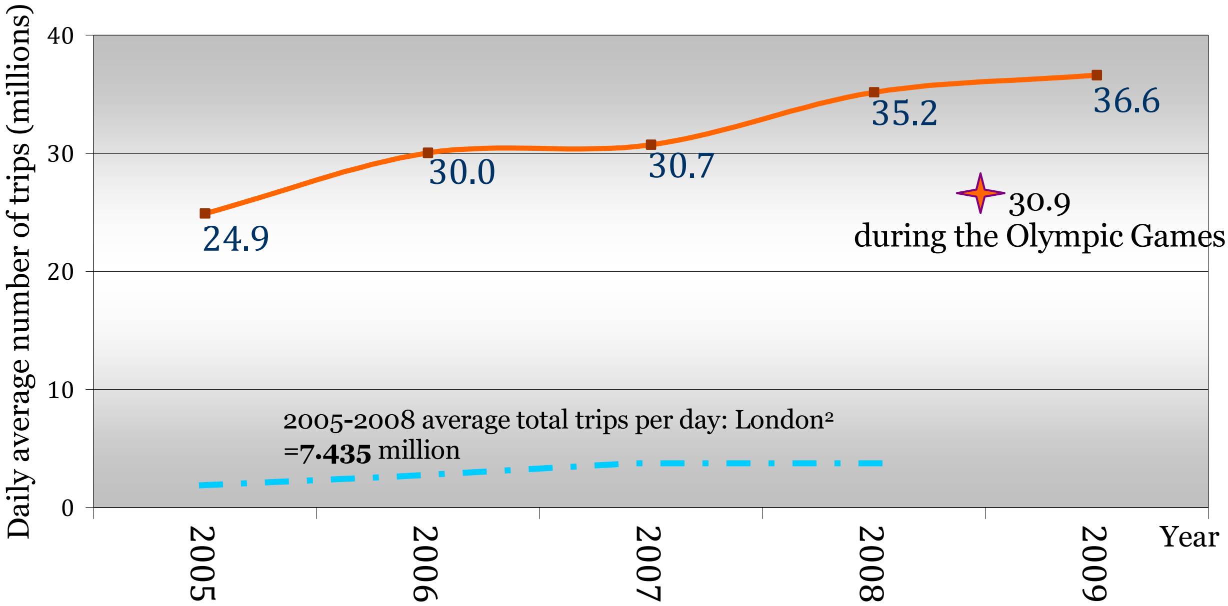
Chapter 6

DATA ANALYSIS: IDENTIFYING THE CATEGORIES OF TRAVEL BEHAVIOUR CHANGES

The daily travel patterns of Beijing residents were observed to have been influenced significantly by the development of infrastructure and transport facilities ('hard factors') and various Travel Demand Management (TDM) measures ('soft factors') associated with the 2008 Olympic Games as discussed in Chapter 4. This Chapter aims to identify the changes in travel behaviours of Beijing residents resulting from the particular transport circumstance of the Olympic Games.

6.1. Trips and Trip rates

Figure 6-1 Daily average number of total trips (including walking trips[1]) of Beijing residents



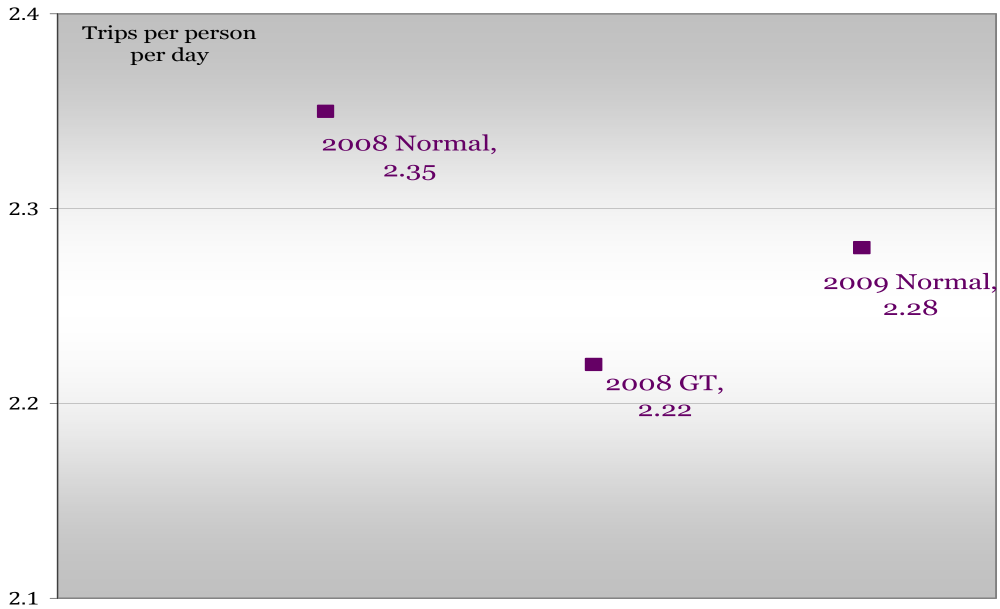
Sources: Beijing Transportation Research Center (2004, 2005, 2006, 2007, 2008a), Travel in London-Report No.1

Note: 1 Walks are counted only when they form complete trips (i.e. walking all the way), not when they are part of trips using other modes of transport.

2 For the 2005-2008 average trips per day in London please refer to the "Urban area" identified in Table 4-3. The total includes Central and East London.

As discussed in Chapter 4, the travel demand in Beijing is huge, with a substantial number of daily trips. The trip volume of Beijing residents has continually climbed up in recent years with an average annual growth of about 5.4 per cent, from 10.8 million in 1986 to 34.4 million in early 2008 (Figure 6-1). However, this trend was interrupted and dipped during the Olympic Games, when various Travel Demand Management (TDM) measures were introduced. As can be seen in Figure 6-1 that, the total number of daily trips during the Olympic Games dropped to 30.9 million, which was 3.5 million less than the average level of 2008. Furthermore, the rate of growth for daily total trips showed after the Olympic Games, reflecting a lasting effect of the Travel Demand Management (TDM) on residents' travel pattern. The total number of daily trips only increased by 6.4% between 2008 and 2009, compared to 12.1% between 2007 and 2009.

Figure 6-2 Average trip rates (trips per person per day) in different waves of the surveys



Source: database owned by Beijing Transportation Research Center.

Accordingly, trip rates (trips per person per day) for Beijing residents moved in a similar way, which were observed to grow steadily in recent years, from 2.42 in 2004 to 2.53 in 2007 (Beijing Transportation Research Center, 2005, 2008a).

This movement is clearly stated in the comparison among the different waves of the survey. It is shown in Table 6-1 that, changes in trip rates (trips per person per day) were statistically significant across the Pre-Games period (June 2008), 2008 Olympic Games time (August 2008) and the Post-Games period (June 2009).

Table 6-1 Trip rate (trips per person per day) in different waves of the survey (1)

Periods	N	Mean	SD	Difference in trip rate (compared with Pre-Games in June 2008)			
				Num.	%	t	Sig (two tails)
Pre-Games (June 2008)	7,648	2.35	.909	-	-	-	-
Games time (August 2008)	7,775	2.22	.715	-0.127	-5.40%	-9.504	<.0001
Post-Games (June 2009)	6,928	2.28	.790	-0.069	-2.94%	-4.796	<.0001

Source: database owned by Beijing Transportation Research Center
Note: Including walking trips only.

Table 6-2 Trip rate at different waves of the survey (2)

Difference in trip rate between	Mean diff.	%	T	Sig (two tails)
Post-Games (June 2009) & Games time (August 2008)	+0.061	+2.75 %	4.766	<.0001

Source: database owned by Beijing Transportation Research Center
Note: Including walking trips only.

Beijing residents reduced their daily travel significantly over the time of the Olympic Games. As shown in Figure 6-2 and Table 6-1, the Beijing trip rates (trips per person per day) reached its lowest point at 2.22 in August 2008. According to an accompanying questionnaire, it is understood that the 5.40% reduction in resident travel was due to a mixture of the launch of Travel Demand Management (TDM) measures and traffic control, the public transport promotion schemes, the holiday programs, and the fear of crowds in the street.

After the Games, travel levels grew again when the main traffic regulations were removed. The average trip rate rebounded to 2.28 in June 2009, which was however still noticeably less than that before the Games. Compared with the same month in 2008, there was still a decrease of 2.94% in trip rates in the survey of June 2009. But as can be seen in Table 6-2, the change in trip rates was smaller between Games time in August 2008 and Post-Games in June 2009, implying that some residents maintained their changed habits from Games time.

6.2. Mode shares and Modes used

6.2.1. Mode shares

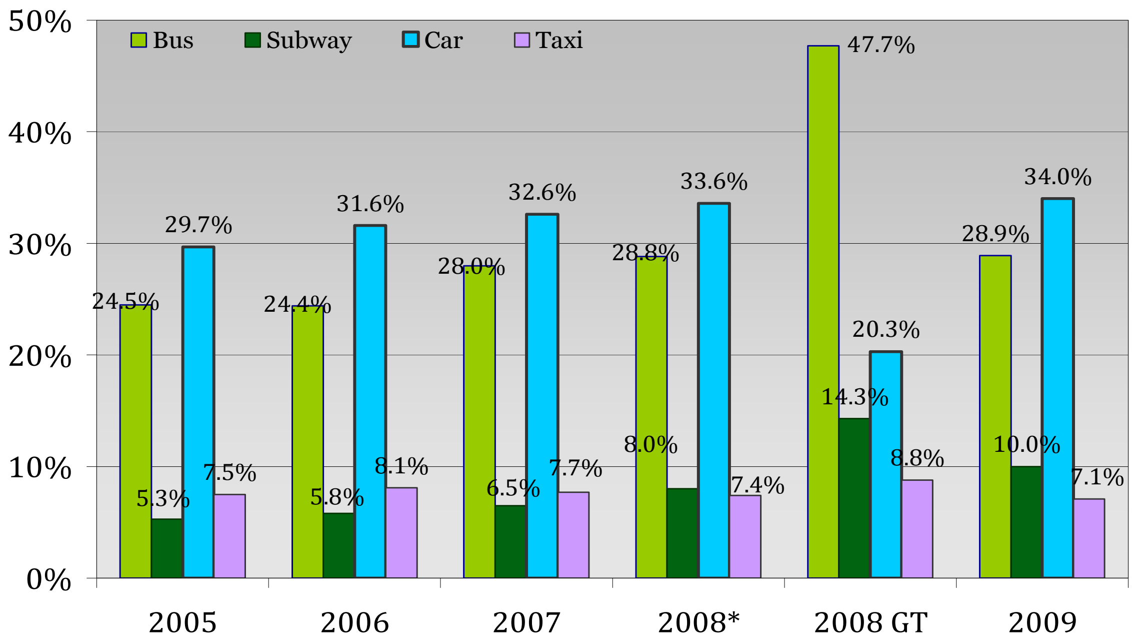
With Beijing's economic development in the recent decades, Beijing residents have been showing their great enthusiasm for private car use. As discussed in Section 4.2, private car ownership increased significantly in Beijing during recent years, from 48 cars per 1,000 inhabitants in 2002 to 135 cars per 1,000 inhabitants in 2008 and 161 cars per 1,000 inhabitants in 2009. The rate of increase in private car ownership reached 14.3% for the period of 2007~2008, and 19.0% for 2008~2009. Meanwhile, the mode share of car travel increased much faster than public transport during the last 20 years as can be seen in Figure 6-3, outpacing both bus and subway in 2006.

Table 6-3 Chi-squared tests for changes in mode share

Periods	Chi-squared test for changes in mode share (compared with Pre-Games in June 2008)	
	Chi^2	Sig (two tails)
Games time (August 2008)	767.148	<.0001
Post-Games (June 2009)	85.682	<.0001

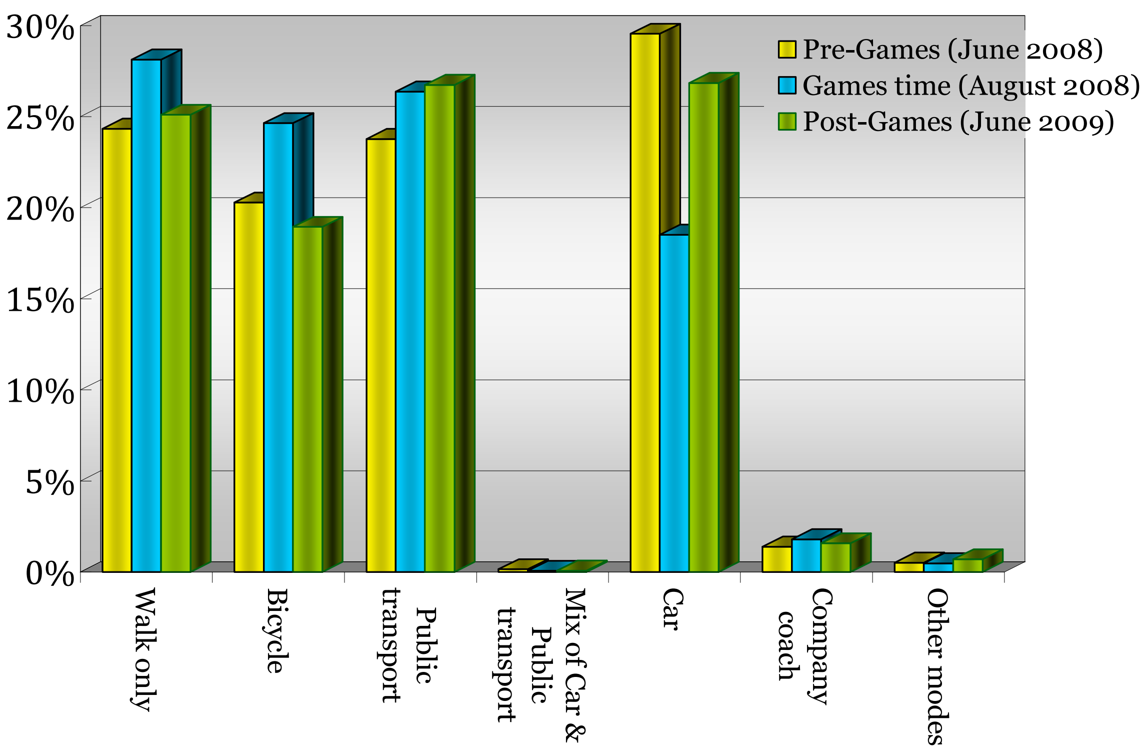
Source: database owned by Beijing Transportation Research Center

Figure 6-3 Changes of mode share in daily travel (excluding walking trips[1])



Note: 1. Walking trips are counted only when they form complete trips (i.e. walking all the way), not when they are part of trips using other modes of transport.
Sources: Beijing Transportation Research Center (2004, 2005, 2006, 2007, 2008a, 2009)

Figure 6-4 Travel modes in different waves of survey



Source: database owned by Beijing Transportation Research Center

This trend shifted during the Olympic Games. We can see from Figure 6-3 that Beijing residents turned to public transport when Games-related TDM measures applied. During the Olympic Games, the share of public buses reached as high as 47.7%, while those of subway and taxi were also increased to 14.3% and 8.8%. Meanwhile, the share of car travel dropped from 33.60% in normal days in 2008 to 20.3% during Games time. Investigating the different waves of surveys, changes in mode share appeared statistically significant in Chi-squared tests as shown in Table 6-3 for both periods of Games time and Post-Games, compared to the normal days prior to the Games in June 2008.

As the details show in Figure 6-4, changes in mode share were significant in the different modes. The changes can be summarized as below:

1. Non-motorized travel modes, walking and cycling, gained a big increase in mode share during Games time. Bicycle travel grew by 4.36% during the Games period, compared with normal levels in 2008. Shares of walking and cycling both fell back when the Games finished. The share of cycling trips dropped to an even lower level than Pre-Games period, at 18.95% in 2009.
2. Public transportation, the public buses, subway and taxi, received noticeable increases in share during Games time. The growth lasted long after the Games. Within public transport modes, the usage of public buses continued its increase, climbing up to an even higher popularity after the Games. This will be discussed further in Section 6.2.2.
3. Car usage decreased significantly during the Olympic Games period as expected, due to the widespread traffic control and Travel Demand Management (TDM) measures. It was demonstrated from the add-on questions in surveys that the car owners also reduced car usage on the days not under control during Games time. Though its share rebounded after the Games, a noticeable decrease was observed compared with the pre-Games scenario.
4. Company coaches and shuttles also increased use during Games time as a result of the decrease in car usage. Data shows that quite number of people

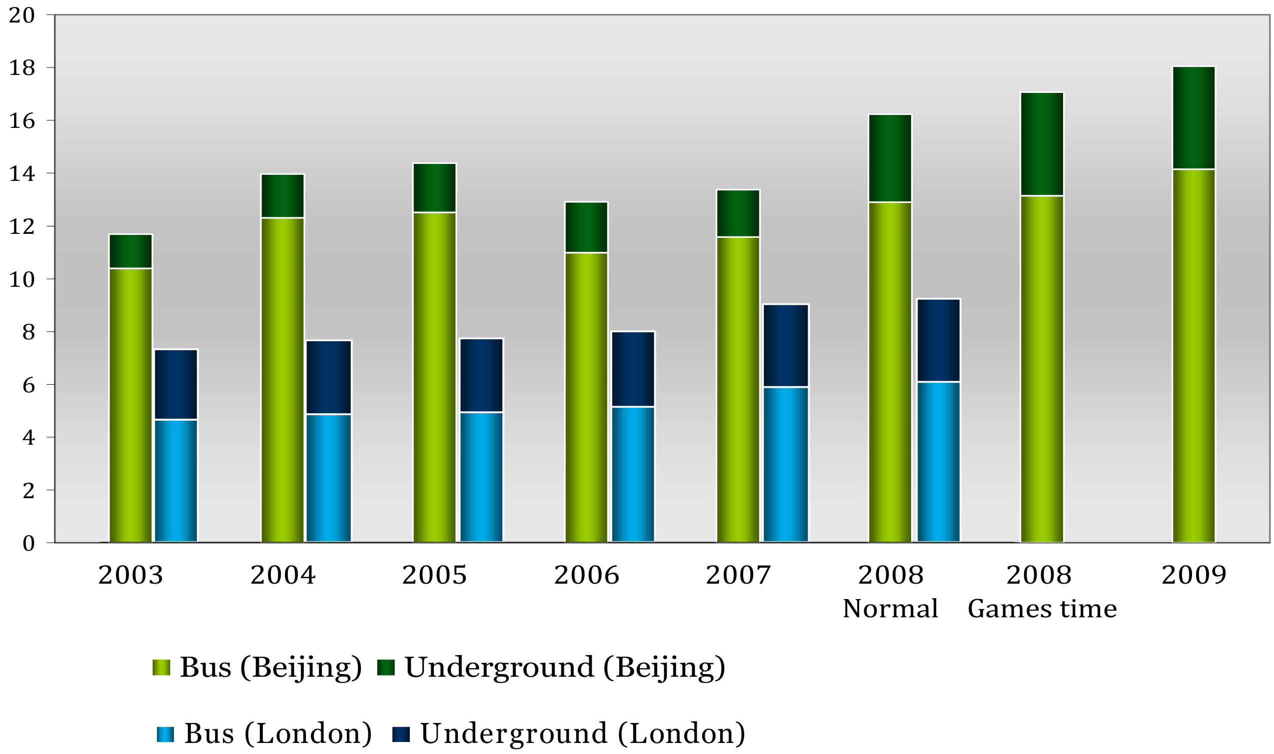
continued using company coaches after the Games.

5. Furthermore, the mix use of car and public transport changed in line with the changes in car use. Its share decreased by more than a half during Games time. However, compared with the change in car use, only 7.4% of original users returned after the Games, showing quite a few travellers in this category had altered their daily travel mode to others and stayed away.

6.2.2. Public transport

Similar to other Olympic Games, public transport modes were greatly improved and encouraged during Games time. As a result of Travel Demand Management measures and traffic controls, public transport as the main alternative to car travel received huge increase in patronage. This increase was similar to previous Games such as Atlanta 1996 and Sydney 2000, showing the popularity of subway system during Games time. The patronage of public transport including buses and subway in Beijing reached 17.07 million persons per day, 5.18% more than the amount before the Games (Source: Beijing Transportation Research Center).

Figure 6-5 Daily average number of stages[1] of Beijing/ London public transport



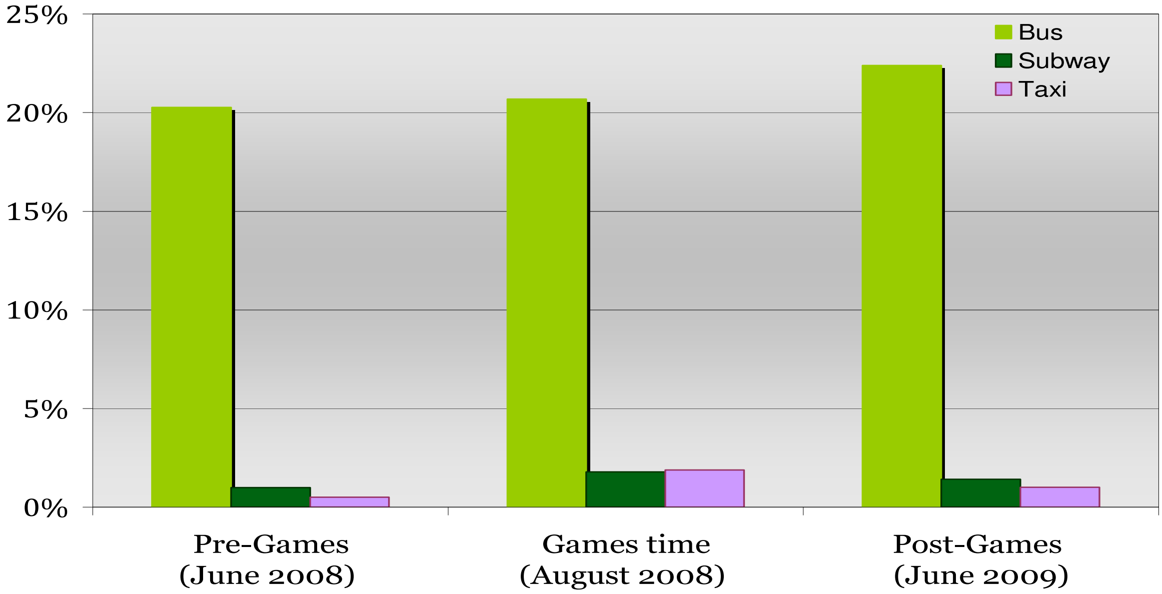
[1]:Stage: A journey stage is a part of a trip made by a single mode of transport. Bus journey stages are counted as starting a new journey stage each time a new bus is boarded. Underground journey stages are counted by station entries; interchanges within stations are ignored. (TFL, 2009)

Sources: Beijing Transportation Research Center (2004, 2005, 2006, 2007, 2008a), database owned by Beijing Transportation Research Center, TfL Service Performance data, Travel in London-Report No.1

Compared within the public transport modes, the buses had contributed the most, because the subway network in Beijing was to some extent limited, in both aspects of capacity and coverage. According to the records from the Beijing Transport Research Center, the public buses carried more than 13 million people per day on average in Games time, with 15 million people on the peak day (Source: Beijing Transportation Research Center). Meanwhile, the subway system transported about 3.93 million people daily on average, with a growth of 19.7% over that of normal days prior to the Games (Source: Beijing Transportation Research Center). Looking back to Atlanta 1996 and Sydney 2000, subway patronage increased from 0.23 million to 0.90 million in Atlanta and from 0.92 million to 1.55 million in Sydney during Games time, representing a growth rate of 293.6% and 68.5% respectively (Source: Amodei et al. 1997, Rail Coordination Centre (Rail Development)). Because of the background baseline travel demands, the immediate pressure appeared significantly different, while the net increases in patronage were very close: Beijing 2008 - 0.65 million / day, Sydney 2000 – 0.63 million / day, Atlanta 1996 – 0.67 million / day. The increase concerned with both changes in the number of tourists and the travel behaviour change of local residents. As the numbers of visitors to the cities during Games time were not available, we could not tell what percentage of this net increase was contributed by visitors vs. residents. Meanwhile, we need to note that ticketed-spectators might not be accurately counted into the total due to the free-ride scheme.

As can be seen from Figures 6-4 and 6-5, the share of public transport continued increasing after the Olympic Games in Beijing. By investigating the database of different waves of surveys, it is found that this growth came from the public buses, which kept climbing up from 20.69% in Games time's survey to 22.38% in 2009 survey. Meanwhile, the share of the subway came down to 1.41% in 2009, from 1.79% during Games time as shown in Figure 6-6, which was believed to be a result of the inevitable shrink in the use of Olympic Line and Airport Line. However, this figure was still 0.99% higher than in the June 2008 survey.

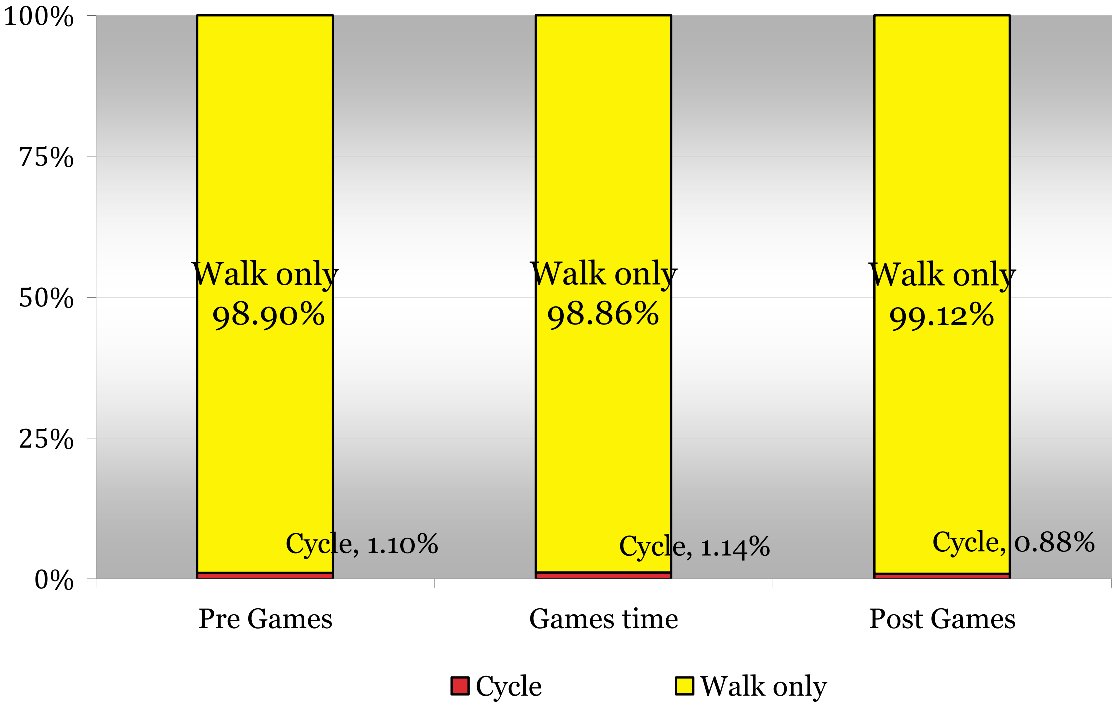
Figure 6-6 Public transport modes' share in the surveys



Source: database owned by Beijing Transportation Research Center
Note: Including trips of walk only.

Furthermore, when the growth of daily average number of stages and the mode share are examined together, we can see that the daily average number of stages increased by 5.18% from normal circumstance to Games time, while the growth of public transport in mode share was only about 2.6%. With the earlier discussion of decrease in trip volume in Games time, we could find that the additional increase in the daily average number of stages was made by non-residents, including spectators, visitors and travellers.

Figure 6-7 Access modes for public transport



Source: database owned by Beijing Transportation Research Center

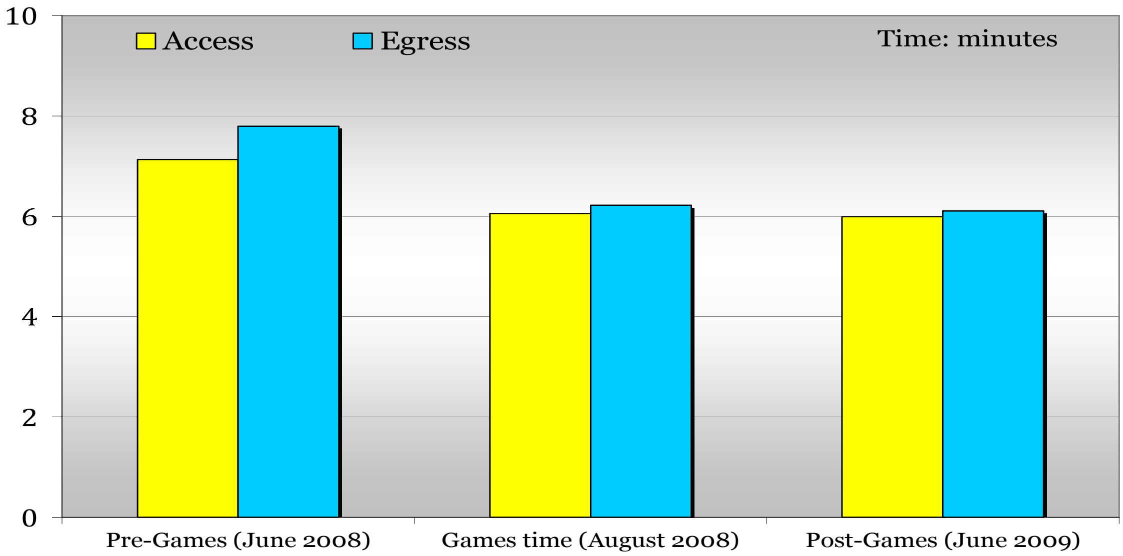
In order to better understand the changes in public transport, the conditions of access/egress and transfer were compared below for public transport, as well as their effects on public transport usage during the Games and after.

Access / egress conditions

It was learnt from Figure 6-7 that, most residents walked to the stations of public transport, while only around 1% went by bicycle. The shares were nearly the same in the three investigated periods, with walking gaining a slight increase in 2009.

With the improvements in public transport, it was much more convenient for people to use public transport services during their daily travels than before. It can be seen in Table 6-4 that, time spent in accessing public transport services significantly decreased across the survey periods. During the third survey in June 2009, the average access time was 5.99 minutes, while the egress time was 6.10 minutes.

Figure 6-8 Access /Egress time for public transport （Unit: minute）



Source: database owned by Beijing Transportation Research Center

Table 6-4 Changes in Access/Egress time for public transport

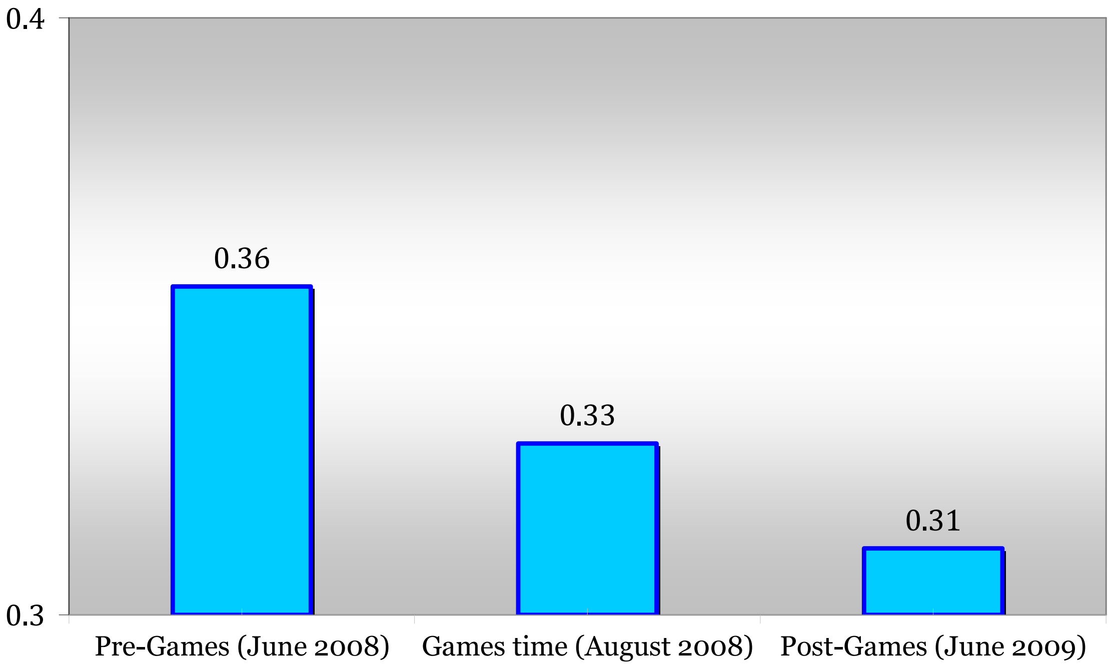
	N (June, 08)	Mean (June, 08)	SD (June, 08)	Differences between waves of survey (compared with Normal period in June 2008)							
				Games time & Pre-Games				Post-Games & Pre-Games			
				Num.	%	t	Sig (two tails)	Num.	%	T	Sig (two tails)
Access time	4,270	7.13	4.93	-.681	-9.55%	-7.056	<.0001	-1.177	-16.50%	-12.197	<.0001
Egress time	4,270	7.79	7.31	-1.166	-14.96%	-8.701	<.0001	-1.695	-21.76%	-13.101	<.0001

Source: database owned by Beijing Transportation Research Center

Transfer conditions

The number of transfer on public transport showed a steady decrease in 2008-2009, while the change between June 2008 and 2009 was much more significant as seen in Table 6-5. On the one hand, this was due to the improvements in the connection of public transport. On the other hand, it implies that people were inclined to trips with less need for transfer.

Figure 6-9 Average numbers of transfers for public transport



Source: database owned by Beijing Transportation Research Center

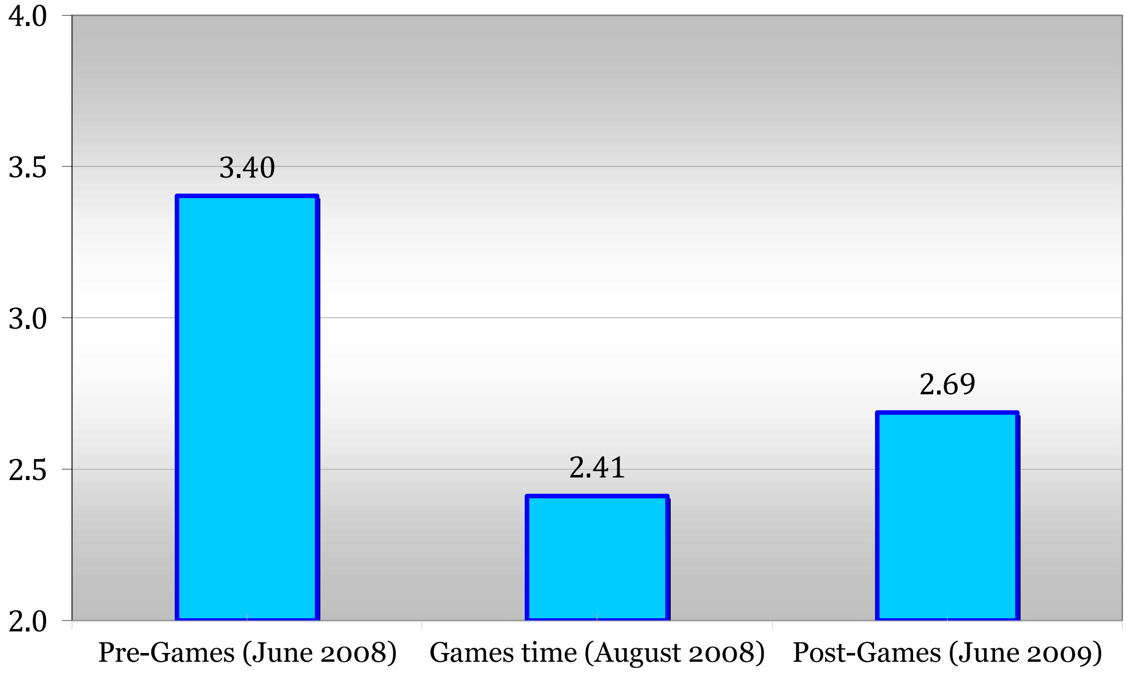
Table 6-5 Changes in Number of transfers of public transport

Mean (June, 08)	SD (June, 08)	Differences between waves of survey							
		Games time & Pre-Games				Post-Games & Pre-Games			
		Num.	%	t	Sig (two tails)	Num.	%	T	Sig (two tails)
0.36	0.594	-0.005	-1.37%	-0.436	0.663	-0.048	-13.44%	-4.009	<.0001

Source: database owned by Beijing Transportation Research Center

The time spent in transferring between public transport stages decreased significantly during Games time as well as the post-Games period. It reached a very low point during Games time, at 2.41 minutes, while the average transfer time was 3.4 minutes in June 2008, and 2.69 minutes in June 2009.

Figure 6-10 Transfer time of public transport (minutes/trip)



Source: database owned by Beijing Transportation Research Center

Table 6-6 Changes in Transfer time of public transport (minutes/trip)

Mean (June, 08)	SD (June, 08)	Differences between waves of survey							
		Games time & Pre-Games				Post-Games & Pre-Games			
		Num.	%	t	Sig (two tails)	Num.	%	T	Sig (two tails)
3.40	9.647	-0.833	-24.51%	-4.595	<.0001	-0.759	-22.32%	-4.161	<.0001

Source: database owned by Beijing Transportation Research Center

From the above comparisons, we could find that the condition of access/egress and transfer for public transport were improved during and after the Olympic Games, reflecting the continuing input and improvement in services of public transport. These indeed encouraged the residents to switch from cars to public transport, which was not only vital for a smooth operation during Olympic Games time, but also helped build the Games' legacies in promoting a sustainable transport style.

6.2.3. Car use

Car use was strictly limited during Games time. On one hand, more than 70% of government vehicles were sealed (disallowed to use) and stored. On the other hand, measures such as the "Odd-even alternate day-off scheme" and Olympic lanes were applied to most private vehicles. Accordingly, car use in Beijing changed significantly in 2008.

First of all, the car usage dropped greatly during Games time as shown in Figure 6-4. The share of car usage was 29.50% Pre-Games and 18.50% during Games time, showing the mass impacts of those measures and controls to the car users.

Secondly, a lot of people went back to their cars when the Games finished and the government lifted the bans, but some decided to stay away from cars after the Games. According to the survey, the share of car use in June 2009 was 26.90%. Compared with the share of 29.50% in early 2008, the drop of 2.60% was significantly different from previous developing trend of mode share as shown in Figure 6-4, demonstrating a number of car users moved from cars to other travel modes, even after the restriction were decontrolled.

Thirdly, the way cars are being used has changed in Beijing. The Chi-squared test shows that the changes in the way people used their car were significant between 2008 to 2009. Before the 2008 Games, occupants per car in Beijing continued to trend downward, from 1.52 persons per car in 2002 to 1.26 in 2005 to 1.17 in 2007. However, car share became more popular in the Games period, with 1.28 occupants per car during Games time (Source: Beijing Transportation Research Center). It could be found from the comparison in Table 6-7, 6-8 and Figure 6-11 that, car sharing was well received during Games time.

Table 6-7 Car use in three waves of the surveys

	Pre-Games (June 2008)		Games time (August 2008)		Post-Games (June 2009)	
Total	5,307	100%	3,195	100%	4,233	100%
Private car (drive)	4,104	77.33%	2,194	68.67%	3,318	78.38%
Private car (passenger)	768	14.47%	787	24.63%	632	14.93%
Government/company car (drive)	364	6.86%	126	3.94%	238	5.62%
Government/company car (passenger)	71	1.34%	88	2.75%	45	1.06%

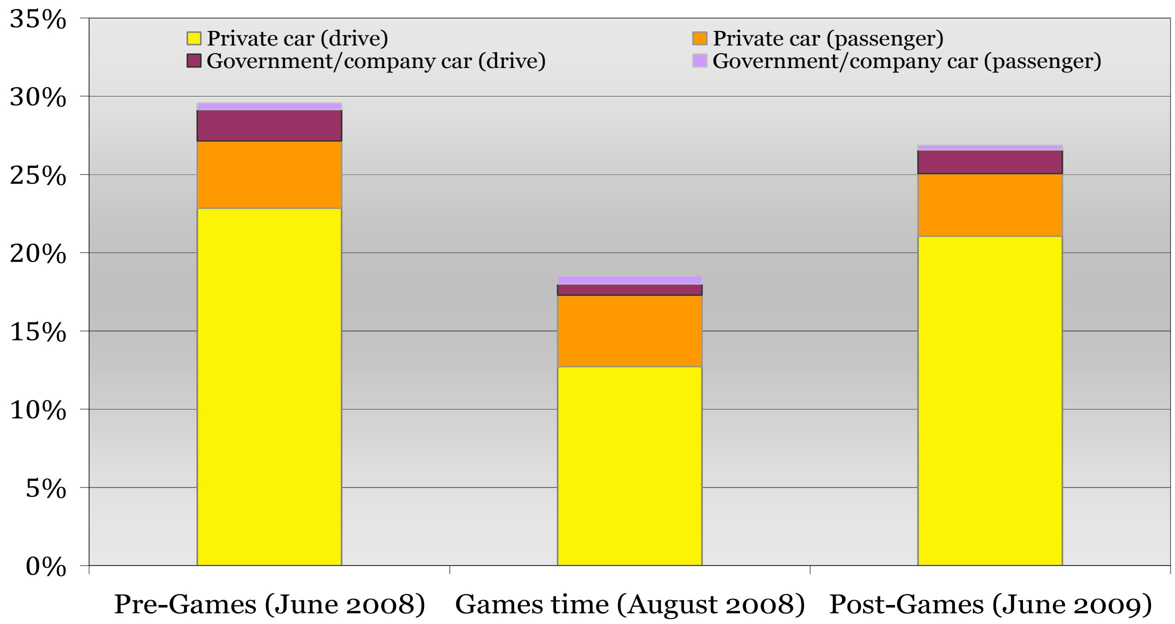
Source: database owned by Beijing Transportation Research Center

Table 6-8 Chi-squared tests for changes in the way of car use

Periods	Chi-squared test for changes in the ways of car use (compared with Pre-Games in June 2008)	
	Chi²	Sig (two tails)
Games time (August 2008)	190.622	<.0001
Post-Games (June 2009)	10.261	0.0165

Source: database owned by Beijing Transportation Research Center

Figure 6-11 Share of different ways of car use



Source: database owned by Beijing Transportation Research Center

6.2.4. Summary

Altogether, Beijing residents altered their travel modes when the Olympic Games came, while some changes lasted until one year after. It was understood that these changes in mode share might be because:

1. Strict control schemes and Travel Demand Management (TDM) measures applied to car use during Games time limited car use during Games time. However, this restriction didn't show a noticeable lasting effect on car users after the Games. The travel demands and the travel patterns of car users returned to a similar scenario as before the Games;
2. The improved coverage and services of public transport network, as well as sorts of relevant promotions, attracted many people to use public transport during Games period. After the Games, continuing investments and improvements in public transport, especially to improve convenience, helped the alterations last longer;
3. The government's efforts to promote "travel wisely", which gave detailed information on public transport for venues and suggested the advantage of travelling by alternative methods, encouraged people to choose sustainable transport modes to instead of private cars during Games time. Meanwhile, there were various events launched through different media channels, such as programmes on TV and radio, special pages in newspapers, exhibitions, etc, to introduce and encourage sustainable travel patterns to the public. According to the Beijing Transport Research Center, this campaign was acknowledged by more than 80% of residents, through various media channels like television, internet, newspaper, short message, and so on. However, the lasting effect of this campaign was not obvious for car users after the Games.

6.3. Journey purposes

6.3.1. Changes in journey purposes

The journey purposes also changed significantly across the investigating periods, as seen in Table 6-9.

Table 6-9 Chi-squared tests for changes in Trip purposes

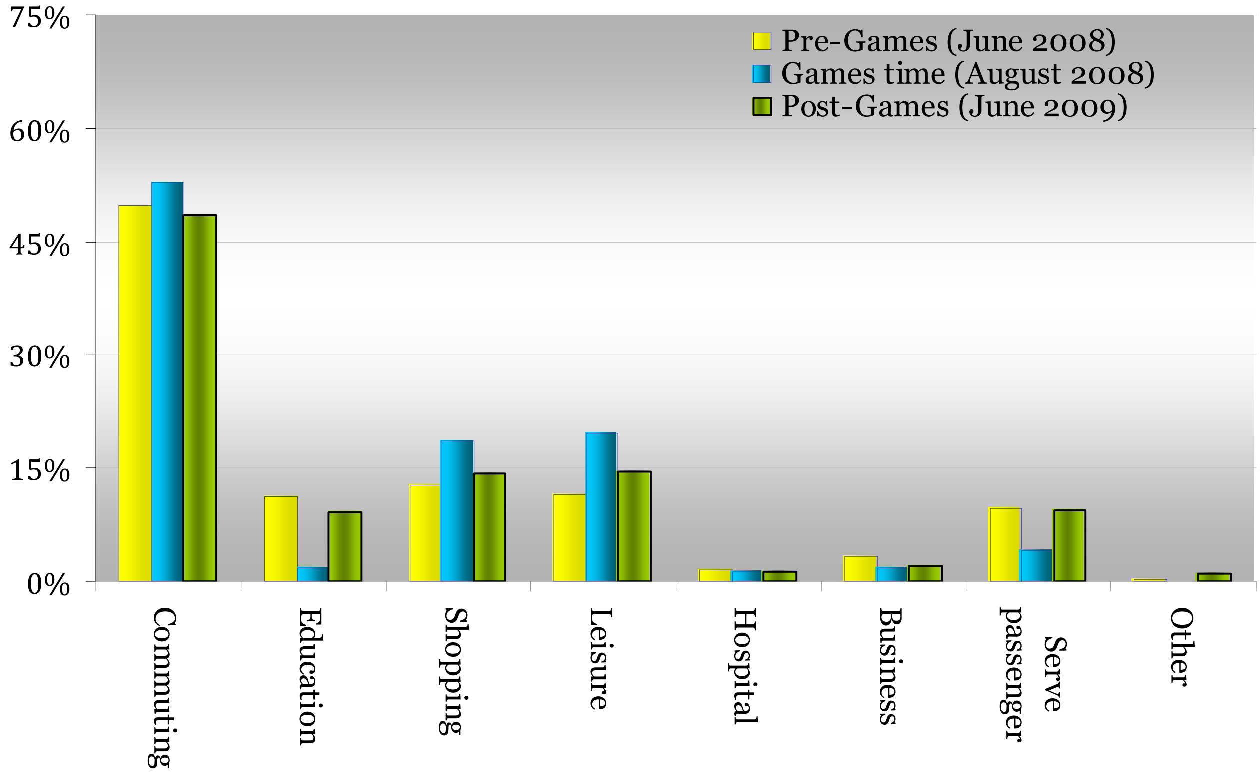
Periods	Chi-squared tests for changes in Trip purposes (compared with Pre-Games in June 2008)	
	Chi²	Sig (two tails)
Games time (August 2008)	1198.426	<.0001
Post-Games (June 2009)	109.982	<.0001

Source: database owned by Beijing Transportation Research Center

As shown in Figure 6-12, there were two main changes in journey purpose from the period of pre-Games to Games time,

1) Education related trips reduced sharply, due to the summer vacation in August. The share of trips for school went from 11.3% to 1.7%, while those serving passengers dropped from 9.8% to 4.2%.
2) Share of travelling for shopping, leisure and entertainment increased noticeably, from 24.4% to 36.0%.

Figure 6-12 Travel purposes in waves of the surveys



Source: database owned by Beijing Transportation Research Center

After the Games, students finished summer vacation and went back to school. The share for journeys with education purposes (for education and serving passengers) came back to more than 10% of all journeys. Meanwhile, the share of journey for shopping and leisure stayed at a much higher level than before.

Furthermore, while looking into those journeys by public transport and by car individually, the changes appeared in very different ways.

6.3.2. Journey purposes of trips with public transport

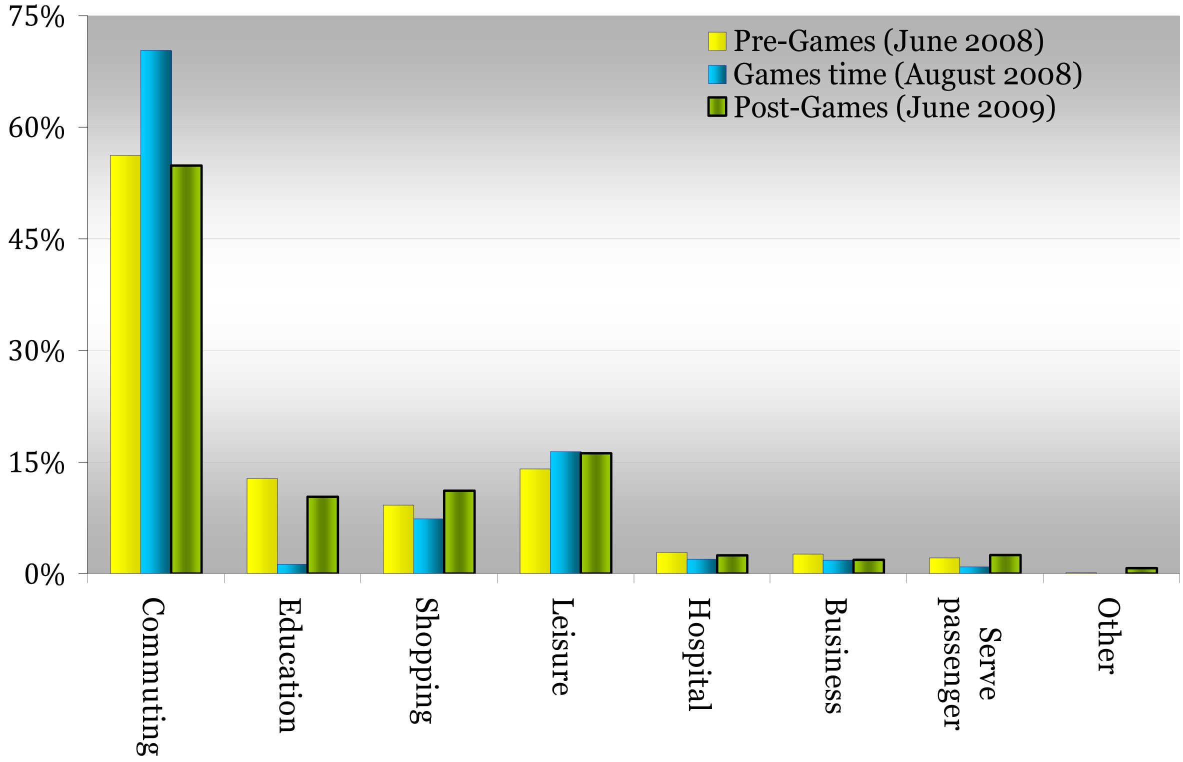
Comparing Figure 6-12 and 6-13, it can be seen that the changes of trips with public transport were in line with the overall changes in journey purposes in general. However, people travelled for work by public transport more often during Games time. On the other hand, the rate of change in trips to serve passenger by public transport was significantly smaller than that of the overall change in Figure 6-12. It suggests that people often used their cars to pick up passengers, rather than public transport.

After the Games, the share of commuting with public transport fell more significantly than the overall decrease, so did those with the purpose of education. But the residents showed their interests in travelling for shopping by public transport.

6.3.3. Journey purposes of trips with car

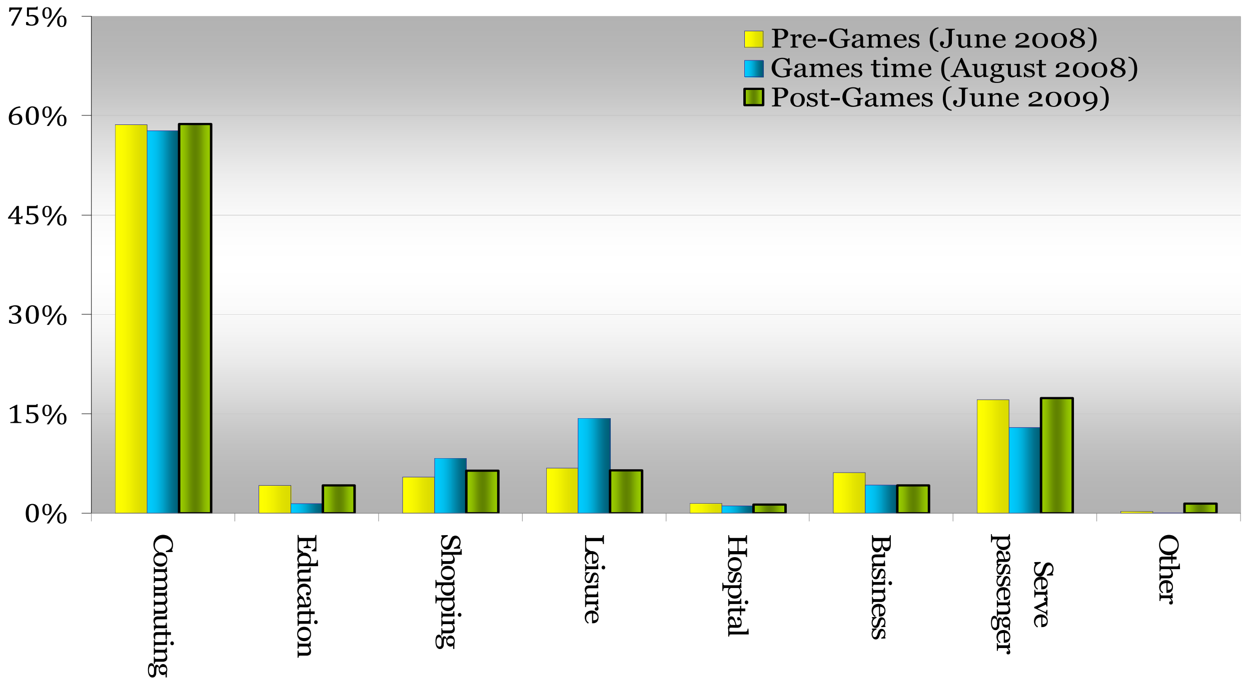
As shown in Figure 6-14, many commuters gave up using cars during Games time. However, it was also noticed that car trips were still popular for going to hospitals or serving passengers.

Figure 6-13 Travel purposes for the PUBLIC TRANSPORT trips in the surveys



Source: database owned by Beijing Transportation Research Center

Figure 6-14 Travel purposes for the CAR trips in the surveys



Source: database owned by Beijing Transportation Research Center

After the Games, commuting trips came back to a high share in car journeys, as well as those for serving passengers. Compared with the overall changing trend in Figure 6-12, the gaps in shares show the car trips were more focusing on commuting trips, rather than those for leisure or shopping.

6.4. Journey distance and Journey time

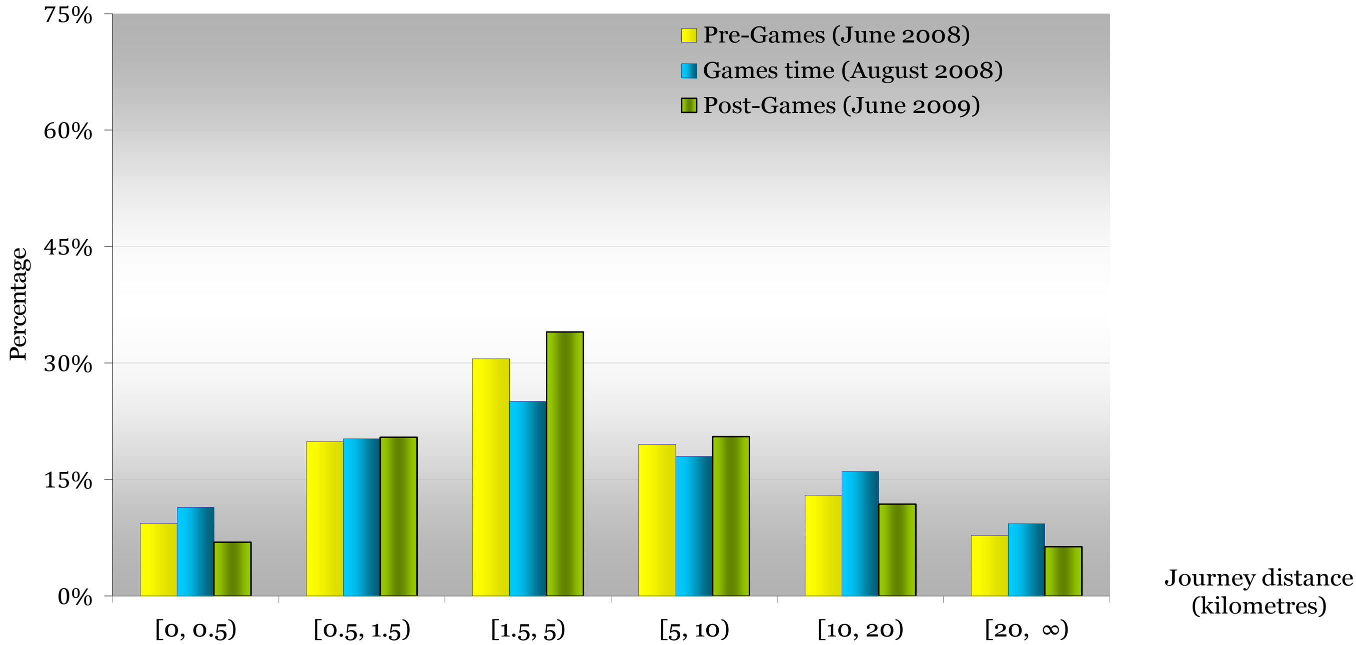
6.4.1. Journey distance

Table 6-10 Changes in Journey distance by travel modes (unit: metre)

Travel modes	Mean (June, 08)	Differences between waves of survey							
		Games time & Pre-Games				Post-Games & Pre-Games			
		Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)
All	6,727.3	1,057.9	15.72%	8.731	<0.0001	-486.1	-7.23%	-4.232	<0.0001
Public transport	8,967.8	3,889.0	43.37%	19.20	<0.0001	-825.9	-9.21%	-5.207	<0.0001
Car	11,758.7	3,699.5	31.46%	8.813	<0.0001	-1171.2	-9.96%	-3.921	<0.0001

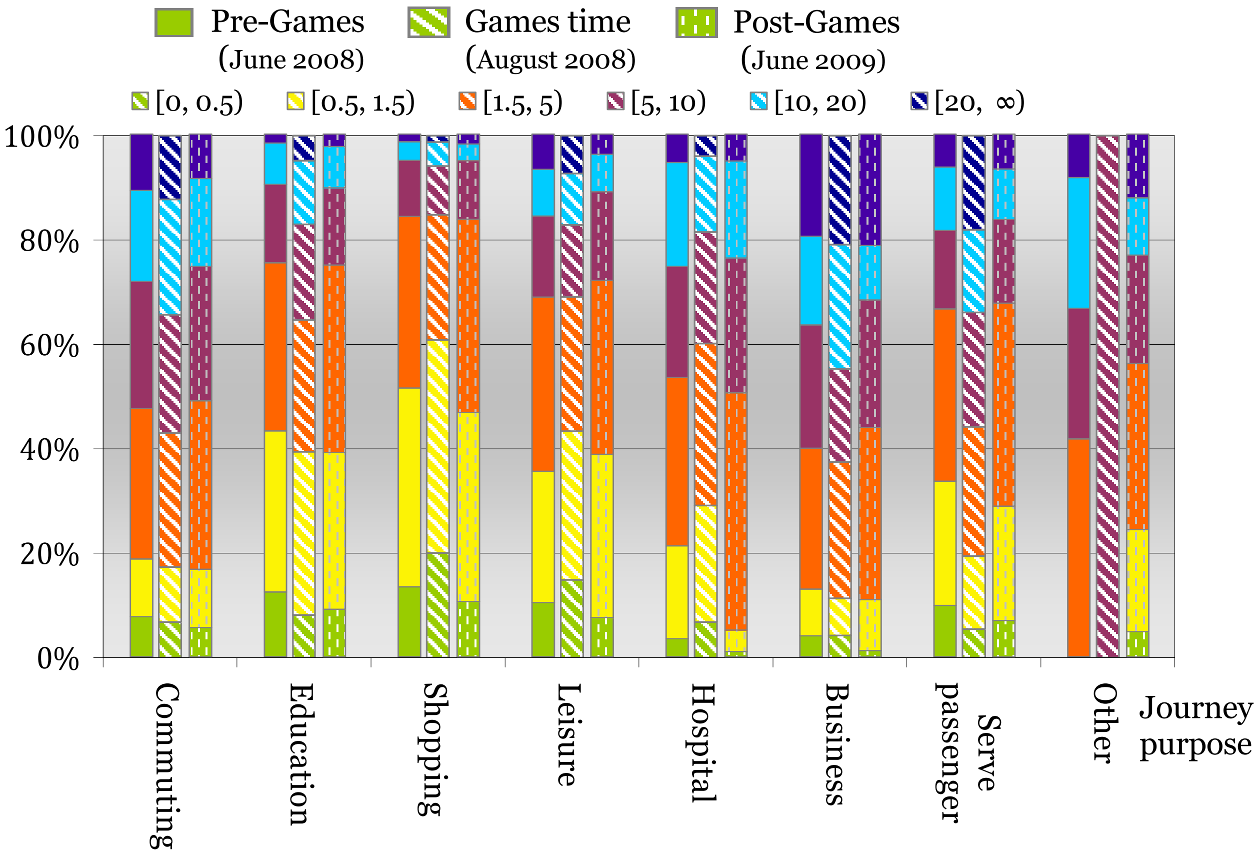
Source: database owned by Beijing Transportation Research Center

Figure 6-15 Journey distance in waves of the surveys



Source: database owned by Beijing Transportation Research Center

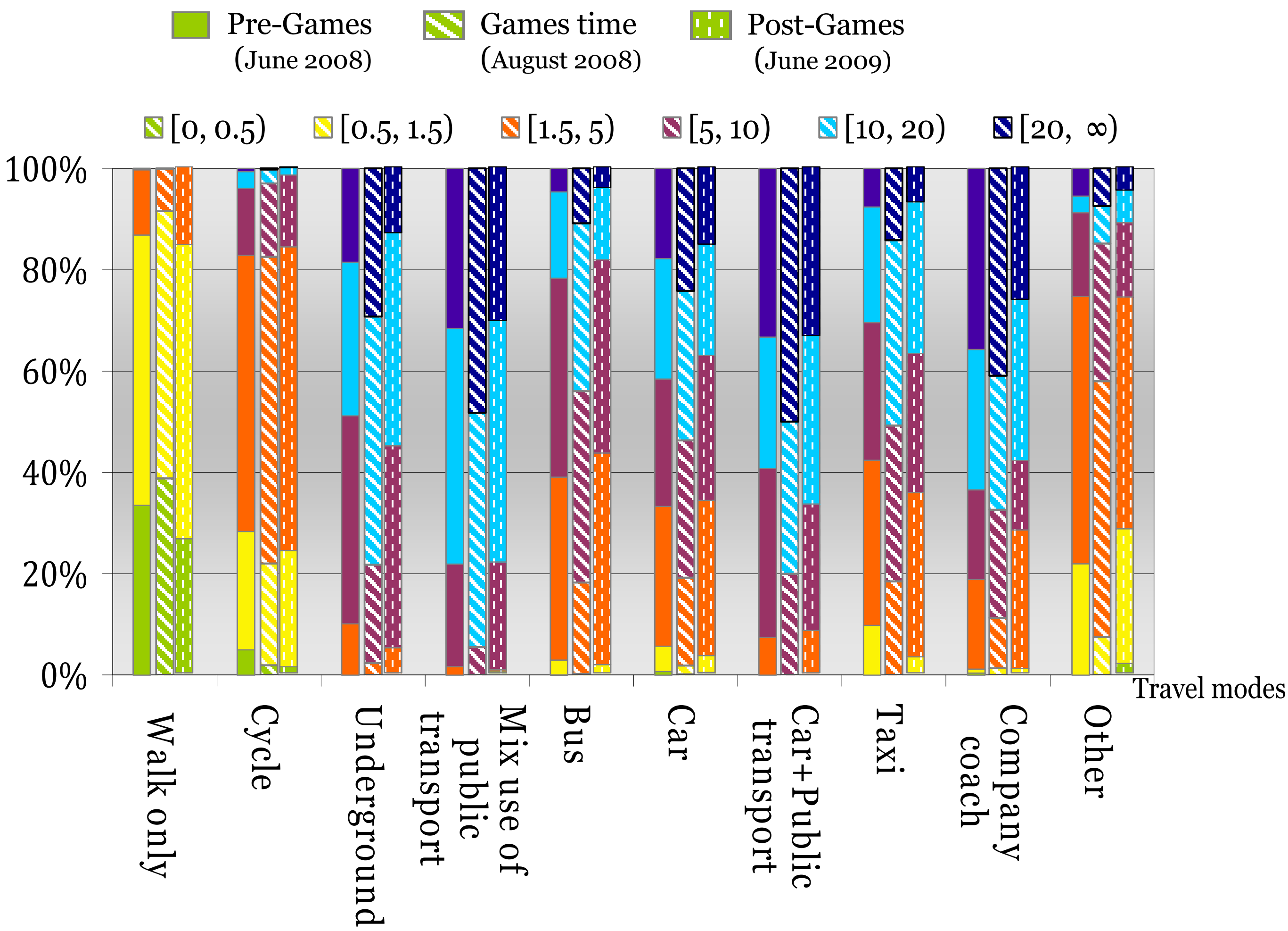
Figure 6-16 Journey distance by travel purposes in waves of the surveys



Source: database owned by Beijing Transportation Research Center

The survey records shows that people travelled much longer distance during Games time as shown in Table 6-10. The increase in average travel distance for trips was over 15%. When looking into the share of different distance for journeys in Figure 6-15, we could find that the share of journey with distance between 1.5 kilometres and 10 kilometres decreased significantly during Games time, while those with other distance increased. On journey purposes, the comparison in Figure 6-16 shows that people travelled further for work or education purposes (including the trips for business or serving passengers) during Games time, while the trips for leisure and shopping were shortened. On travel mode, most trips by walking finished in 5 kilometres, while underground were used for longer distance travel (> 5 kilometres) as shown in figure 6-17. Comparing the periods of pre-Games and Games time, it was noticed that, most trips went with longer distance during Games time, except those by walk. For the trips by car, the share of short trips (<5 kilometres) decreased significantly during Games time (from 33.3% in pre-Games to 19.2% in Games time).

Figure 6-17 Journey distance by travel modes in waves of the surveys



Note: Trips of 'Walk only' are counted only when they form complete trips (i.e. walking all the way), not when they are part of trips using other modes of transport.
Source: database owned by Beijing Transportation Research Center

In 2009, while the traffic controls finished after the Games, the average travel distance came down from Games time by 20.0%, and also had a reduction of 7.23% when compared with pre-Games period in 2008. This trend was in line with the public opinions reported by various media channels that more and more people preferred closer destinations, to have dinners, take entertainment activities to avoid wasting too much time in being congested in the street. As compared in Figure 6-15, distance of about 75% trips was distance between 0.5 kilometres and 10 kilometres in 2009, while only the share for same distance was only 69.9% before the Games and 63.2% during the Games. On journey purposes, we could find from Figure 6-16 that, people changed back to a similar level of travel distance for various purposes. However, travel for shopping became farther in 2009. About 83.7% trips for shopping were made within 5 kilometres in 2009, while this rate was 84.2% in June 2008 and 84.9% during the Olympic periods. On travel modes, the changing trends in travel distances for trips with public transport or cars were in line with the changes of all modes as seen in Table 6-10. From Figure 6-17, it was learnt that travel distance decreased for almost kinds of travel, except the walking trips.

6.4.2. Journey time

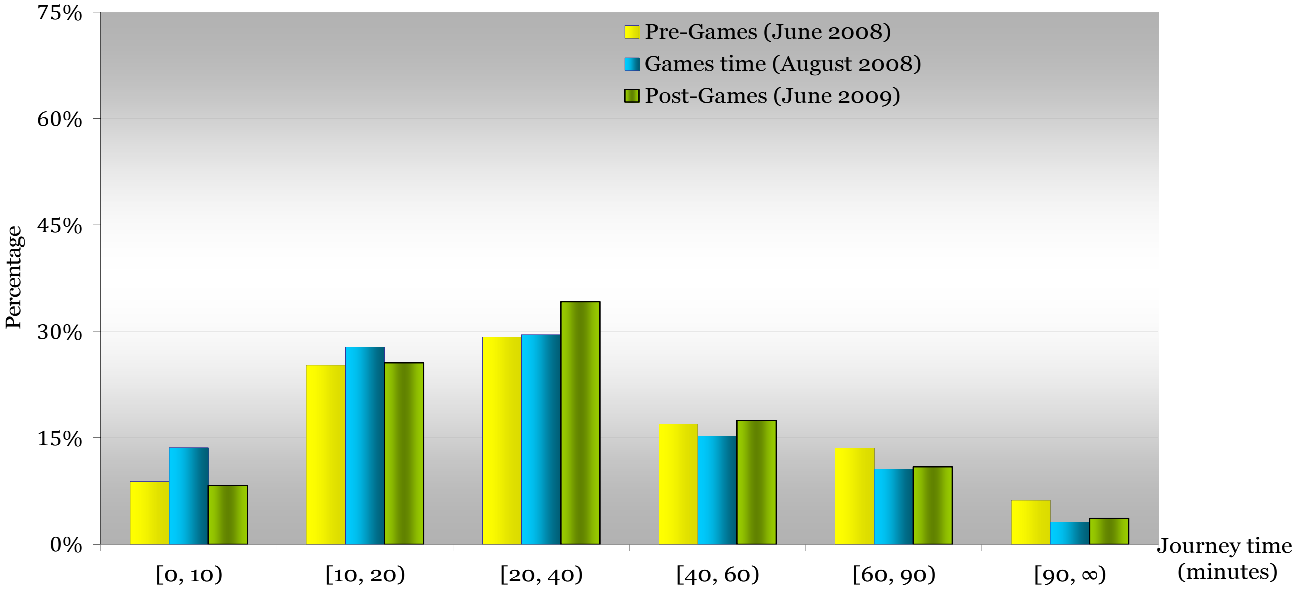
Table 6-11 Changes in Journey time (unit: minute)

Original travel mode	Mean (June, 08)	Differences between waves of survey							
		Games time & Pre-Games				Post-Games & Pre-Games			
		Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)
All	35.95	-5.95	-16.54%	-20.698	<0.0001	-2.40	-6.66%	-7.540	<0.0001
Public transport	62.36	-6.73	-10.79%	-11.802	<0.0001	-8.59	-13.78%	-13.862	<0.0001
Car	42.93	-7.39	-17.21%	-12.969	<0.0001	-5.41	-12.61%	-9.740	<0.0001

Source: database owned by Beijing Transportation Research Center

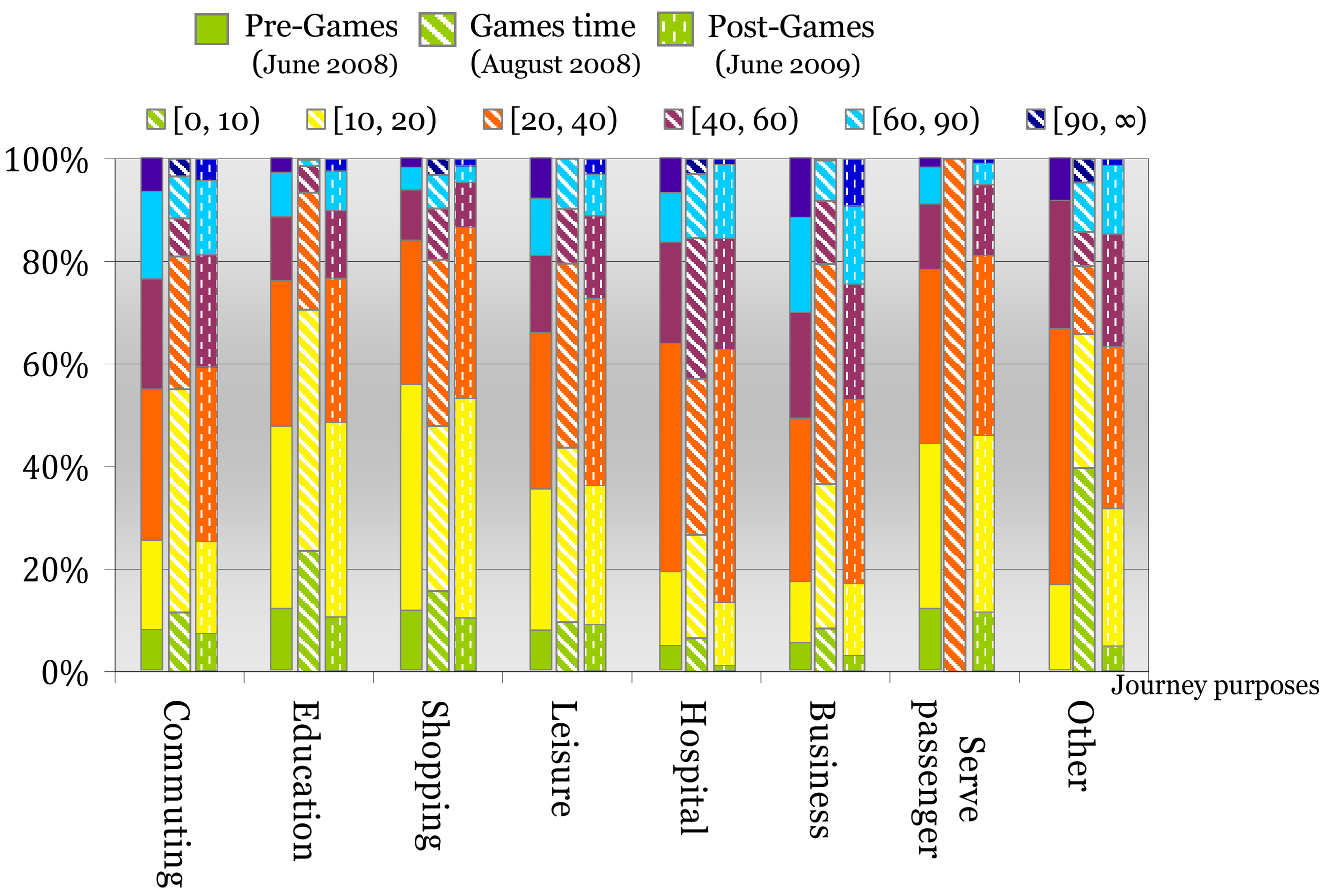
From Table 6-11, we could find that the average journey time changed in very different way. The average journey time for all modes decreased 16.54% from Pre-Games time to Games time, while grew to 33.25 minutes on average after the Games, which was 11.4% higher than that in Games time, but 6.66% lower compared with the pre-Games period. From Figure 6-18, it could be found that the trips within 40 minutes increased, while longer trips decreased during the Olympic Games. After the Games, the short trips (journey time <20 minutes) came back to a same level as pre-Games time, while the long trips (journey time > 60 minutes) decreased significantly.

Figure 6-18 Journey time in waves of the surveys



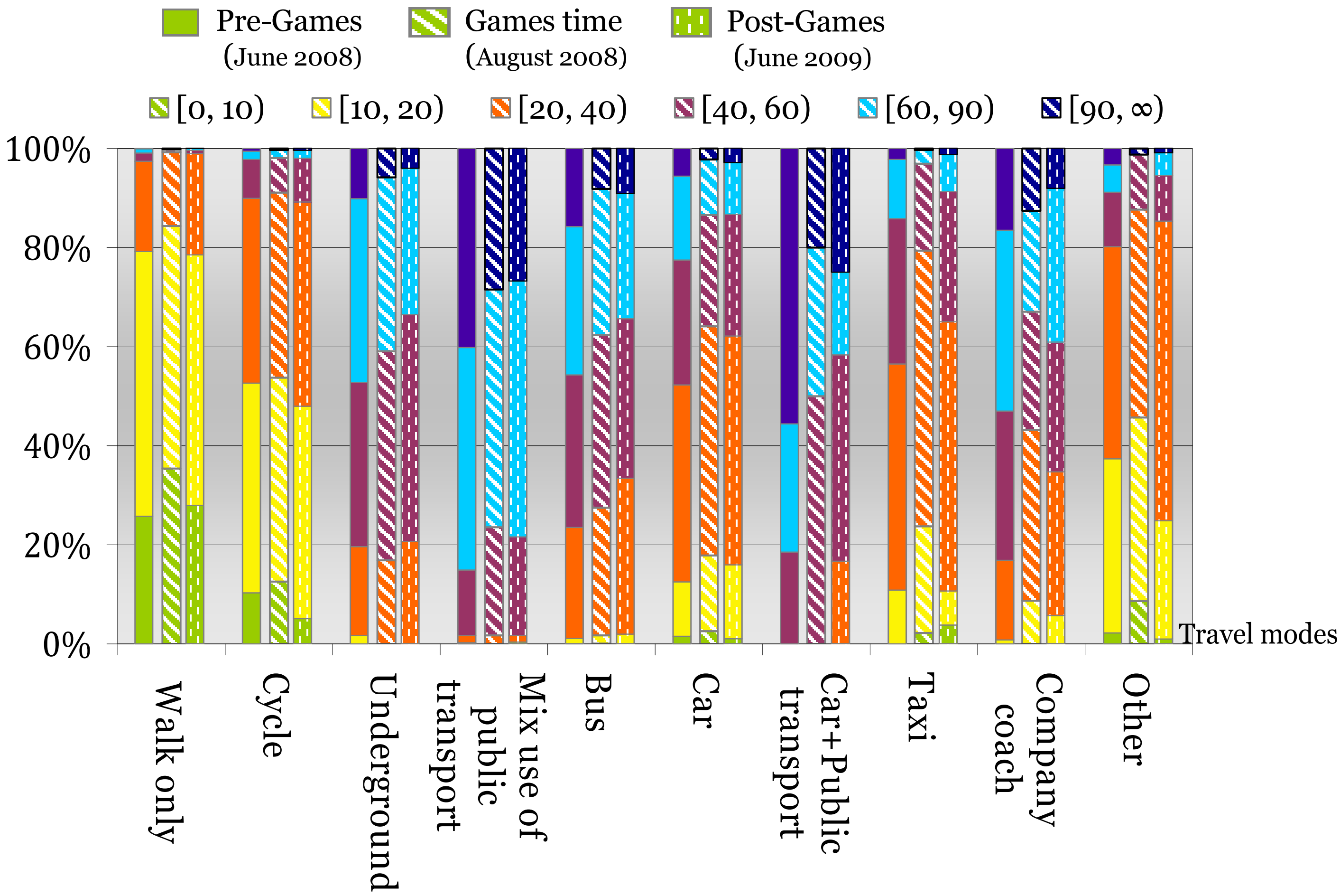
Source: database owned by Beijing Transportation Research Center

Figure 6-19 Journey time by travel purposes in waves of the surveys



Source: database owned by Beijing Transportation Research Center

Figure 6-20 Journey time by travel modes in waves of the surveys



Note: Trips of 'Walk only' are counted only when they form complete trips (i.e. walking all the way), not when they are part of trips using other modes of transport.
Source: database owned by Beijing Transportation Research Center

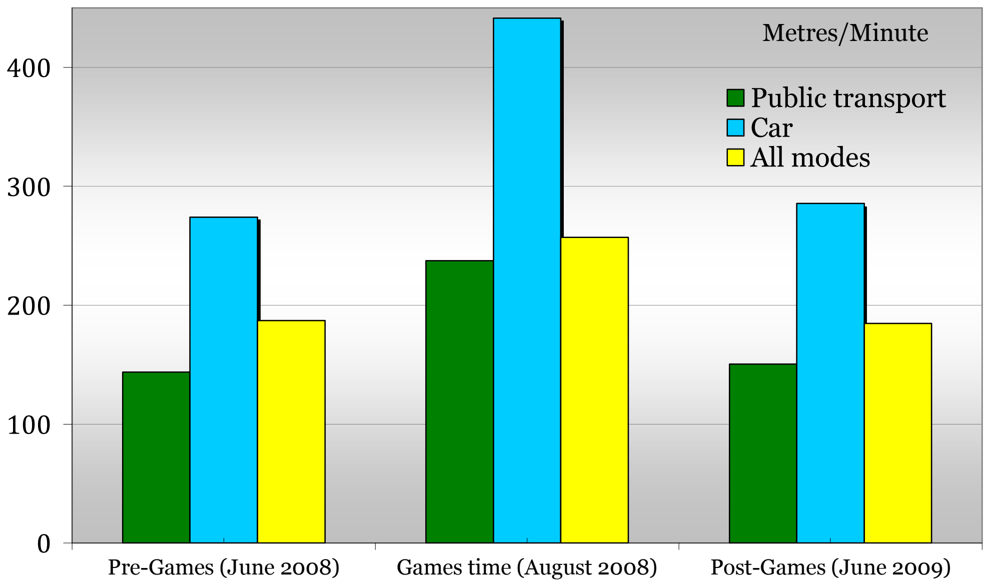
From Figure 6-19, we could find that the journey time for most trips decreased significantly during Games time, especially for commuting. However, travel for shopping took longer. After the Games, journey times grew longer again, though still significantly shorter in duration than pre-Games period as shown in Table 6-11. Different from the changes of other trips, the journey time for shopping trips in post-Games period was much less than that of pre-Games and Games time.

The car journeys became much shorter in duration during Games time, but saw a small rebound after the Games as seen in Table 6-11. Differently, the average journey time on public transport continued to reduce across the investigating periods. This could also be seen in Figure 6-20.

Comparing the journey distance and journey time in Figure 6-21, we could find that, (1) the average travel speed during Games time was much higher than other periods for public transport and car, as well as the overall travel modes. (2) Car travel was more efficient than other travel means over all compared periods, especially during Games time. (3) During Games period, the efficiency of car travel increased much more than other travel means. (4) After the Games, the efficiencies of public transport and car travel decreased significantly from Games time, but still saw a slight increase from pre-Games period.

6.4.3. Travel efficiency

Figure 6-21 Changes in travel efficiencies (Average journey distance/Average journey time)



Source: database owned by Beijing Transportation Research Center

Comparing the journey distance, journey time and travel efficiency together, we find that travel efficiency increased significantly during Olympic Games time. Though the average travel distance during Games time became longer, the average journey time was shortened by 16.54%. Particularly for the cars, the decreasing rate was 17.21%. However, Games time effects on travel efficiency didn't last long, dropping back immediately after. The changes can be summarized as below:

(1) The Games' pressure on transport encouraged residents to select near places as destination, with the share of short trips (<1.5 kilometres) increasing from 29.2% in pre-Games period to 31.6% during Games period. Particularly, for those trips for shopping or entertainment, the travel distance was found to be much shorter during Games time. The share of shopping trips within 500 metres increased from 13.4% to 20.1%. However, this change did not last after the Games. As seen in Figure 6-16, the travel distance for various purposes after the Games dropped to a similar level as that of pre-Games, except the trips for leisure purpose which were shortened more.

(2) Traffic control and certain road closures forced people to circumnavigate Games relevant traffic and travel farther during Games time, reflecting in the increase of long trips (>10 kilometres), which grew from 20.8% in pre-Games to 25.4% during Games time. Particularly for those trips with fixed destinations such as work place or school, people had to travel much farther during Games period. This "compulsory" change returned to normal immediately after the Games when the controls and bans disappeared.

(3) The inconvenience of using cars made a few car users give up using car for short trips. However, this effect disappeared after the Games.

(4) As a result of car-use restriction, the number of vehicles on the road dropped significantly. Accordingly, the average traffic speed for the road network increased significantly and the travel efficiency of cars as well as buses was greatly improved during Games time. But this improvement didn't last long. When the restrictions finished, the average travel speed dropped to a similar level as pre-Games.

(5) The widely recognized advancement in public transport such as adding buses into operation and reducing interval time for both buses and subways, made contributions in boosting the travel efficiency, especially during Games time.

6.5. Travel to work

As discussed in Chapter 5, the survey information was collected on specific days during each wave. Residents might have different activities on the selected days, with different travel needs and methods. The day-to-day variation in behaviour may bring bias for comparisons across different waves. Thus, we would like to compare trips by purpose to get more accurate and comparable results. Because commuting trips are the most important component of Beijing residents' daily travel, we compare residents' travel patterns to work in this section.

Table 6-12 Chi-squared tests for changes in modes of trips for work

Periods	Chi-squared test for changes in mode share for work (compared with Pre-Games in June 2008)	
	Chi^2	Sig (two tails)
Games time (August 2008)	378.597	<.0001
Post-Games (June 2009)	20.426	0.002

Source: database owned by Beijing Transportation Research Center

The comparisons in Figure 6-22 and Table 6-12 show that people changed their travel modes for work significantly during Games time.

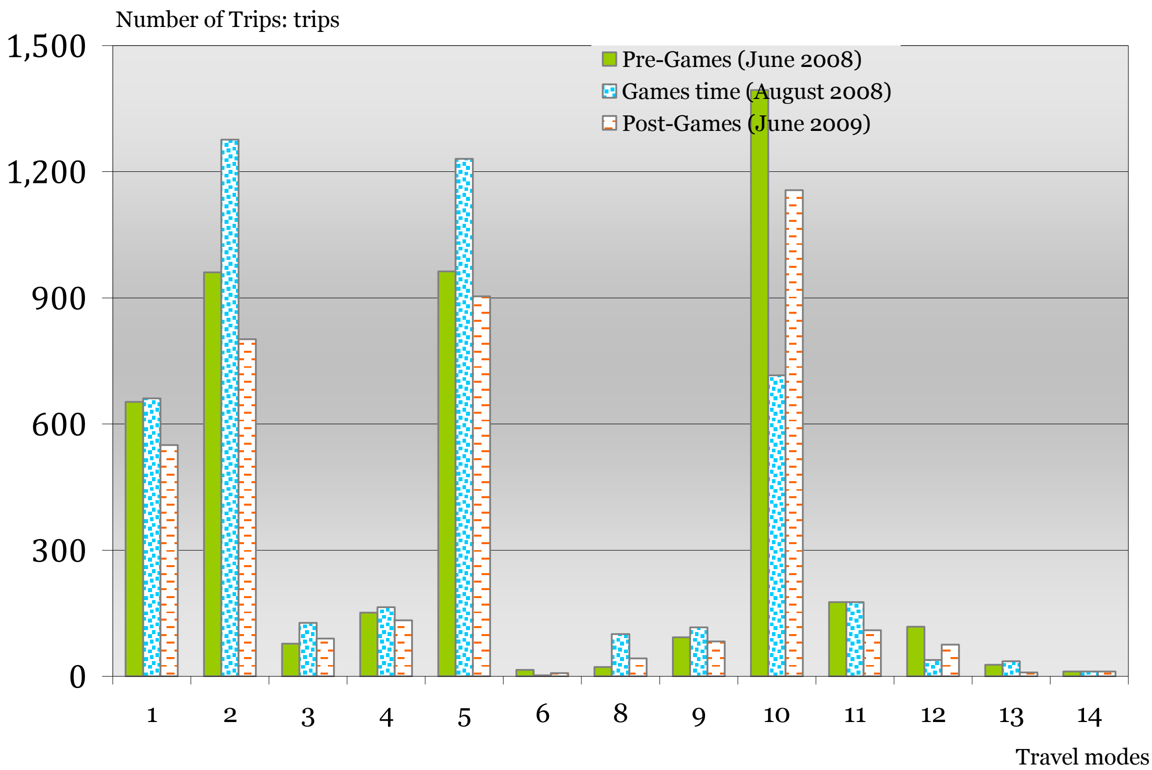
However, it was observed that the shares of walking and going by company coach for work changed much less than others across these three waves of surveys.

6.5.1. Commuting trips during Games time

Beijing residents were encouraged to use sustainable travel patterns during Games time. It can be seen from Figure 6-22 that a lot of commuting trips were switched to public transport and even bicycles. Within all modes used to travel for work, the share of car decreased from 36.82% before the Games to 20.78% during the Games, which was much sharper than that of trips for all purposes as shown in Figure 6-4. Meanwhile, mode share of public transport and cycling for work also changed more than the trips for all purposes, which changed from 26.04% to 34.84% and

20.60% to 27.41% respectively from pre-Games period to Games time.

Figure 6-22 Commuting trips by travel modes in different waves of the surveys



Travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus;
6. Car+Public transport; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger); 12. Company car (drive);
13. Company car (passenger); 14. Other

Note: Trips of 'Walk only' are counted only when they form complete trips (i.e. walking all the way), not when they are part of trips using other modes of transport.
Source: database owned by Beijing Transportation Research Center

6.5.2. Commuting trips during Post-Games time

The residents returned to 'normal pattern' after the Games. However, public transport remained more popular than before. By analyzing the data result from surveys, people returned to using cars for work. Over 13% of all commuting trips changed back to cars after the Games. However, public transport still saw moderate increase in mode share when compared with the pre-Games period, having taken over about 3.4% share from cars. Meanwhile, the share of bicycle trips fell down to similar level as seen during the pre-Games period.

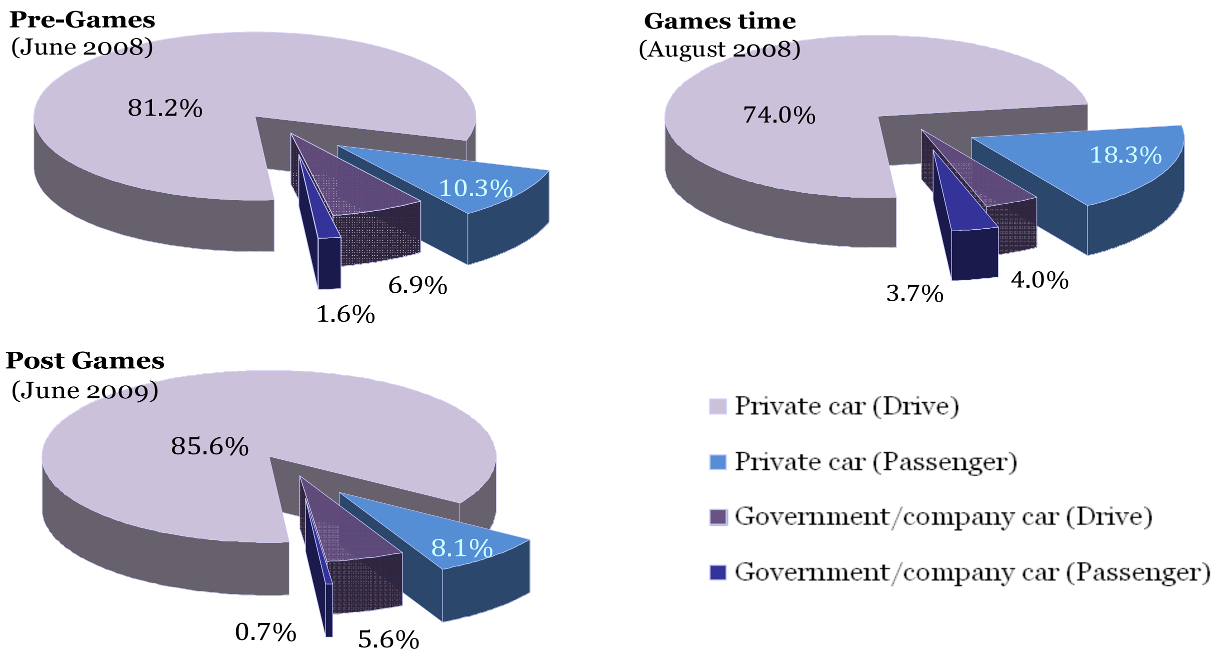
6.5.3. Car sharing for work

When doing further detailed comparison in Figure 6-23 and Figure 6-24, we learn that:

1. Change was more significant with private vehicle trips (travel with private vehicles) than non-private vehicle trips (travel with non-private vehicles, such as the government vehicles or company vehicles). As seen in Figure 6-24, changes made with private vehicle trips were much bigger. Investigating single-occupancy cars, the decrease of private vehicle trips in Games time was 7.23% while the non-private vehicle trips only came down by 2.84%. For multi-occupancy cars, the former got a 7.98%'s increase, while the latter only gained 2.09%.
2. Car sharing was more adopted during Games time. Within all driving trips to work, only 11.9% were made by shared cars (including private cars and company cars) in early 2008, while 22.0% were made by a shared car in August 2008. This significant growth helped reduce overall car use during Games time in Beijing.
3. The growth of car sharing didn't last after the Games. It could be found from Figure 6-24 that the share rate in 2009 dropped to an even lower level than 2008, for both private and non-private cars. The trend of driving private cars alone was very strong after the Games - only the trips by private car alone increased in share when the Games finished, while all other categories reduced. However, no record was found to show a negative experience for car sharing during Games time. There were two possible reasons for the decrease: (1) the even faster increase in car ownership which was led by the economic growth after the Games; (2) pursuing private travelling accommodation became a sign of life quality in Beijing.
4. Looking at the usage of government or company cars for work, shares fell much more than other vehicles. As discussed in Chapter 4, there were all sorts of restriction and communication plans applied on government cars, causing an obvious reduction during Games time and after. The rates of

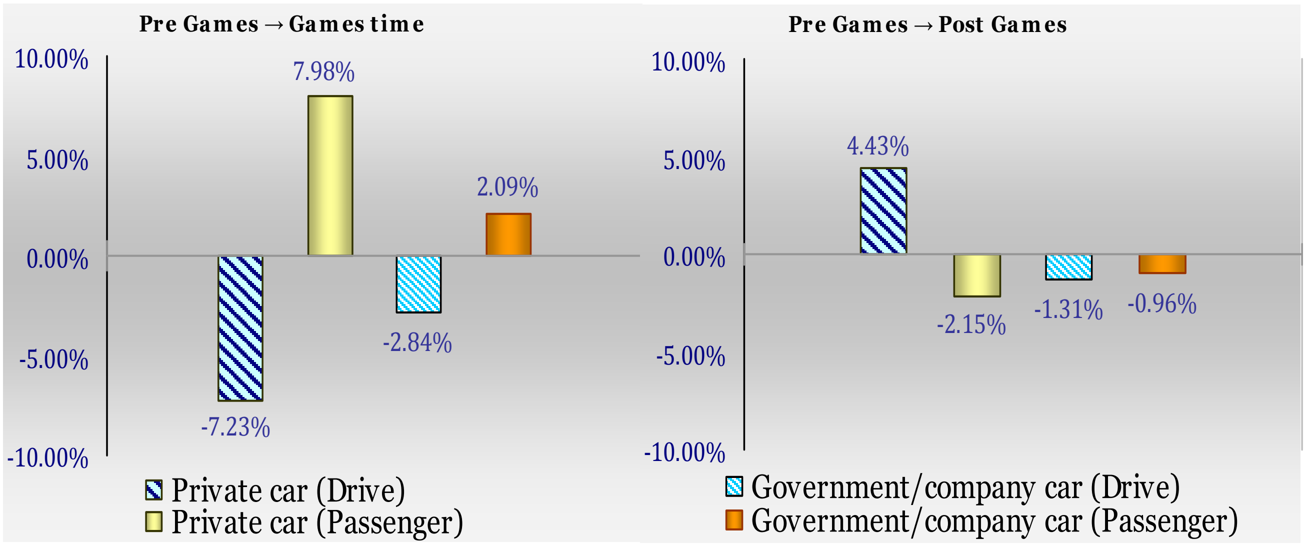
decrease from Pre-Games to Games time and Post-Games time were 48.8% and 25.6% respectively.

Figure 6-23 Car share for work in selected waves of the surveys



Source: database owned by Beijing Transportation Research Center

Figure 6-24 Changes of share of car usage for work



Source: database owned by Beijing Transportation Research Center

6.6. Discussion

This chapter describes the travel behaviour changes of Beijing residents prior to, during, and after the Olympic Games, by comparing the results of the three-wave surveys for travel patterns. The comparisons show:

1) Local residents' daily travel was interrupted by the Travel Demand Management (TDM) measures and significantly changed during the Olympic Games. The changes appeared significantly in the following aspects:
   - Trip rate (trips per person per day) decreased by 12.2% during Games time.
   - Mode share: residents preferred to use public transport and non-motored travel means such as walking and cycling for travel during Games time. The mode share of car travel decreased by 37.3% when the Olympic Games were held in Beijing.
   - Journey purposes: for all travel means, education related trips decreased during Games time due to the coincidence with summer vacation. While looking into the journey purposes by travel modes, it could be found that cars were used less for commuting trips, but still popular for shopping and leisure.
   - Journey distance and journey time: the average journey distance increased by 15.72% during the Olympic Games, with both short-distance trips (<1.5 kilometres) and long-distance trips (>10 kilometres) increasing. Residents travelled farther during the Games for commuting but selected nearer destinations for shopping or leisure purposes. It was learnt from the sample data that, about 33% people changed their job between 2008-2009. The longer-term trend of the distance for commuting declined as seen from Figure 6-16. Considering that the surveys were undertaken at the same home address for residents across waves, the Games-time increase of journey distance especially for work may be because people need to

detour their trips for work to avoid the Games related traffic or restrictions. On mode choice, subway was proved popular for long-distance trips. Meanwhile, the average journey time decreased by 16.54% during the Olympic Games. Travel efficiency was significantly improved during the Games, especially for car travel.

- Travel to work: the mode alteration for commuting trips was more significant than that for the other trips. Many people travelled to work by public transport, rather than by car. For car users, sharing car for work commutes increased notably during the Games.

2) The impacts of the Olympic Games didn't appear to have a significant lasting effect on local travel patterns in most aspects. However, they did slow down the rebound of travel volume and encourage adoption of public transport. By comparing daily travel in June 2008 and June 2009, the lasting effects of Games impacts were found in the following aspects:
   - Residents reduced or slowed down the increase of travel demands to a certain extent. Looking at survey data, the average trip rate (trips per person per day) increased by 2.75% between Games time and June 2009, but it was still 2.94% less than that of June 2008 as shown in Table 6-1 and 6-2.
   - Public transport received a continued increase in mode share after the Olympic Games as shown in Figure 6-4. As discussed in 6.1.2.2, public transport received great investments and improvements in its coverage and service levels during and after the Olympic Games. It not only give travellers a positive experience with public transport during Games time, but also contributed to building a lasting positive impact after the Games.

3) It could also be observed from the surveys that car users changed back to their previous travel patterns after the Games. Some changes remained after the Olympic Games which were positive to sustainable urban transport:

- The mode share for car use rebounded after the Games, but a noticeable decrease was observed when compared with the pre-Games scenario as in Figure 6-4, showing a number of car users moved from cars to other travel modes, even after the restriction were decontrolled.
- People reduced short-distance (<1.5 kilometres) car travel during and after the Games. Figure 6-17 shows that 5.7% of people used car for trips within 1.5 kilometres in June 2008, while only 1.8% during the Olympic Games and 3.4% in the post-Games period for that distance. This implied that some car users altered to other transport for short-distance travel.

We also noticed some points that need to be taken into account when analysing the survey data:

- The background growth in travel demands and development in transport facilities and services have significantly impacted on Beijing residents' travel behaviours even before the 2008 Olympic Games. It is difficult to separate the Games' impacts from the underlying growth trends with in this data base. Thus, for this research, we need to pay attention to this when discussing on the changes.
- The aggregate results may ignore crossing changes at individual level, particularly in the analysis for mode share. For example, the share of car dropped by 13.3% during Games time. It is difficult to tell whether this decrease was because 13.3% of the car users gave up driving during Games time, or because 16.3% of the car user started using public transport while 3% of bus passengers became car dependents. To get a better insight of the individual behaviour changes among travel modes, analysis with Churn metrics (Goodwin, 2005) is suggested in Chapter 7.
- The survey only took one-day snapshot for residents' travel behaviour in each wave. As the sample size is very large, we assume

that the individual's day-to-day travel is habitual and a one-day record of behaviour constitutes a sufficient data base for analysis. However, we need to be aware of the day-to-day variation with the 'random' changes in transport condition and travel behaviour, which affects in the analysis for long-term changes. The 'random' changes usually come in following scenarios: 1) People on vacation or holiday may stay at home or make different travel from usual. As mentioned earlier, the students and teachers were on summer vacation when the second wave of survey was carried out. There were also some employees observed to stay at home in one wave of survey but commute in the other waves. 2) People travelled for different activities. e.g. People might cycle to work but take a taxi to hospital. 3) Changes in travel condition such as bad weather, etc. The 'random' changes made occasionally for different reasons often return to their original status when the situations come back. There was no definitive approach for this issue in empirical studies, while Stated-preference techniques and Special-purpose surveys are often used to calibrate or assist with interpreting the results (Mahmassani 2000, Petersen & Vovsha 2008). It was also suggested by Hanson & Huff (1982) that employed people exhibit a much smaller variation in daily travel than others. Considering the nature of the survey, we conduct specific analysis on commuting travels to get a better understanding on longer-term behaviour change.

Chapter 7

DATA ANALYSIS: HOW THE RESIDENTS CHANGED THEIR TRAVEL BEHAVIOUR DURING THE OLYMPIC GAMES

As discussed in Chapter 6, there were many changes found in Beijing residents' daily travel patterns during the Olympic Games, and some of those lasted to the post-Games period. Who were most impacted by the Games and changed their daily travel patterns when the Olympic Games came and travel conditions became different? The answer is very interesting and essential for forecasting the transport demands for upcoming mega events and planning the urban sustainable transport policies. This chapter examines the background and demographic characteristics of those most affected residents and their behaviour changes during Games time and after.

7.1. Sample data set

In order to track the changes in individual travelling methods, we study the sample data set which surveyed 2,450 residents during three periods: Pre-Games, Games time and Post-Games as introduced in Section 5.6.

Table 7-1 Whole data set and Sample data set

	Survey date	Survey area	Num. of Samples	
			Inhabitants	Num. of Trips[1]
Whole data set				
Wave 1 (Pre-Games)	June, 2008	Beijing urban areas[2] (Districts 1~8)	7,648	17,919
Wave 2 (Games time)	August, 2008		7,763	18,205
Wave 3 (Post-Games)	June, 2009		6,928	15,764
Sample data set				
Wave 1 (Pre-Games)	June, 2008	Beijing urban areas[2] (Districts 1~8)	2,450	6,137
Wave 2 (Games time)	August, 2008		2,450	5,705
Wave 3 (Post-Games)	June, 2009		2,450	5,724

Source: database owned by Beijing Transportation Research Center
Note: 1. including walking trips only.
2. Refer to Table 4-3.

7.2. Approach

The preliminary comparison in Chapter 6 finds that the factors of gender, age, residential area, car accessibility, driving experience, and primary travel mode significantly influence residents' behaviour changes. In this section we statistically analyse residents' travel behaviour changes against such factors, including the Weighted-Euclidean distance test of Probability Mass Function (PMF) and cluster analysis, to categorize the behaviour changes for different residents.

7.2.1. Weighted-Euclidean distance PMF test

In order to find the objective groups with significantly different characteristics, we must learn the difference between specific groups and the others in investigated aspects. For this purpose, Probability Mass Function (PMF) and their comparison maps were used. PMF, which is defined as below, is a function that gives the probability that a discrete random variable is equal to some value and is positive for at most a countable number of values of a (Johnson, Kemp & Kotz 2005, Ross 2009).

$$p(a) = P\{X = a\}$$

As X must take on one of the value x_i, we have

$$\sum_{i=1}^{\infty} p(x_i) = 1$$

To obtain comparison maps, we need to measure the distance between the select group and overall population on specific characteristics. Initially, we choose the Euclidean distance test to calculate the distances. It must be noted that PMF values are used here instead of frequencies, which are used in traditional statistical tests to permit examination of bivariate relationships.

Euclidean distance test

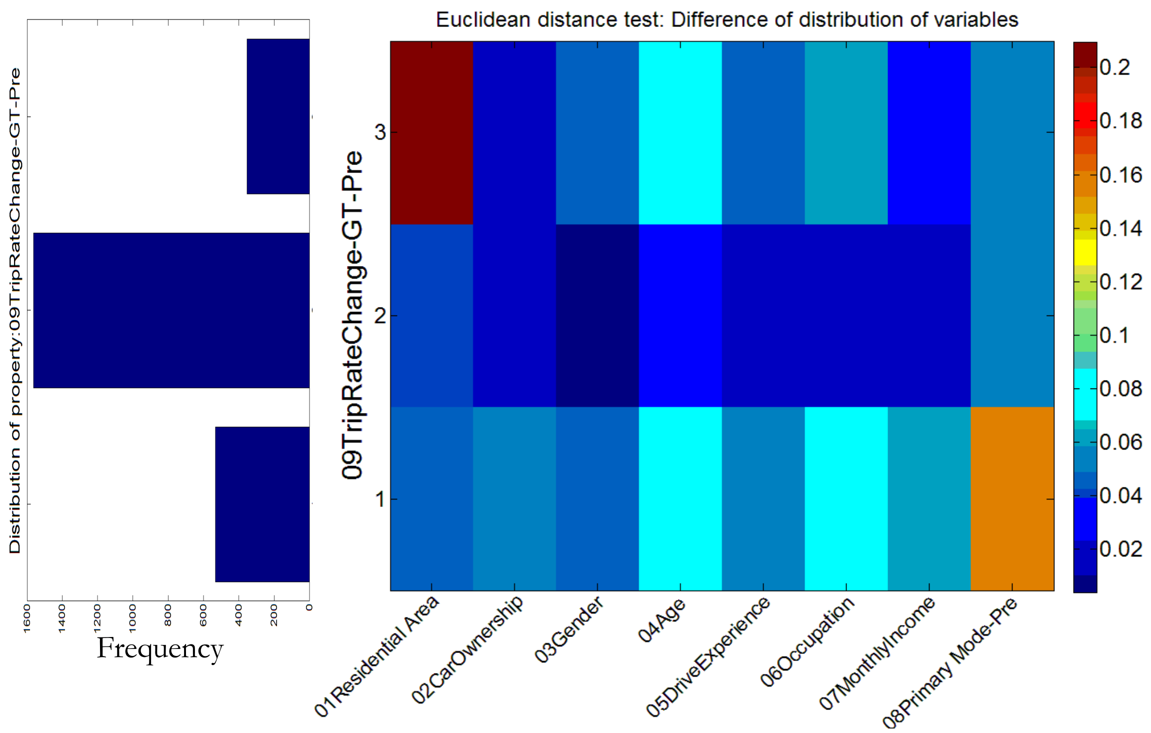
$$\textit{Euclidean distance test of PMF} = \sqrt{\sum_{i} (\ \mathrm{PMF}_{\mathrm{overall}}(\mathrm{i}) - \mathrm{PMF}_{\mathrm{specific\ group}}(\mathrm{i})\ )^2}$$

where the $\mathrm{PMF}_{\mathrm{overall}}$ is the probability mass function of all people for the compared variable, while $\mathrm{PMF}_{\mathrm{specific\ group}}$ is the probability mass function of a specific group of people being investigated, who come with a specific value of the studied variable.

In the comparison map, distances between each identified group and overall population are calculated respectively on selected characteristics, while the brighter blocks represent more significant difference. It should be noted that the PMF values were used here instead of frequencies, which were used in traditional statistical tests to permit examination of bivariate relationships.

We take the comparison map for the changes of trip rate between pre-Games and Games time as an example. The studied variable is the change of trip rates between pre-Games and Games time. As seen in Figure 7-1, the distribution of the studied variable is attached to the left of the map. We can see that more than half the people didn't change their trip rates during this period, and more people reduced their daily travel frequencies than those who increased theirs. In the comparison map, the X-axis is the characteristics of residents, while the Y-axis is the studied variable. The lowest row (trip rate change=1) represents people who reduced their trip rates between pre-Games and Games time, while the second row (trip rate change=2) represents people who didn't change their trip rates, and the third row (trip rate change=3) represents people who increased their trip rates during this period. Each colour block represents the difference between the PMF distribution of specific group of people ($PMF_{specific}$) and that of all people in the selected sample ($PMF_{overall}$). In Figure 7-1, we can see that the block at the crossing of Row 3 and Column 1 is dark red, indicating that the residential area of those people who did increase their trip rate during Games time is significant, when compared to the overall population in the sample. We can also see the block at the crossing of Row 1 and Column 8 is bright orange, indicating that the pre-Games mode share for people who reduced their trip rate during Games time was significantly different from others.

Figure 7-1 Euclidean distance PMF test for trip rate changes during the pre-Games and Games time



Change of Trip rates between pre-Games and Games time (Y-axis):
1. Decreased; 2. Unchanged; 3. Increased

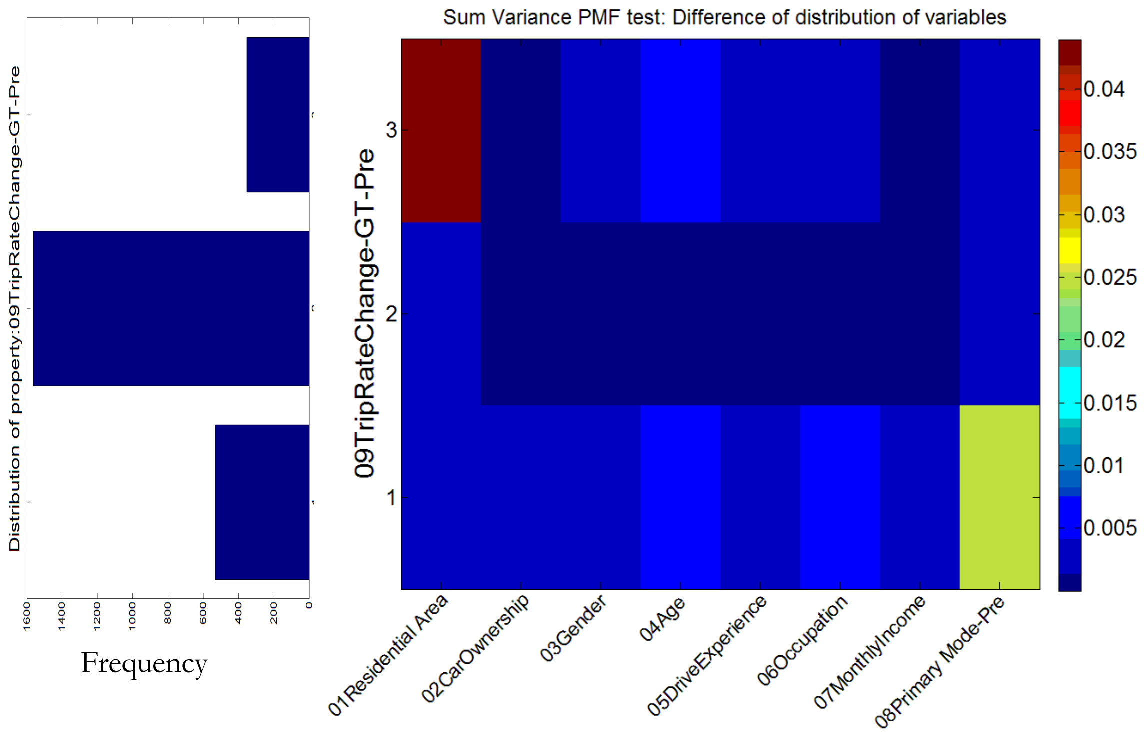
In order to obtain a better comparison map with clear details, three other kinds of tests including Sum of squared difference test, Normalized variation test, and Square root of Average Chi-Squared test were used to calculate the difference between the PMF distribution of specific group of people ($PMF_{specific}$) and that of all people in the selected sample ($PMF_{overall}$).

Sum of squared difference test

$$Sum\ of\ \ squared\ difference\ of\ \ PMF = \sum_{i} (\ PMF_{overall}(i) - PMF_{specific\ group}(i)\ )^2$$

where the $PMF_{overall}$ is the probability mass function of all people for the compared variable, while $PMF_{specific\ group}$ is the probability mass function of the specific group of people being investigated, who come with a specific value of the studied variable.

Figure 7-2 Map of Sum of squared difference PMF test for trip rate changes during the pre-Games and Games time



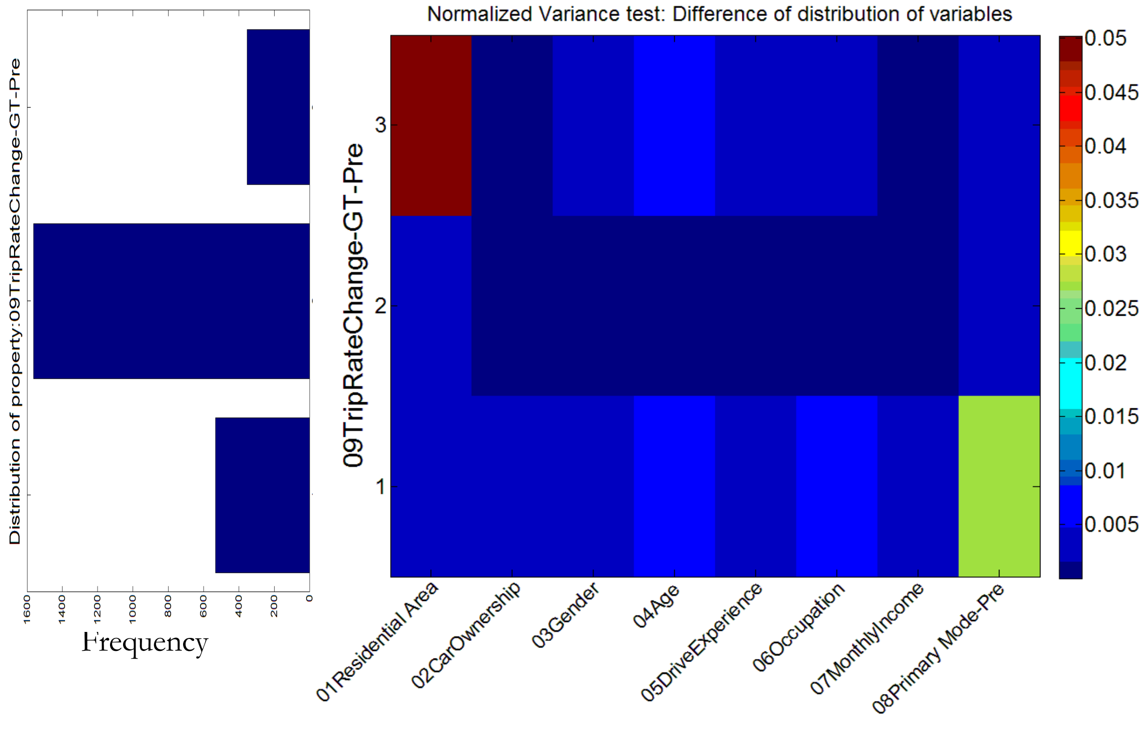
Change of Trip rates between pre-Games and Games time (Y-axis):
1. Decreased; 2. Unchanged; 3. Increased

Normalized Variance test

$$\text{Normalized Variance test PMF} = \frac{\text{variance}(PMF_{overall} - PMF_{specific\ group})}{\text{mean}(PMF_{overall})}$$

where the $PMF_{overall}$ is the probability mass function of all people for the compared variable, while $PMF_{specific\ group}$ is the probability mass function of the specific group of people being investigated, who come with a specific value of the studied variable.

Figure 7-3 Map of Normalized variance PMF test for trip rate changes during the pre-Games and Games time



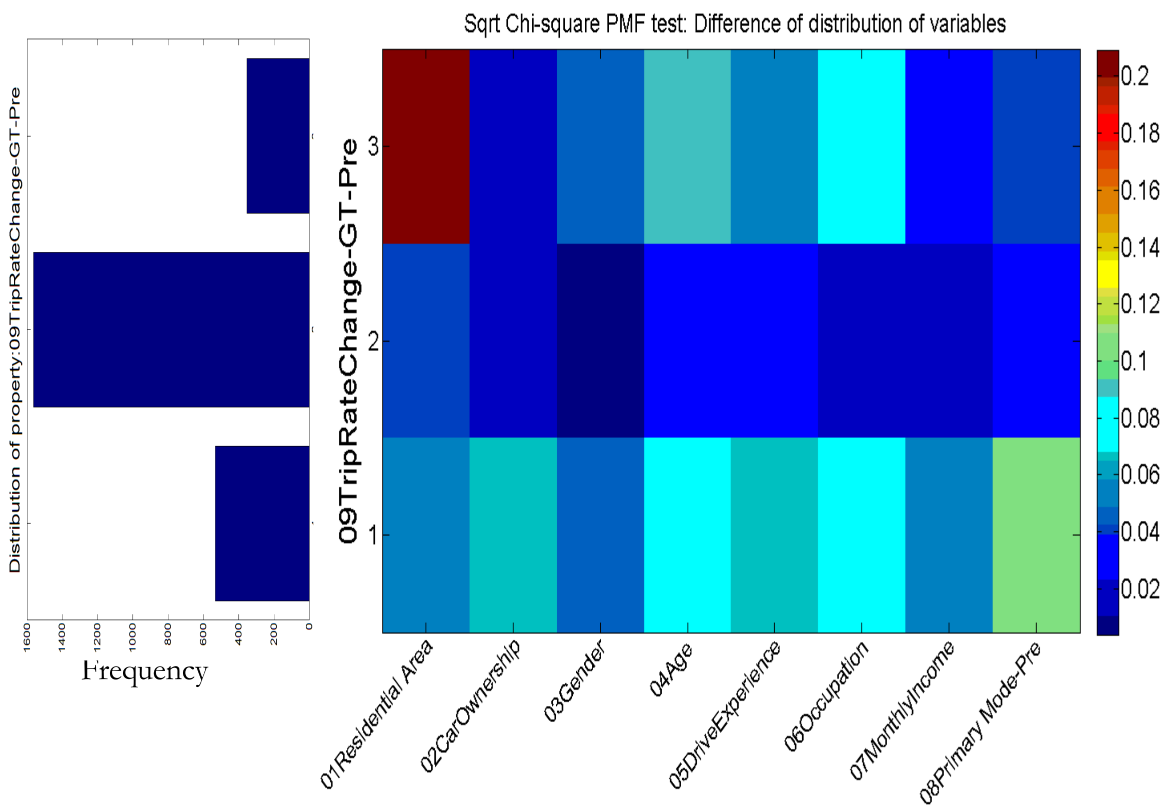
Change of Trip rates between pre-Games and Games time (Y-axis):
1. Decreased; 2. Unchanged; 3. Increased

Square root of Average Chi-squared of PMF test

$$\text{Square root of Average Chi-squared of PMF} = \sqrt{\frac{\sum_i \frac{(PMF_{overall}(i) - PMF_{specific\,group}(i))^2}{PMF_{overall}(i)}}{N}}$$

where the $PMF_{overall}$ is the probability mass function of all people for the compared variable, while $PMF_{specific\,group}$ is the probability mass function of the specific group of people being investigated, who come with a specific value of the studied variable. The N is the amount of possible discrete value points of compared variables.

Figure 7-4 Map of Square root of Average Chi-squared PMF test for trip rate changes between the pre-Games and Games time



Change of Trip rates between pre-Games and Games time (Y-axis):
1. Decreased; 2. Unchanged; 3. Increased

By comparing these four maps, it can be seen that the results of the four tests coincide generally, with similar highlighted areas on corresponding rows and columns in the comparison maps. For example, the middle row is less highlighted than other rows in all of these four maps, while the most highlighted block in these maps are located on the intersection of Row 3 and the Column 1, showing the residential area of those people who increased their travel demands during Games time was very different from the overall population.

Comparing these four tests, the Euclidean distance PMF test is better in showing the details than others. It can be learnt from Figure 7-1 that small differences are easy to observe through the Euclidean distance PMF test than others, as a result of the computation of square root, which balances the effect of the computation of square.

The Sum of squared difference PMF test is similar to the Euclidean distance PMF test, but the computation of the square amplifies the significance of the data and makes some small changes not very noticeable.

The Normalized variance PMF test has less bias on the attribute differences between characters, due to the computation of dividing the mean value of PMF. However, the effect of the square operation remains. Thus its map appears similar to the one of the Sum of squared difference PMF test.

The Square root of Average Chi-squared PMF test uses the Chi-squared test as the base operation and replaces the frequencies with PMF values. It reduced the bias on the attribute differences between characters through dividing the Chi-squared value by the amount of possible discrete value points of compared variables (N). In order to get a closer distribution level to the original significances, the test used square root computation as the final step. The results of the Square root of Average Chi-squared PMF test were mostly similar to those of the Euclidean distance PMF test, showing details for the small changes, especially for the big groups.

We need to notice that all these maps show less significant difference on the middle row. According to the distribution chart on the left, the middle row reflects the largest group among the three, which includes more than half of all participants, so the differences between them and the whole population are very small. In contrast, the differences are more sensitive when groups are smaller. Thus, we need to notice that the small groups might have significant statistical bias, while groups with large population are better in presenting the significances and connections between data. In this research, we only discuss the rows with more than 3% people of the whole sample set to avoid the bias.

According to the definition of Probability Mass Function (PMF), the PMF values sum up to 1 (Ross, 2009). Thus, individual PMF values are less than 1. With the computation of square, the significances become too small to reflect the actual changing trends very well. Considering the comparisons, the Euclidean distance PMF test is better than the others to investigate the significantly different groups in specific choices on the selected questions. However, in order to compare the degree of significant between groups, we weigh the results of Euclidean distance PMF test as shown below:

Euclidean distance test (weighted)

$$Euclideandistancetest\ (weighted)\ of\ \ PMF = \sqrt{\frac{\sum_i (\ \mathrm{PMF_{overall}}(\mathrm{i}) - \mathrm{PMF_{specific\,group}}(\mathrm{i})\ )^2}{\sum_i (\ \mathrm{PMF_{overall}}(\mathrm{i}))^2}}$$

where the $PMF_{overall}$ is the probability mass function of all people for the compared variable, while $PMF_{specific\ group}$ is the probability mass function of the specific group of people being investigated, who come with a specific value of the studied variable.

In the comparison map, we calculate $PMF_{specific=1,\ 2,\ 3}$ and $PMF_{overall}$ values of residential area and set them as two vectors in a multi-dimensional space. We calculate the Euclidean distance of the two vectors, and then weigh the distance to scale the significance. The weighted result reflects in the cell at the crossing of Rows 1, 2, 3 and Column 1. We refer to the value obtained from the combined test of Euclidean distance for the PMF and weighting operation of each character for different groups of people as Weighted-Euclidean distance PMF value (E-PMF') and consider the difference to be significant on the selected character between the specific group and the overall sample when their Weighted-Euclidean distance PMF value (E-PMF') is greater than 0.15 in this research.

We still use the comparison map for the Changes of trip rate between pre-Games and Games time as an example to explain the approach as below:

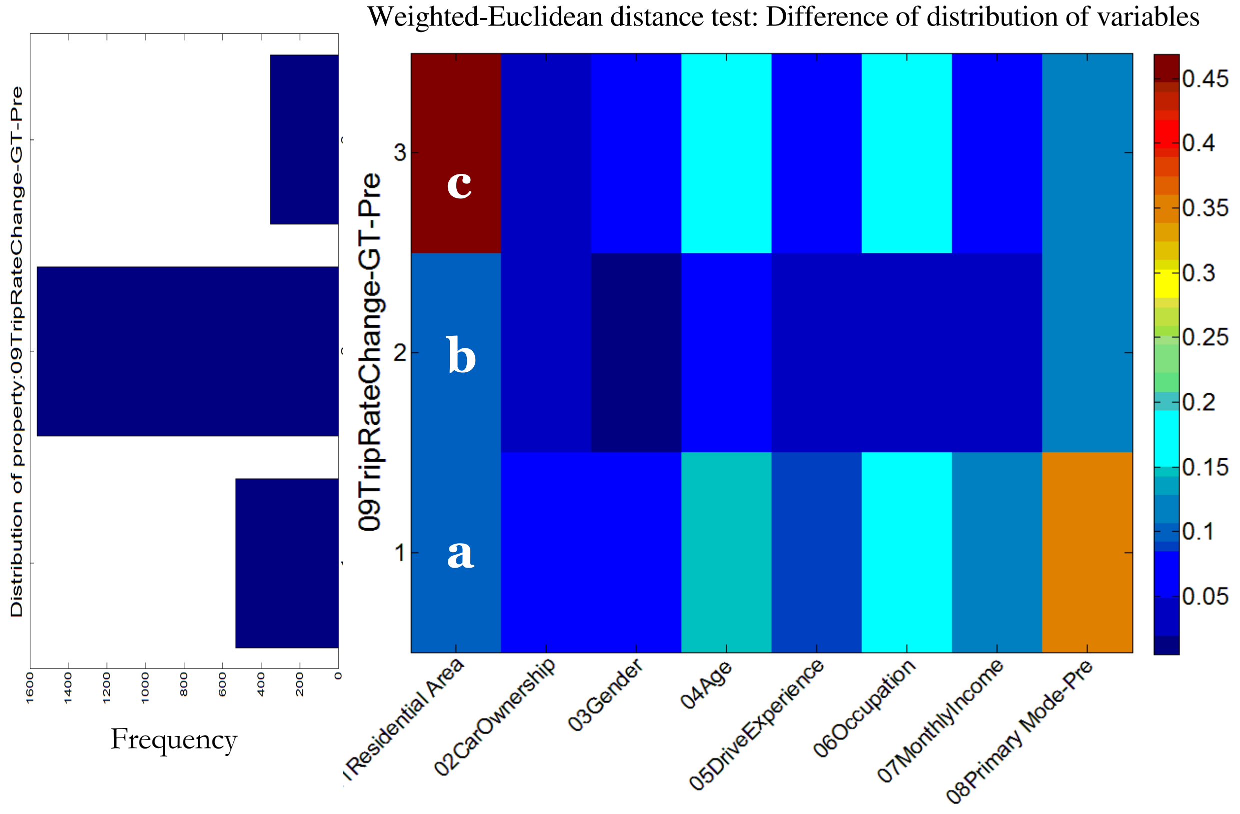
1. Produce a chart for the distribution of the studied variable (e.g. change of trip rate between pre-Games and Games time) and put it to the left of the map as seen in Figure 7-5.

2. Calculate E-PMF' value of different residents on the studied variable on Y-axis (e.g. people with Increased, Unchanged, Decreased trip rate during Games time) by every selected character on X-axis (e.g. 'Residential area') and produce the comparison map by locating the values into corresponding colour blocks as seen in Figure 7-5. The bright cell indicates that the group it represents (e.g. people with Increased trip rate during Games time) is significantly different from the overall sample data set on the compared character (e.g. 'Residential area'). For the following discussion, we name three blocks 'a', 'b' and 'c' as shown in Figure 7-5, corresponding to the feature 'residential area' of people who 'reduced', 'didn't change' and 'increased' their trip rates during Games time respectively.

3. Then we drill further by looking at the comparisons of $PMF_{specific}$ groups and $PMF_{overall}$ on 'Residential area' in Figure 7-6. In Figure 7-6, Chart I shows the feature of 'Residential area' for overall population in the sample, while the Charts II, III and IV correspond to Blocks 'a', 'b' and 'c'. We can see that residents who increased their daily trip rate (Chart IV) were much more significantly different from the overall (Chart I) on feature 'Residential area'

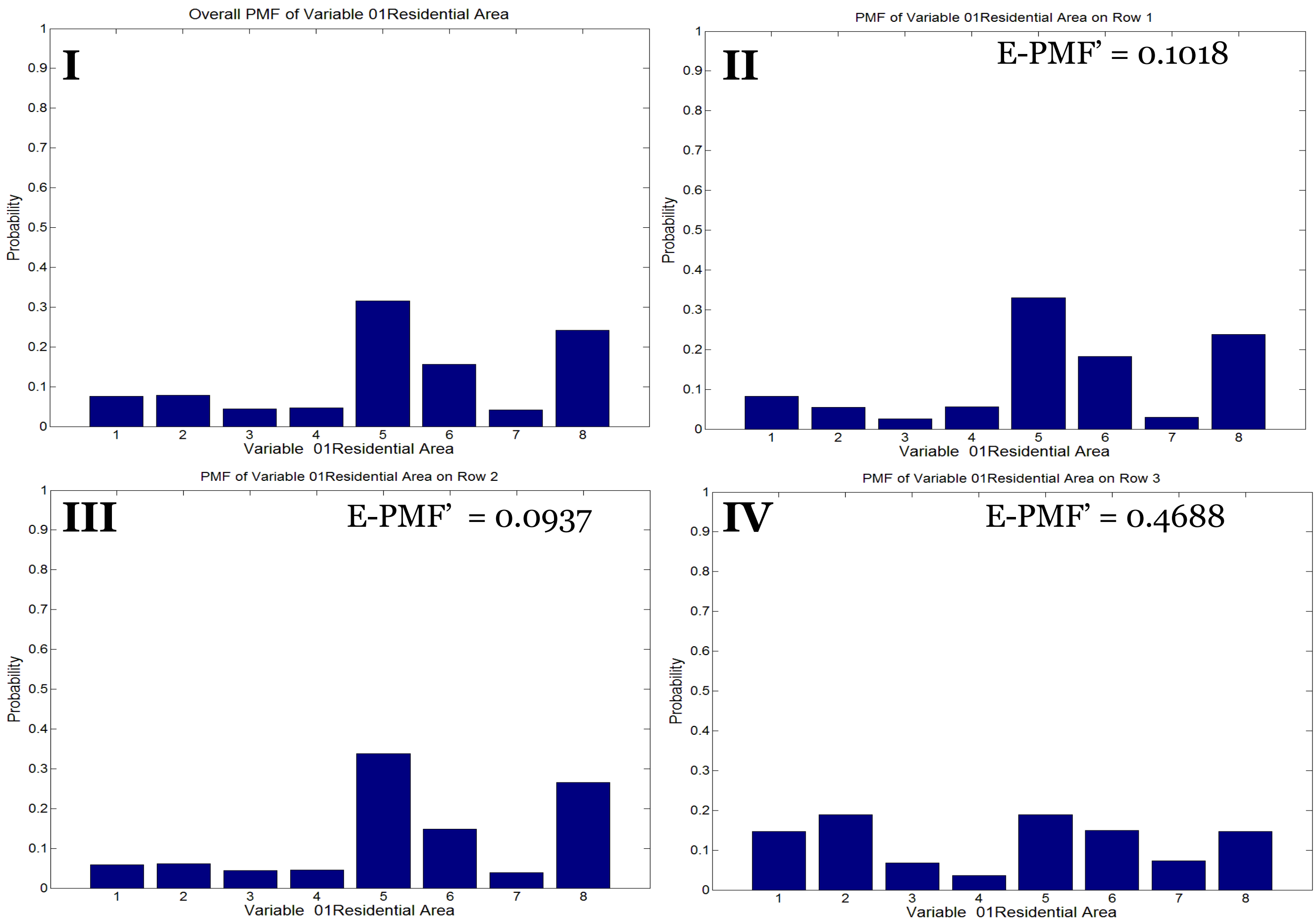
(E-PMF' = 0.4688), indicating that residents living in Zones 1, 2, 3 and 7 were more likely to increase their daily travel demands during Games time. Meanwhile, Charts II (E-PMF' = 0.1018) and III (E-PMF' = 0.0937) show a much smaller significance than Chart IV, indicating that the differences found in the feature 'Residential area' for those people who reduced or didn't change their trip rates from the overall population are much less significant. This result corresponds to Figure 7-5, where Blocks 'a' and 'b' are in less bright colour.

Figure 7-5 Map of Weighted-Euclidean distance PMF test for trip rate changes between the pre-Games and Games time



Change of Trip rates between pre-Games and Games time (Y-axis):
1. Decreased; 2. Unchanged; 3. Increased

Figure 7-6 Comparison of $PMF_{specific\ group=1,2,3}$ and $PMF_{overall}$ of Variable **Residential area**



Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

7.2.2. Cluster analysis

Cluster analysis is a data-driven technique which is rooted in statistics. Its importance and interdisciplinary nature can be found in many contexts and in different disciplines, as reflected by previous research such as Kantor (1953), Kemeny (1959), Punj & Stewart (1983), Jain et al (1999), Everitt et al (2001), Rencher (2002), Anable (2005), Dodson et al (2010), Manaugh et al (2010), Pronello & Camusso (2011) and Scherer & Weidmann (2011). This multivariate statistical tool identifies homogenous groups of clusters of patterns based on similarity, so that the patterns within each cluster possess strong internal similarities and the clusters are dissimilar to other groups. Unlike other statistical methods for classification, cluster analysis provides unsupervised classification to group multivariate samples with no prior information about the underlying groupings. It is a useful analytical method for capturing the natural structure and patterns of the data, to bring out meaningful groups for interpretation (Punj & Stewart 1983, Everitt et al 2001, Anable 2005).

The cluster analysis for travel behavioural research can be found in Pas (1982, 1984, 1988), Romesburg (1984), Hanson & Huff (1986), Curtis & Headicar (1997), Jensen (1999), Redmond (2000), Everitt et al (2001), Rencher (2002), Goulias et al (2003), Gotz (2003), Krizek (2003), Anable (2005), Dodson et al (2010), Manaugh et al (2010) and Scherer & Weidmann (2011). Researchers used cluster analysis to summarize the travel behaviours of people into different patterns or styles, in terms of several relatively homogeneous groups either by socio-economic or travel characteristic variables, to allow the data to 'speak for itself' (Pas 1982, Curtis & Headicar 1997, Anable 2005).

7.2.2.1. Definitions

In accordance with Jain et al. (1999), key definitions in cluster analysis are given below.

Features

The individual scalar components x_i of a pattern $\mathbf{x}$ are called features or attributes (Jain et al., 1999). Features can be either quantitative or qualitative. According to Gowda and Diday (1991), the features include following types:

- Quantitative features: continuous values, discrete values, interval values, etc. Of this type, features can be measured with a meaningful reference value.
- Qualitative features: nominal or unordered, and ordinal.

Pattern

A pattern **x** is a single data item used by the clustering algorithm, which can be measured by either a physical object or an abstract notion. It is usually represented conventionally by multidimensional vectors, where each dimension is a single feature, consists of a vector of d measurements: $\mathbf{x} = (x_1, x_2, \ldots x_d)$ (Duda & Hart, 1973; Jain et al., 1999).

In cluster analysis, patterns are obtained solely from the data, where the data are more similar to each other within a valid cluster than they are to a pattern belonging to a different cluster. The objective and procedure of clustering are normally to group or classify a given collection of unlabelled patterns into meaningful clusters (Jain, et al., 1999).

Pattern set

A pattern set is denoted $\Psi = \{\mathbf{x}_1, \ldots \mathbf{x}_n\}$. The i^{th} pattern in Ψ is denoted $\mathbf{x}_i = \{x_{i,1}, \ldots x_{i,d}\}$. In many cases a pattern set to be clustered is viewed as an n X d pattern matrix (Jain, et al., 1999).

Class

A class, in the abstract, refers to a state of nature that governs the pattern generation process in some cases. More concretely, a class can be viewed as a source of patterns whose distribution in feature space is governed by a probability density specific to the class. Clustering techniques attempt to group patterns so that the classes thereby obtained reflect the different pattern generation processes represented in the pattern set (Jain, et al., 1999).

Distance measure

A specialization of a proximity measure, which is a metric or quasi-metric on the feature space used to quantify the similarity of patterns. It is most common to calculate the dissimilarity between two patterns using a distance measure defined on the feature space.

Furthermore, *d* is the dimensionality of the pattern or of the pattern space in the definitions above for cluster analysis.

7.2.2.2. Approach

Typical pattern clustering activity involves the following steps (Jain & Dubes, 1988):

(1) pattern representation (optionally including feature extraction and/or selection),

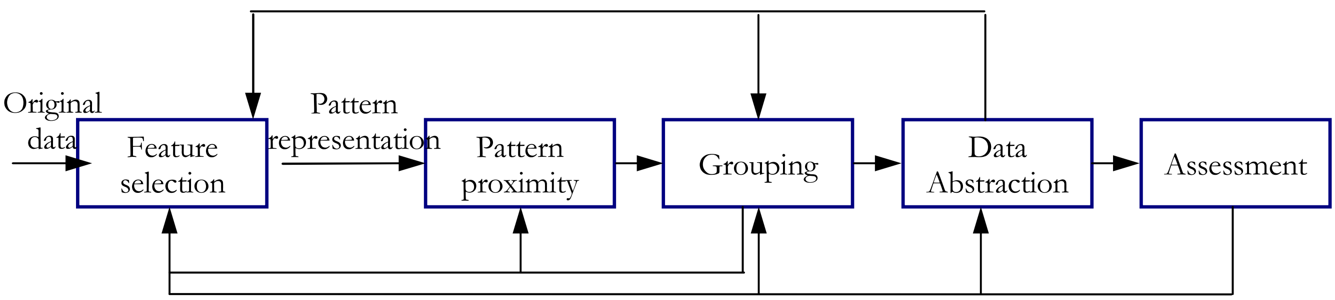
(2) definition of a pattern proximity measure appropriate to the data domain,

(3) clustering or grouping,

(4) data abstraction (if needed), and

(5) assessment of output (if needed).

Figure 7-7 Steps of clustering



In this approach, feature selection is the key starting point that identifies and determines the effective subset of the original features to use for clustering. It is often valuable to isolate only the most descriptive and discriminatory features in the input set, and utilize those features exclusively in subsequent analysis. The main goal of this step is to improve classification performance, while this procedure might require repeats with the outcome or preliminary results from following steps. For this step, some feature extraction processes not depending on labelled data such as principal components analysis are popular in practice. To the procedure itself, reduction of the number of features is a benefit (Jain, et al., 1999).

Since clustering is a data driven method, the process of pattern representation is usually not controllable, or at least not directly controllable. However, factors and conjectures about the data are gathered through this process. A good pattern representation can often yield a simple and easily understood clustering, which is based on careful investigation and comprehensive understanding of the features and their background (Jain, et al., 1999).

Following pattern representation which normally refers to the number of classes, the number of available patterns, and the number, type, and scale of the features available to the clustering algorithm, Pattern proximity is an essential procedure for most clustering projects, by applying distance measures that are defined on the feature space towards patterns identified from previous steps. For continuous features, Euclidean distance is one of the most popular metrics for distance calculation, while it has been found to be problematic for non-continuous features even though certain combined methods have been developed for this (Jain et al., 1999; Michalski & Stepp, 1983; Wilson & Martinez, 1997).

Original data and objective information are categorized into clusters in the step of Grouping, based on the selected features. Since the research by Sokal (Jain et al., 1999; Sokal, 1963), there have been various clustering techniques developed in both research and practices, such as Hierarchical clustering algorithms, Partitional Algorithms, Density-based clustering, Grid-based clustering, Model-based clustering and Graph-based clustering (Jain et al., 1999; Zahn, 1971). Different techniques lead the output clusters to different forms. Hierarchical clustering algorithms produce a nested series of partitions based on a criterion for merging or splitting clusters based on similarity, while Partitional clustering algorithms identify the partition that optimizes (usually locally) a clustering criterion (Jain et al., 1999).

Data abstraction is the process of extracting an efficient description of each cluster, which helps simplify the data representation in terms of cluster prototypes or representative patterns for intuitive understanding or further analysis by machine (Jain et al., 1999)

The Assessment of a clustering procedure appears in two forms, one is assessing the cluster tendency of the data domain, investigating if it is suitable for a clustering algorithm; while the other is cluster validity analysis by statistical methods and testing hypotheses commonly, which assesses a clustering procedure's output and determines whether the output is meaningful. From previous research, there are three types of validation studies: external, internal and relative examinations (Jain, et al., 1999).

7.2.2.3. Clustering Techniques

There are various clustering techniques, while hierarchical and partitional are the main branches. Hierarchical methods produce a nested series of partitions, while partitional methods produce only one (Jain & Dubes, 1988).

Hierarchical Clustering

A hierarchical clustering yields a dendrogram representing the nested grouping of patterns and similarity levels at which groupings change. The dendrogram can be broken at different levels to yield different clusters of data (Jain & Dubes, 1988). In this approach, each pattern is initially considered as a cluster, the two groups that are closest are combined, while such process continues till a single cluster containing all patterns is obtained and a hierarchy of clusters is generated. This process can also be applied in reverse manner which begins with all patterns in a single cluster and performs splitting based on some criterion to obtain a partition of singleton clusters.

Referring to the way of charactering the similarity between clusters, there are methods of single-link, complete-link, as well as minimum-variance. The complete-link method is most popular in practice (Jain & Dubes, 1988).

Partitional clustering

A partitional clustering obtains single partitions of the data, which shows advantage in processing large data sets. The initial partitioning is used to divide the patterns into several clusters or several cluster centres are initially demarcated. Then the patterns are reallocated to the clusters by optimizing a criterion function defined either locally (on a subset of the patterns) or globally (defined over all of the patterns). In practice, the algorithm is typically run multiple times with different starting states, and the best configuration obtained from all of the runs is used as the output cluster.

Of partitional clustering approaches, squared error clustering and k-means clustering are more popular than others. Here, the dataset is usually partitioned into K partitions on certain criterions. Squared error clustering algorithms tend to isolate and compact clusters by repeatedly assigning the centroid of each cluster and pattern to its closest cluster centre until convergence is achieved, while k-means clustering re-compute the cluster centres while requiring that the initial partition is selected properly.

7.2.2.4. Discussion

Cluster analysis is a method rooted in statistics and decision theory, which facilitates the grouping of similar observations based only on information found in the data that describes the observations and their relationships. It can be regarded as a form of classification in that it generates groups of data with group labels which are also from the data. Considering there are few prior assumptions given for the database studied in this research and that false assumptions of homogeneity can lead to bias in interpretation and explanation for travel behaviour, a multivariate data mining technique which allows the data to present itself with the naturally generated association of travellers is appropriate here, such as cluster analysis. We learned from previous research that the number of clusters and their relative size is also not known until the process has been completed (Jain et al 1999, Anable 2005, Manaugh et al 2010). However, it was emphasized from literature and previous practice that a good understanding of the data itself and a careful investigation of the available features and any available transformations of the dataset will significantly improve the clustering results and interpretation (Jain et al 1999). On techniques, the iterative partitioning methods were found superior to hierarchical methods in empirical research. In particular, K-means clustering showed its advantage in processing large dataset to retrieve the patterns in the data (Punj & Stewart 1983, Anable 2005).

In previous research by Romesburg (1984), Curtis & Headicar (1997), Redmond (2000) and so on, cluster analysis proved its abilities in dealing with a combination of explanatory variables including the built environment, demographic characteristics, psychological factors, existing travel patterns, etc, and provides an opportunity in identifying homogenous groups of people in the context of travel behaviour change. In particular, Anable (2005) demonstrated that cluster analysis provides an effective approach to identify the groups for different travellers in different physical and psychological situations to improve the understanding of travel behaviour which is useful for decision making, marketing, etc. The study in this thesis has a similar objective in discovering the travel behaviour changes for different groups of people with different situations. So we choose cluster analysis to examine how travellers can be meaningfully grouped to obtain intuitive interpretations of the data and further details of the relationships between internal characteristics embedded in a high-dimensional space, and how these groups compare and support the analysis from other approaches such as the Weighted-Euclidean distance PMF test. However, because the dataset has a shortage in psychological information to give an analysis in the context of the Theory of Planned Behaviour (and similar models), this research will focus on the relationship between the demographic background of Beijing residents and their behaviour changes in daily travel across the pre-Games, Games time, and post-Games periods of Beijing 2008 Olympic Games. Considering the nature and size of the dataset, the approach of k-means clustering is used for this research.

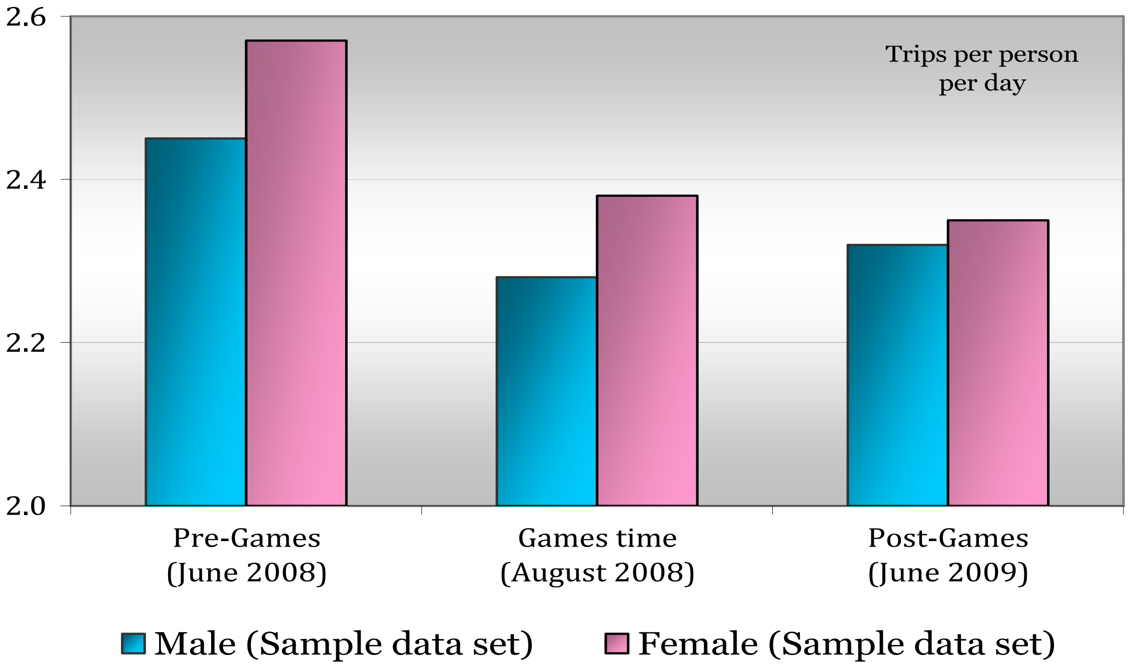
7.3. Changes in trip rate

7.3.1. Comparison by demographic characters

7.3.1.1. By gender

As stated in Table 7-2, the average female resident (2.57 trips per person per day) took a few more trips than the average male resident (2.45 trips per person per day) in normal daily life. Data clearly demonstrates that both male and female residents made significant changes in their travel patterns when the Olympics were held and the changes remained thereafter. Looking closer at Games time, the decrease in female trip rates was bigger than those of males. After the Games, male trip rates rebounded quickly, while female residents further reduced the number of daily trips. It shows that females were more sensitive than males to the impacts of mega events and related traffic measures. When the conditions changed, they adjusted their travel habits promptly. On the other hand, males were more likely to be set in their original ways of daily travel, for they were less likely to change their travel during the Games and turned their travel patterns back more quickly when those restrictions had gone. This difference between male and female travellers can also be observed in Figure 7-8.

Figure 7-8 Trip rates by gender of the surveys



Source: database owned by Beijing Transportation Research Center.

Table 7-2 Changes in Trip rates by GENDER in selected waves of the surveys

	N (June, 08)	Mean (June, 08)	SD (June, 08)	Differences between waves of survey											
				Games time & June 08				June 09 & June 08				Games time & June 09			
				Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)
Female	1,129	2.57	1.265	-.19	-7.35%	-5.76	**<.001**	-.22	-8.37%	-5.31	**<.001**	-.03	-1.05%	-.78	.436
Male	1,321	2.45	1.084	-.17	-6.78%	-5.34	**<.001**	-.13	-5.27%	-3.69	**<.001**	.04	1.51%	1.24	.216

Source: database owned by Beijing Transportation Research Center

7.3.1.2. By age

According to the results from the surveys, different age groups responded at different levels to the transport measures instituted due to the Olympic Games as shown in Table 7-3.

Table 7-3 Changes in Trip rates by AGEs in selected waves of the surveys

	N (June, 08)	Mean (June, 08)	SD (June, 08)	Differences between waves of survey (compared with Normal period in June 2008)											
				Games time & June 08				June 09 & June 08				Games time & June 09			
				Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)
0-14	65	2.14	.556	0	0.00%	0	1.000	-.05	-2.15%	-.46	.651	-.05	2.15%	-.44	.658
15-24	159	2.07	.564	.06	2.75%	1.01	.313	.09	4.54%	1.51	.132	.04	1.84%	.57	.572
25-34	429	2.38	.932	-.15	-6.26%	-2.91	**.004**	-.14	-5.80%	-2.67	.794	.01	0.50%	.26	.794
35-44	518	2.60	1.140	-.28	-10.69%	-5.38	**<.001**	-.26	-9.81%	-4.15	**<.001**	.02	0.88%	.46	.644
45-54	828	2.56	1.156	-.16	-6.74%	-4.11	**<.001**	-.17	-6.45%	-3.35	**.001**	-.01	-0.20%	-.12	.907
55-64	334	2.59	1.029	-.20	-8.54%	-3.23	**.001**	-.23	-8.92%	-3.26	**.001**	-.03	-1.04%	-.42	.672
65-74	92	2.73	1.498	-.24	-8.75%	-1.61	.111	-.21	-7.58%	-1.12	.268	.03	1.21%	.22	.826
75+	25	2.64	1.150	-.40	-15.15%	-1.68	.106	-.04	-1.52%	-.13	.896	.36	13.64%	1.44	.164

Source: database owned by Beijing Transportation Research Center

During the first survey in June 2008, the 35-44 and 65+ age groups travelled more than others, averaging 2.62 trips per person per day.

From baseline levels in 2008 to Olympic Games time, residents aged between 25 and 64 showed significant changes in travel (sig<0.005). Particularly, the 35-44 age group had the biggest decrease (-10.69%) during this period. However, the Games impacted the younger (<25) and older (65+) age groups much less, as these groups didn't show significant changes in their travel patterns.

Viewing the longer term changes in post-Games in June 2009, no age group shows significant change between the Games period and June 2009. However, the changing trend was different for the different groups. The 45-64 age group continued to reduce daily trip numbers after the Games, which was different from other age groups. Similar to Games time, the youngest and oldest groups changed less significantly than others in the long-term period.

In summary, middle-aged (25-64) people responded to the impacts of the Olympic Games and relevant measures more actively than others, while those people aged between 45-64 were most likely to keep their 'Games time' changes after the Games. In another word, the impacts of Olympic Games seemed to be more effective on people aged between 45-64 in the longer term in Beijing.

7.3.1.3. By residential area

Turning our attention to residential areas, it can be seen that changes in Chaoyang, Fengtai, Shijingshan and Haidian districts (Districts 5, 6, 7 and 8), particularly Chaoyang and Haidian districts (Districts 5 and 8), were much more significant during Games time. This is likely due to traffic controls and Olympic lanes being more prominent in the regions, where most competition venues and appointed accommodation hotels were located. Accordingly, residents in these areas were forced to or voluntarily had to make more significant changes on their daily travel.

Table 7-4 Changes in Trip rates by residential areas in selected waves of the surveys

		N (June, 08)	Mean (June, 08)	SD (June, 08)	Differences between waves of survey											
					Games time & June 08				June 09 & June 08				Games time & June 09			
					Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)
1	Dong cheng	24	2.42	.717	-.33	-13.76%	-1.88	.073	-.42	-17.23%	-2.85	**.009**	-.08	-3.43%	-1.00	.328
2	Xi cheng	191	2.46	.993	-.11	-4.27%	-1.42	.158	-.13	-5.12%	-1.44	.151	-.02	-0.85%	-.24	.808
3	Chong wen	108	2.23	.838	-.09	-4.17%	-1.32	.190	-.01	-1.47%	-.11	.911	.08	3.72%	1.10	.274
4	Xuan wu	114	2.59	1.289	-.07	-2.70%	-.52	.606	.13	5.10%	.79	.430	.20	7.80%	1.32	.191
5	**Chao yang**	772	2.44	.957	-.23	-9.51%	-6.55	**<.001**	-.15	-6.11%	-3.49	**.001**	.08	3.40%	2.39	**.017**
6	Feng tai	382	2.58	1.093	-.14	-5.47%	-2.38	**.018**	-.21	-8.22%	-3.12	**.002**	-.07	-2.75%	-1.16	.246
7	Shijing shan	103	2.39	1.012	-.28	-11.80%	-2.72	**.008**	-.33	-13.81%	-2.94	**.004**	-.05	-2.05%	-.76	.448
8	**Hai dian**	593	2.55	1.160	-.12	-4.51%	-2.41	**.016**	-.23	-8.86%	-3.88	**<.001**	-.11	-4.35%	-2.31	**.021**

Source: database owned by Beijing Transportation Research Center
Note: The data/information for the city of Beijing covers the whole city regions as shown in Figure 4-3.

Comparing the longer-term changes, residents in venue areas were more likely to maintain their decreasing trend in trip rates from those in other areas after the Games. From Table 7-4, the residents in Haidian and Chaoyang districts, which hosted 21 out of 28 competition venues including the Olympic park, showed noticeable long-term changes in trip rate between Games time and post-Games. However, residents in Haidian district kept reducing daily travel demands, while those in Chaoyang picked up again after the Games. The reason for this difference is not clear and needs further investigation.

7.3.1.4. By car ownership

As discussed earlier in this chapter, car use was one of the biggest changes due to the Games. People altered their daily travel mode from private vehicles to other travel means during Games time and thereafter. Therefore, understanding the different movements in travel patterns between car users and the other without car access is very interesting and important to identifying the resident groups making changes.

Table 7-5 Changes in Trip rates by car ownership

	N (June, 08)	Mean (June, 08)	SD (June, 08)	Differences between waves of survey											
				Games time & June 08				June 09 & June 08				Games time & June 09			
				Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)
Households with private vehicle[1]	1,337	2.43	.961	-.24	-9.71%	-8.30	**<.001**	-.12	-4.98%	-3.68	**<.001**	.12	4.73%	4.36	**<.001**
Households with non-private vehicle[2]	131	2.80	1.411	-.33	-11.71%	-2.58	.011	-.53	-18.82%	-3.94	**<.001**	-.20	-7.07%	-2.10	**.038**
Households with both private and non-private vehicles[3]	8	2.38	.518	-.25	-10.50%	-1.00	.351	-.13	-5.25%	-.55	.598	.13	5.25%	.42	.685
Households without access to vehicle[2]	974	2.57	1.178	-.07	-2.84%	-1.97	.050	-.19	-7.24%	-4.10	**<.001**	-.11	-4.40%	-2.74	**.006**

1: Households owned private vehicle (s), but without access to government/company vehicle.
2: Households with access to government/company vehicle (s) only, not owned private vehicle.
3: Households with access to government/company vehicle (s), and owned private vehicle (s) as well.
Source: database owned by Beijing Transportation Research Center

As shown in Table 7-5, the surveys demonstrate that,

1) In general, people without car access travelled more frequently than those with car access in normal circumstance before the Games. As stated in Table 7-5, the average trip rate of people with car access was 2.46 trips per person per day, while people without car access made 2.57 trips per person per day.
2) Looking closer at car users, people with access to non-private vehicles (government/company vehicles) travelled the most, with the highest average trip rate of 2.80 trips per day per person in June 2008, topping non-car users.

3) While the Olympic Games took place, people with vehicle access reduced their travel much more significantly than those without vehicle access. The average trip rates of people owning vehicles decreased by 10.07% during Games time, while people without vehicle access reduced daily trips by 2.84%. Statistical analysis tells us that the change made by people owning private vehicles was more significant than the others.
4) The trend change became different after the Games. People without car access and people who only had non-private vehicles (government/company vehicle) stayed with the reducing trend in travelling, while the private vehicle owners didn't. The trip rates of residents without vehicle access continued decreasing from 2.50 during Games time to 2.38 in 2009. Meanwhile, residents with private vehicle access picked up travelling activities after the Games, increasing their average trip rates from 2.19 during Games time to 2.31 in June 2009.

7.3.1.5. By driving experience

In Table 7-6, trip rate is compared against driving experience. For people who drive on a regular basis, their trip rates increase with driving experience. When the Olympic Games came, most people with vehicle access reduced their daily travel demands, except the people whose driving experience was less than 5 years. It was also found that all of them increased their daily trip rates after the Games. However, comparing normal days in 2008 and 2009, we see that people with vehicle access reduced their daily travel demands in the long term. Particularly, people with driving experience between 10-19 years saw the most significant reduction in daily trip rates between 2008 and 2009.

Table 7-6 Changes in trip rates by driving experience[1]

	N (June, 08)	Mean (June, 08)	SD (June, 08)	Differences between waves of survey											
				Games time & June 08				June 09 & June 08				Games time & June 09			
				Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)
Do not drive	552	2.47	1.040	-.25	-9.96%	-5.61	**<.001**	-.15	-6.23%	-2.93	**.003**	.09	3.72%	2.28	**.023**
0~4 years	184	2.30	.770	-.09	-4.00%	-1.34	.181	-.05	-2.35%	-.74	.462	.04	1.65%	.57	.570
5~9 years	239	2.48	1.076	-.22	-8.79%	-2.72	**.007**	-.12	-4.72%	-1.40	.164	.10	4.03%	1.36	.175
10~19 years	349	2.48	1.022	-.28	-11.21%	-4.78	**<.001**	-.20	-7.98%	-2.92	**.004**	.08	3.23%	1.64	.103
20~29 years	118	2.52	1.002	-.30	-11.79%	-2.82	**.006**	-.20	-7.74%	-1.63	.107	.10	4.05%	1.06	.291
>30 years	34	2.74	1.136	-.71	-25.77%	-3.60	**.001**	-.50	-18.25%	-1.87	.071	.21	7.52%	1.19	.242

1: for households with vehicle access only.
Source: database owned by Beijing Transportation Research Center

7.3.1.6. By occupation

Investigating by occupation, change in trip rate was much more significant in the group of students and teachers, due to summer vacation. Meanwhile, employers of technology, manufacturing, retail and business trading showed certain decrease as well. This change is likely due to the government and employers encouraging employee vacations and adjusting work hours to a certain extent. Conversely, the police, drivers and retired people made more trips over the same duration (Source: Beijing Transportation Research Center)

7.3.1.7. By primary travel modes

As seen in Table 7-7, trip rates by different travel modes during June 2008, when the first wave of survey was launched, exhibit the following characteristics:

1. Non-motorized travellers travelled more frequently than motorized travellers. Pedestrians (2.97) and cyclists (2.60) had the highest trip rates of all travellers.
2. Car users travelled more than public transport passengers. As in Table 7-7, the average car user made 2.43 trips per person per day, while public transport passengers only made 2.20 trips per person per day. Meanwhile, those people with company coaches had even less travel, at a level of 2.13

trips per person per day.

3. People using both car and public transport methods for travelling had a high trip rate, at around 2.50 trips per person per day on average, which was more than that of car users.

Table 7-7 Changes in trip rate (Sample data sets) I

	N (June, 08)	% of Sample data set	Mean (Normal, 08)	Differences between waves of survey											
				Games time & June 08				June 09 & June 08				Games time & June 09			
				Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)
Walk only	475	19.4%	2.97	-.29	-9.86%	-4.76	**<.001**	-.55	-18.58%	-7.72	**<.001**	-.26	-8.72%	-4.25	**<.001**
Cycle	496	20.2%	2.60	-.21	-7.97%	-3.98	**<.001**	-.24	-9.06%	-4.01	**<.001**	-.03	-1.08	-.56	.579
Public Transport	587	24.0%	2.20	-.03	-1.47%	-.91	.365	.13	5.88%	2.70	**.007**	.16	7.36%	3.63	**<.001**
Car	819	33.4%	2.43	-.22	-8.88%	-5.54	**<.001**	-.15	-5.97%	-3.39	**.001**	.07	2.92%	2.03	**.042**
Car & Public transport	24	1.0%	2.50	-.17	-6.67%	-.70	.491	-.38	-15.00%	-1.40	.175	-.21	-8.32%	-1.55	.135
Company coach	40	1.6%	2.13	-.05	-2.35%	-.47	.643	.10	4.71%	.78	.440	.15	7.04%	1.43	.160
Other	9	0.4%	2.22	-.22	-10.0%	-1.00	.347	-.22	-10.0%	-1.00	.347	0	0	N/A[1]	N/A[1]

1. t cannot be computed because the standard error of the difference is 0.

Source: database owned by Beijing Transportation Research Center

When investigating the changes across the three waves of surveys, it can be seen that,

1. Trip rates of pedestrians, cyclists and car users changed significantly among the three periods. As detailed in Table 7-8, 23.4% pedestrians, 17.9% cyclists and 20.3% car users reduced their daily trips during Games time. In 2009, the average travel demands by people in these three groups were less than in early 2008.
2. Passengers of public transport didn't change much during Games time, while their change in trip rate was statistically significant in 2009. According to Table 7-8, 18.1% public transport passengers increased their daily travel activities, while 11.8% in this group reduced their trip rates at the same time.

3. Other travellers seemed to stay at the same daily trips level throughout.

Table 7-8 Changes in trip rate (Sample data sets) II

Original travel mode	Pre Games to Games time			Pre Games to Post Games			Games time to Post Games		
	>0	<0	0	>0	<0	0	>0	<0	0
Walk only[1]	12.4%	23.4%	64.2%	11.2%	31.8%	57.1%	14.5%	24.2%	61.3%
Cycle	8.7%	17.9%	73.4%	12.5%	21.0%	66.5%	13.7%	14.7%	71.6%
Public transport	8.3%	11.1%	80.6%	18.1%	11.8%	70.2%	17.0%	8.5%	74.4%
Car	9.2%	20.3%	70.6%	12.7%	21.1%	66.2%	13.2%	10.5%	76.3%
Car & Public transport	4.2%	16.7%	79.2%	8.3%	25.0%	66.7%	4.2%	16.7%	79.2%
Company coach	5.0%	10.0%	85.0%	10.0%	5.0%	85.0%	12.5%	2.5%	85.0%
Other	0.0%	11.1%	88.9%	0.0%	11.1%	88.9%	0.0%	0.0%	100.0%

1 Walks only: when walks are as the only mean to complete trips (i.e. walking all the way), not when they are part of trips using other modes of transport.
Source: database owned by Beijing Transportation Research Center

Tables 7-9 to 7-12 compare the changes in trip rate for public transport passengers and car users with further details.

Table 7-9 Changes in trip rate of public transport passengers (Sample data sets) I

	N (June, 08)	% of public transport users	Mean (Normal, 08)	Differences between waves of survey											
				Games time & June 08				June 09 & June 08				Games time & June 09			
				Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)
Buses	505	86.03%	2.22	-.03	-1.34%	-.76	.449	.11	4.73%	2.08	**.038**	.14	6.08%	2.92	**.004**
Subway	23	3.92%	2.13	.04	2.04%	.20	.847	.30	14.29%	.89	.382	.26	12.25%	.72	.479
Taxi	9	1.53%	2.33	-.33	-14.29%	-1.41	.195	.22	9.52%	.51	.622	.56	23.86%	1.89	.095
Mixed[1]	50	8.52%	2.06	-0.04	-1.94%	-0.47	0.642	0.28	13.59%	1.68	0.099	.32	15.5%	1.91	.062

[1] mixed: use more than one public transport means as the primary travel means (i.e. using bus and subway).
Source: database owned by Beijing Transportation Research Center

Of all public transport passengers, taxi users travelled the most while those using more than one public transport methods travelled the least in both pre-Games and post-Games time. Subway passengers became more active during Games time.

Tables 7-9 and 7-10 show that taxi users reduced their travel activities during Games time to a certain extent, but the rate rebounded soon after the Games. Looking through the periods, most public transport passengers stayed at a similar level in trip volume and didn't seem to be interrupted much by the Olympic Games in this aspect.

Table 7-10 Changes in trip rate of public transport passengers (Sample data sets) II

Original travel mode	Pre Games to Games time			Pre Games to Post Games			Games time to Post Games		
	>0	<0	0	>0	<0	0	>0	<0	0
Buses	8.7%	10.9%	80.4%	18.2%	11.9%	69.9%	17.0%	9.1%	73.9%
Subway	8.7%	8.7%	82.6%	13.0%	8.7%	78.3%	8.7%	4.3%	87.0%
Taxi	0.0%	22.2%	77.8%	33.3%	22.2%	44.4%	33.3%	0.0%	66.7%
Mixed[1]	6.0%	12.0%	82.0%	16.0%	10.0%	74.0%	18.0%	6.0%	76.0%

[1] mixed: use more than one public transport means as the primary travel means (i.e. using bus and subway).

Source: database owned by Beijing Transportation Research Center

Car users were affected much more than public transport users by the Olympic Games. From comparison in Table 7-11 and 7-12, we can see that travellers driving cars, both private and non-private, made significant changes in both Games time and after, while car passengers didn't show much change. For people driving cars, the percentage of decreasing trip rates was significantly higher than that of increasing trip rates, in both Games and post-Games time. Particularly, people driving company cars reduced their daily driving activity greatly, which we believe results from the regulation for government cars.

Table 7-11 Changes in trip rate of car users (Sample data sets) I

	N (June, 08)	% of Car use	Mean (Normal, 08)	Differences between waves of survey											
				Games time & June 08				June 09 & June 08				Games time & June 09			
				Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)	Mean diff.	%	t	Sig (two tails)
Private car (drive)	661	80.71%	2.43	-.23	-9.59%	-5.42	**<.001**	-.12	-5.11%	-2.66	**.008**	.11	4.49%	2.77	**.006**
Private car (passenger)	90	10.99%	2.22	.01	.50%	.12	.904	.06	2.50%	.50	.618	.04	1.98%	.47	**.640**
Government/ company car (drive)	55	6.72%	2.93	-.51	-17.39%	-2.51	**.015**	-.82	-27.95%	-3.77	**<.001**	-.31	-10.55%	-2.82	**.007**
Government/ company car (passenger)	13	1.59%	2.00	.31	15.38%	1.08	.303	.23	11.54%	.90	.387	-.08	-3.85%	-.21	.837

Source: database owned by Beijing Transportation Research Center

Table 7-12 Changes in trip rate of car users (Sample data sets) II

Original travel mode	Pre Games to Games time			Pre Games to Post Games			Games time to Post Games		
	>0	<0	0	>0	<0	0	>0	<0	0
Private car (drive)	8.3%	20.3%	71.4%	12.3%	20.1%	67.6%	13.9%	9.1%	77.0%
Private car (passenger)	12.2%	13.3%	74.4%	18.9%	18.9%	62.2%	13.3%	13.3%	73.3%
Government/company car (drive)	12.7%	34.5%	52.7%	5.5%	38.2%	56.4%	3.6%	21.8%	74.5%
Government/company car (passenger)	15.4%	7.7%	76.9%	23.1%	15.4%	61.5%	15.4%	15.4%	69.2%

Source: database owned by Beijing Transportation Research Center

7.3.2. Weighted-Euclidean distance PMF test for trip rate changes

We investigate residents' changes in trip rate with the Weighted-Euclidean distance PMF test in Figure 7-9. We find,

1. For travellers with reduced trip rates (Row 1 in Figure 7-9), their characters of 'Age', 'Occupation' and 'Pre-Games primary travel mode' appeared significantly different from the overall behaviour. Investigating by age in Figure 7-11, we see that residents between 35-64 (Age=4, 5, or 6) were more likely to reduce their daily travel amount during Games time, while those aged between 25-34 (Age = 3) were less likely to reduce their travel amount.

By occupation, Figure 7-12 tells us that retirees (Occupation=10) were more likely to reduce their daily travel demand during Games time, while Scientists/Researchers (Occupation=2) and Students (Occupation=7) were much less likely to reduce their daily travels.

By pre-Games primary travel mode, it could be learnt from Figure 7-13 that people who travel with non-motorized means such as walking and cycling, as well as those driving non-private vehicles (government/company vehicle) were more likely to reduce their daily travel frequencies, while public transport passengers and private-car users were less likely to reduce their amount of daily trips.

2. For travellers with increased trip rates (Row 3 in Figure 7-9), their 'Residential area', 'Age', and 'Occupation' showed a significant difference from the overall behaviour. Investigating by residential area in Figure 7-10, we see that residents living in Zones 1, 2, 3 and 7 were more likely to increase their daily travel, while people living in Zones 5 and 8, where competition venues were situated, were unlikely to increase their trip rates.

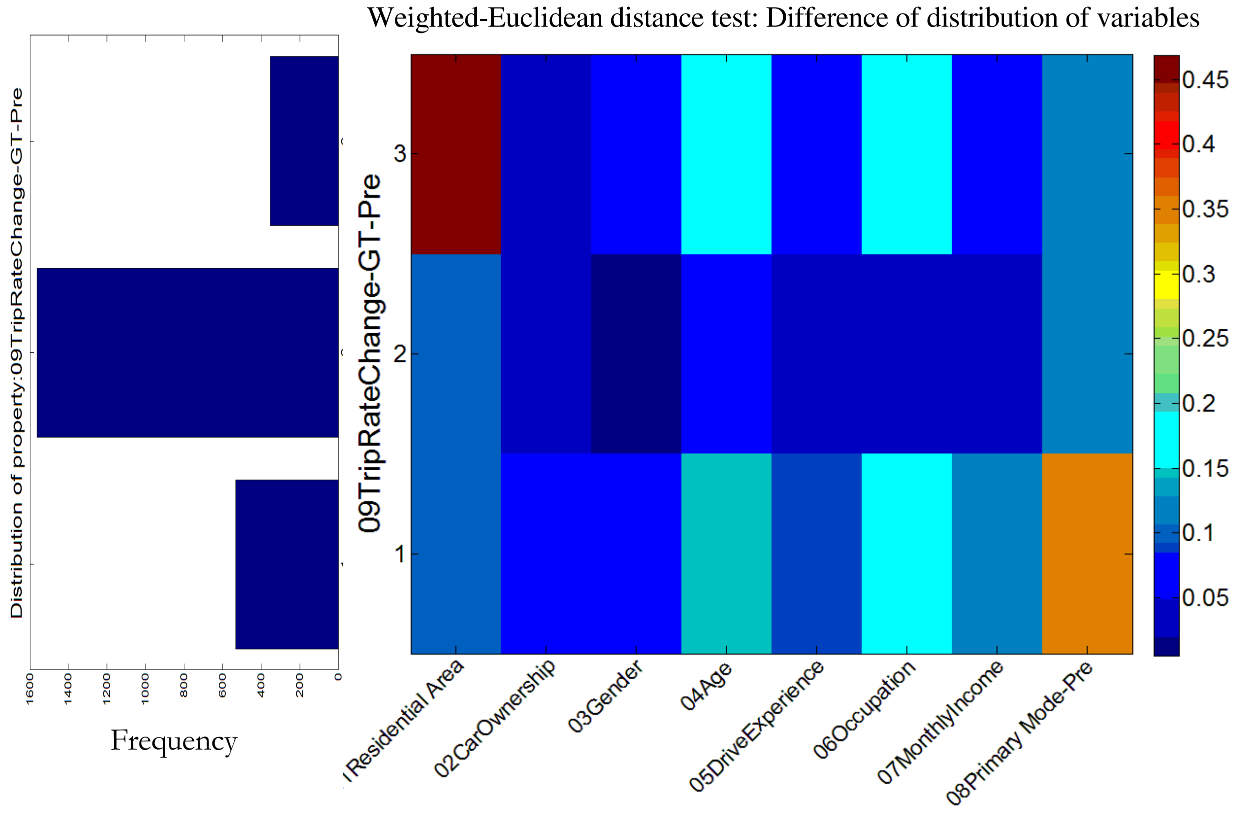
   By age, as shown in Figure 7-11, people between the ages of 15 and 24 (Age=2) were likely to increase their daily trip amount compared to other age groups. Particularly, the age groups of 45-54 (Age=5), 55-64 (Age=6) and 65-74 (Age=7) were much less likely to increase the number of their daily trips. By occupation, Government Officials (Occupation=4), Heath care Staff (Occupation=5) and Police (Occupation=13) were more likely to travel more than normal during the Olympic Games, while self-employers (Occupation=9) were less likely to increase their daily travels in the mean time.

   The significance in 'primary travel mode of pre-Games' between the people who increased travel demands during Games time and overall travellers was smaller than the other factors discussed above. However, we see in Figure 7-13 that, cyclists (pre-Games primary mode=2) were much less likely to increase their daily travel demands during Games time.

3. Investigating the travellers who didn't change their travel demand during Games time (Row 2 in Figure 7-2), we see that their characteristics didn't

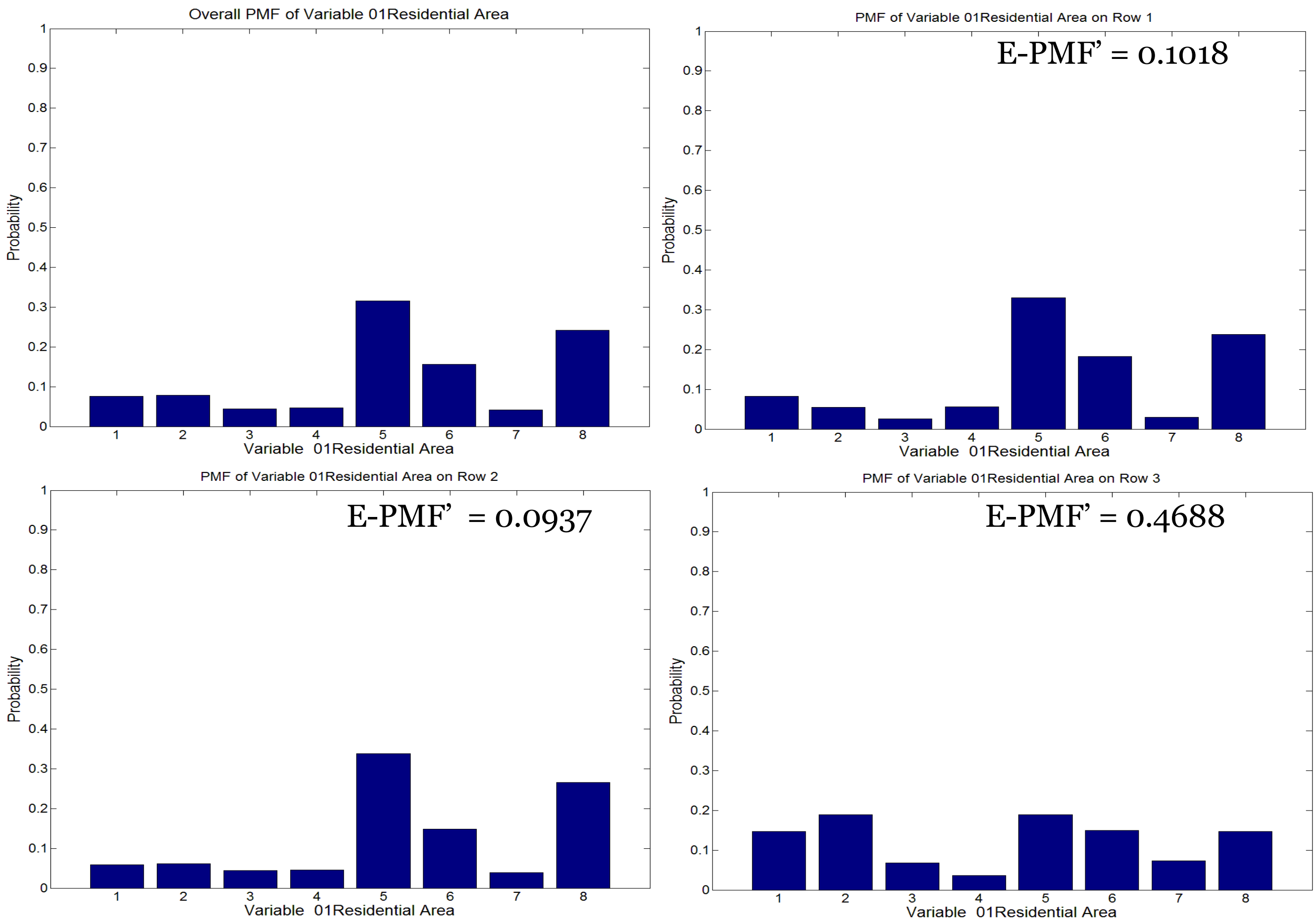
show much significance variation compared with the overall travellers profile, with all E-PMF' values less than 0.125. However, there are still some interesting findings from the comparisons. People aged 35-44 (Age=4) or usually travelling on foot were less likely to maintain their daily travel demands during the Olympic Games.

Figure 7-9 Map of Weighted-Euclidean distance PMF test for trip rate changes between the pre-Games and Games time



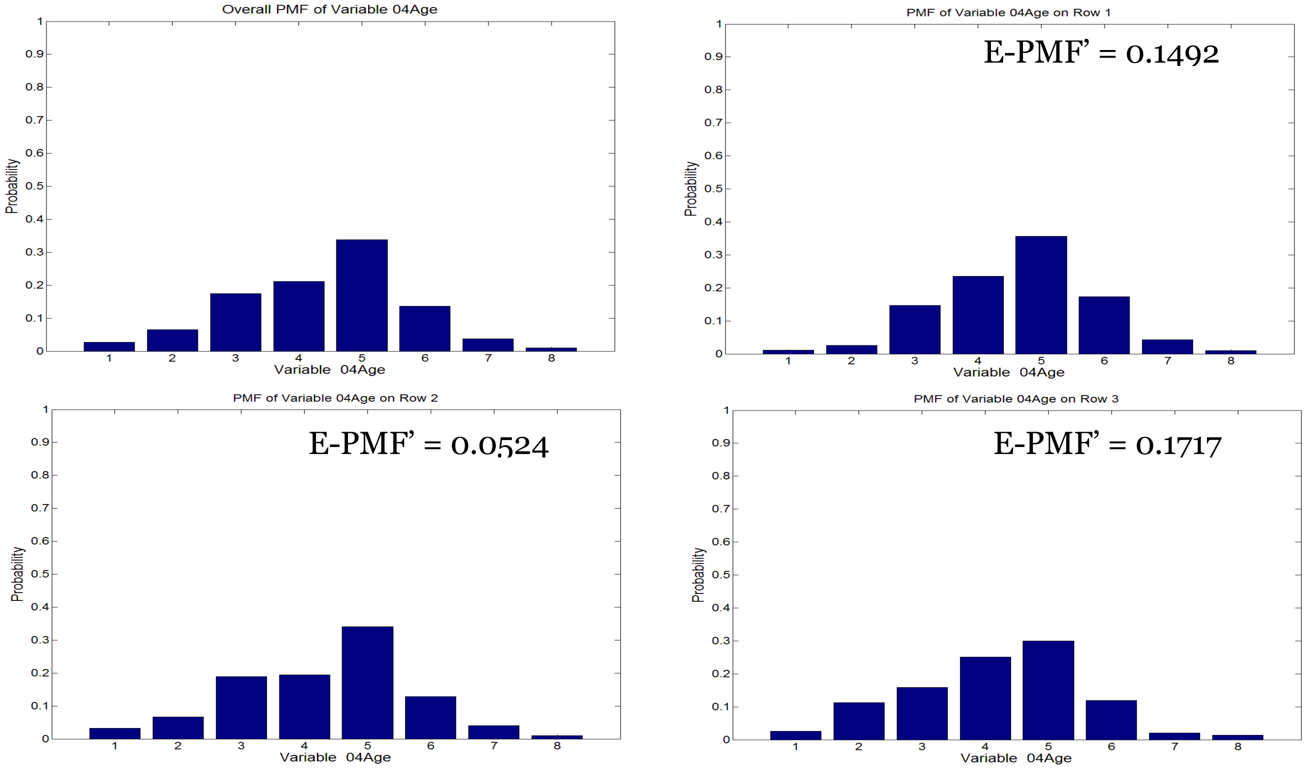
Change of Trip rates between pre-Games and Games time (Y-axis):
1. Decreased; 2. Unchanged; 3. Increased

Figure 7-10 Comparison of $PMF_{specific\ group=1,2,3}$ and $PMF_{overall}$ of Variable **Residential area**



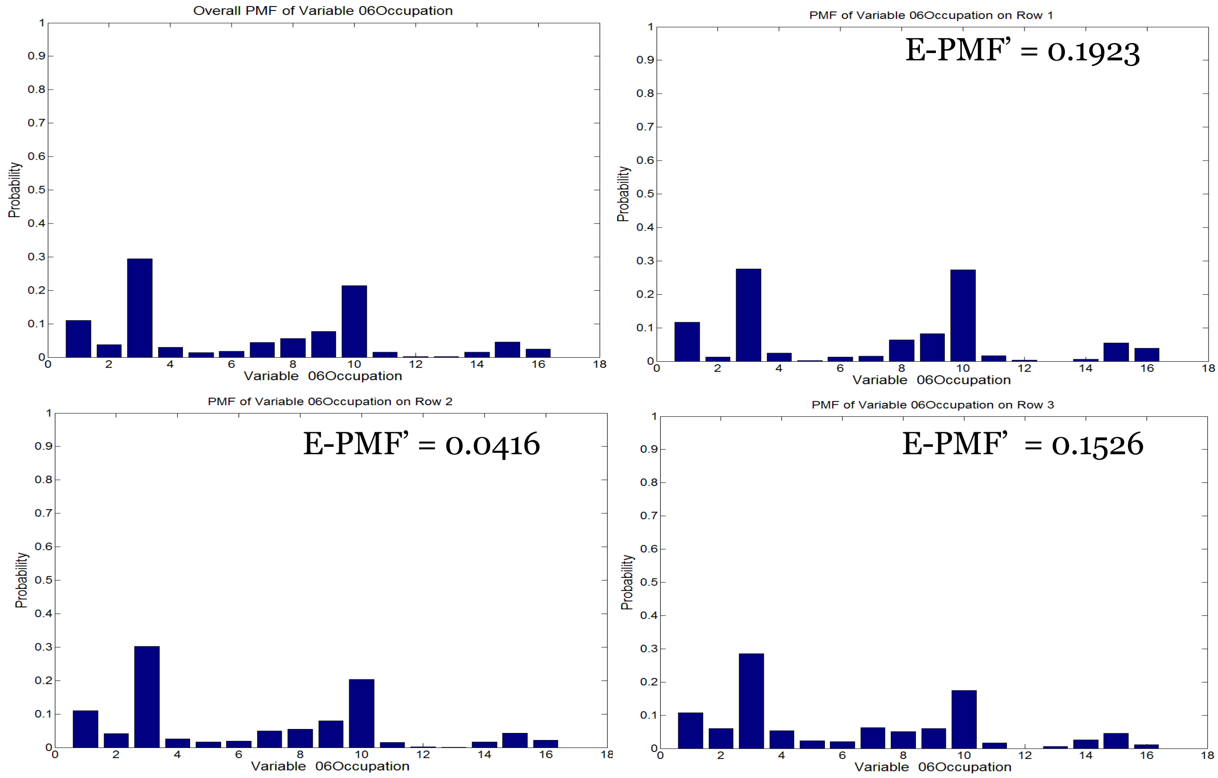
Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

Figure 7-11 Comparison of $PMF_{specific\ group=1,\ 2,\ 3}$ and $PMF_{overall}$ of Variable **Age**



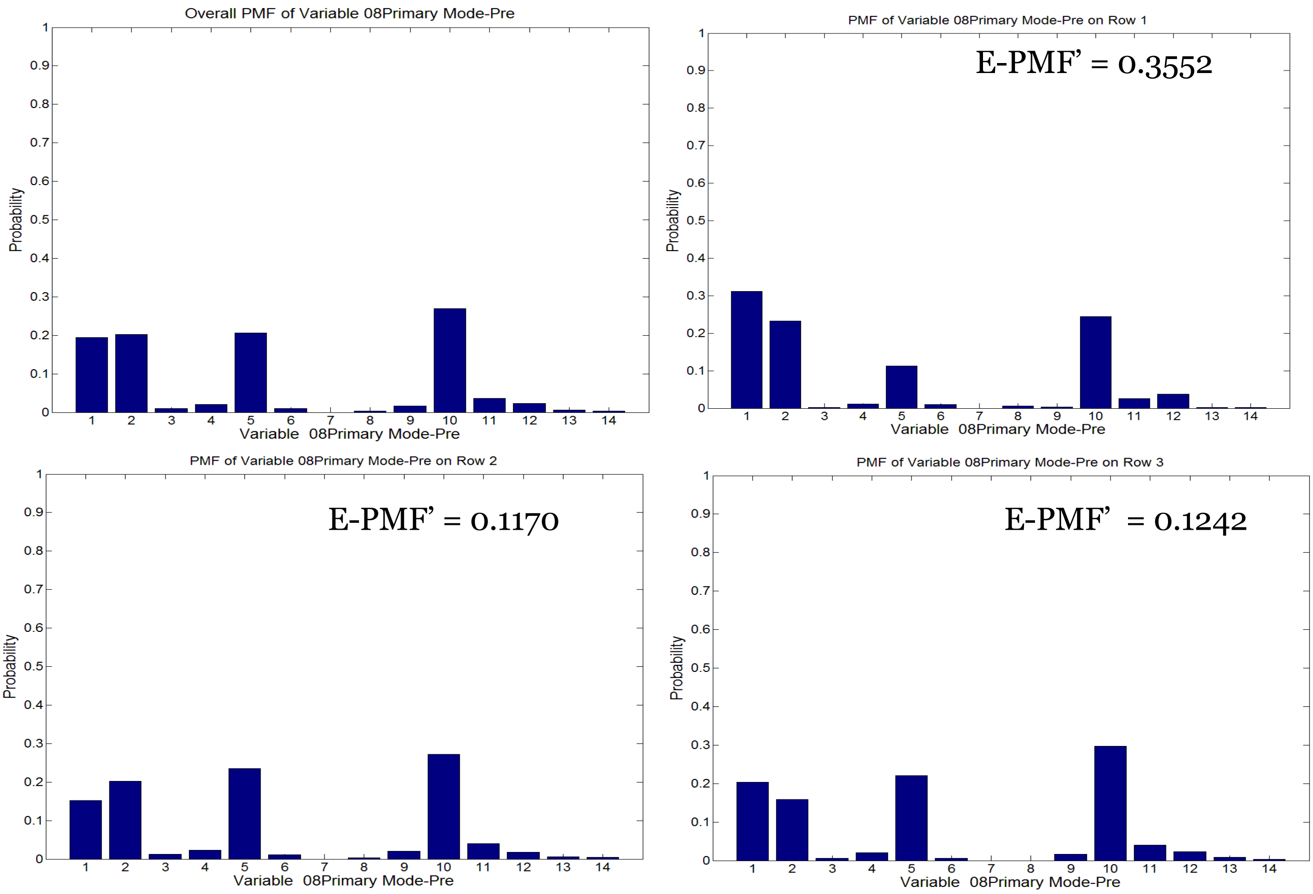
Age (years):
1. 0-14; 2. 15-24; 3. 15-24; 4. 35-44; 5. 45-54; 6. 55-64; 7. 65-74; 8. 75+

Figure 7-12 Comparison of $PMF_{specific\ group=1,2,3}$ and $PMF_{overall}$ of Variable Occupation



Occupation:
1. Factory/Construction worker; 2. Scientist/Researcher; 3. Office-based staff;
4. Government Official; 5. Heathcare staff; 6. Teacher; 7. Student; 8. Waitor/Waitress;
9. Self-employer; 10. Retired; 11. Driver; 12. Farmer; 13. Soldier/Police;
14. Public bus/Underground/Taxi Driver; 15. Unemployed; 16. Other

Figure 7-13 Comparison of $PMF_{specific\ group=1,\ 2,\ 3}$ and $PMF_{overall}$ of Variable Pre-Games primary travel mode



Pre-Games primary travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus;
6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Company car (drive); 13. Company car (passenger); 14. Other

Figure 7-14 is the map of the Weighted-Euclidean distance PMF test for trip rate changes between the pre-Games and post-Games periods. From the comparison, we find that:

1. For travellers with reduced trip rates in 2009 (Row 1 in Figure 7-14), their 'Age', 'Occupation', 'pre-Games primary travel means' and 'Trip rate changes between pre-Games and the Olympic Games' were significantly different from the overall behaviour.

   We compare the charts of Row 1 and the overall values in Figure 7-16 and find that people aged between 35-64 (Age=4, 5, 6) were more likely to reduce their daily travel amount after the Games, while those aged between 15-34 (Age=2,3) were less likely to change.

   By occupation, Figure 7-17 shows that Scientists/Researchers, Office-based staff, and Students (Occupation=2, 3 or 7) were less likely to reduce their travel after the Games.

   By primary travel means during pre-Games period, Figure 7-18 shows that people who travelled with non-motorized means as well as people driving non-private vehicles (government/company vehicles) were more likely to reduce their daily travel frequencies, while public transport passengers and private-car users were less likely to reduce their amount of daily trips.

   By the trip rate changes from pre-Games to Games time, which are compared in Figure 7-19, we see that people who reduced their daily travel demands during the Olympic Games were very much more likely to keep reducing or stay with the reduced level of travel for a longer term after the Games.

2. For travellers with increased trip rates (Row 3 in Figure 7-14), their 'Residential area', 'Age', 'Occupation', 'Pre-Games travel mode' and 'Trip rate changes between pre-Games and the Olympic Games' were significantly different from the overall.

   Investigating by residential area in Figure 7-15, we find that residents living in Zones 6 and 7 were more likely to increase their daily travel, while those living in Zones 1, 2, 5, and 8, which hosted competition venues and games-related accommodation sites during Games time, were much less likely to increase their trip rates (number of trips per person per day) after the Olympic Games.

By age, as shown in Figure 7-16, residents aged 15-44 (Age=2, 3, 4) were more likely to increase their daily trip amount after the Olympic Games than other age groups, while those aged 45-54 (Age=5) didn't appear likely to increase the number of their daily trips during the post-Games period.

By occupation, we see from Figure 7-17 that waiters/waitresses and retirees (Occupation =8 or 10) were less likely to increase their daily travel demand after the Games finished, while students and bus drivers (Occupation =7 or 14) were more likely to travel more than before.

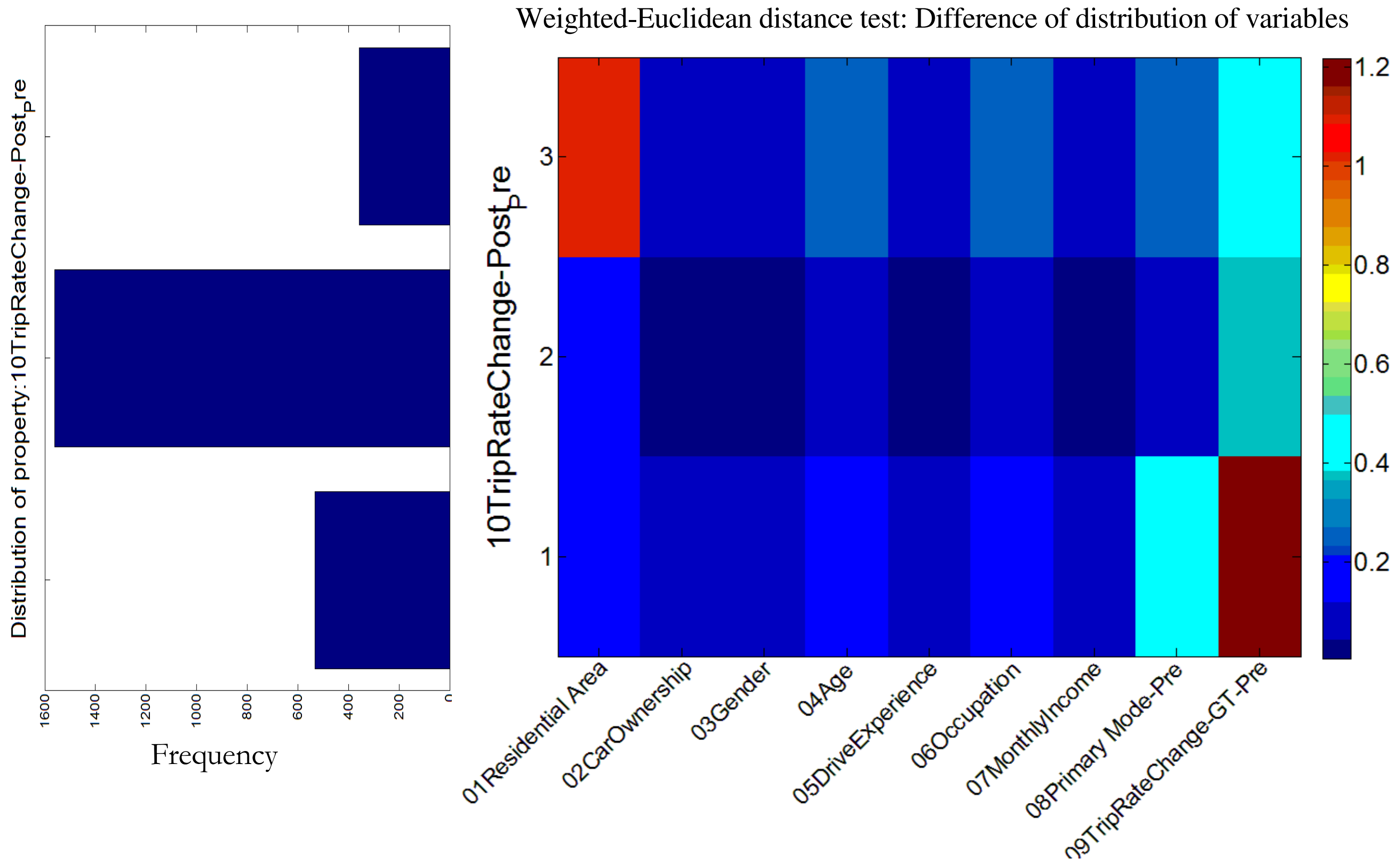
Upon examining the trip rate changes from pre-Games to Games time shown in Figure 7-19, we see that people who increased their daily travel demands during the Olympic Games were more likely to grow their daily travel demands in the post-Games period. Besides, travellers who maintained similar travel demand during the Games might increase their trip rates (number of trips per person per day) after the Games as well.

The significances in 'primary travel mode of pre-Games' between the people who increased travel demands after Games time and the average traveller were smaller than the other factors discussed above. However, we could find in Figure 7-18 that, people who travelled by walking or cycling before the Games (pre-Games primary travel mode=1 or 2) were less likely to increase their daily travel frequencies, but the public bus passengers (pre-Games primary travel mode=5) were observed to be more active in daily travels in the long term.

3. Investigating travellers who maintained the same travel frequency between pre-Games and post-Games periods (Row 2 in Figure 7-14), we find the attributes of 'Residential area' and 'the trip rate changes from pre-Games to Games time' showing significant difference from the others. Figure 7-19 shows that people who didn't make change in daily trip rates from pre-

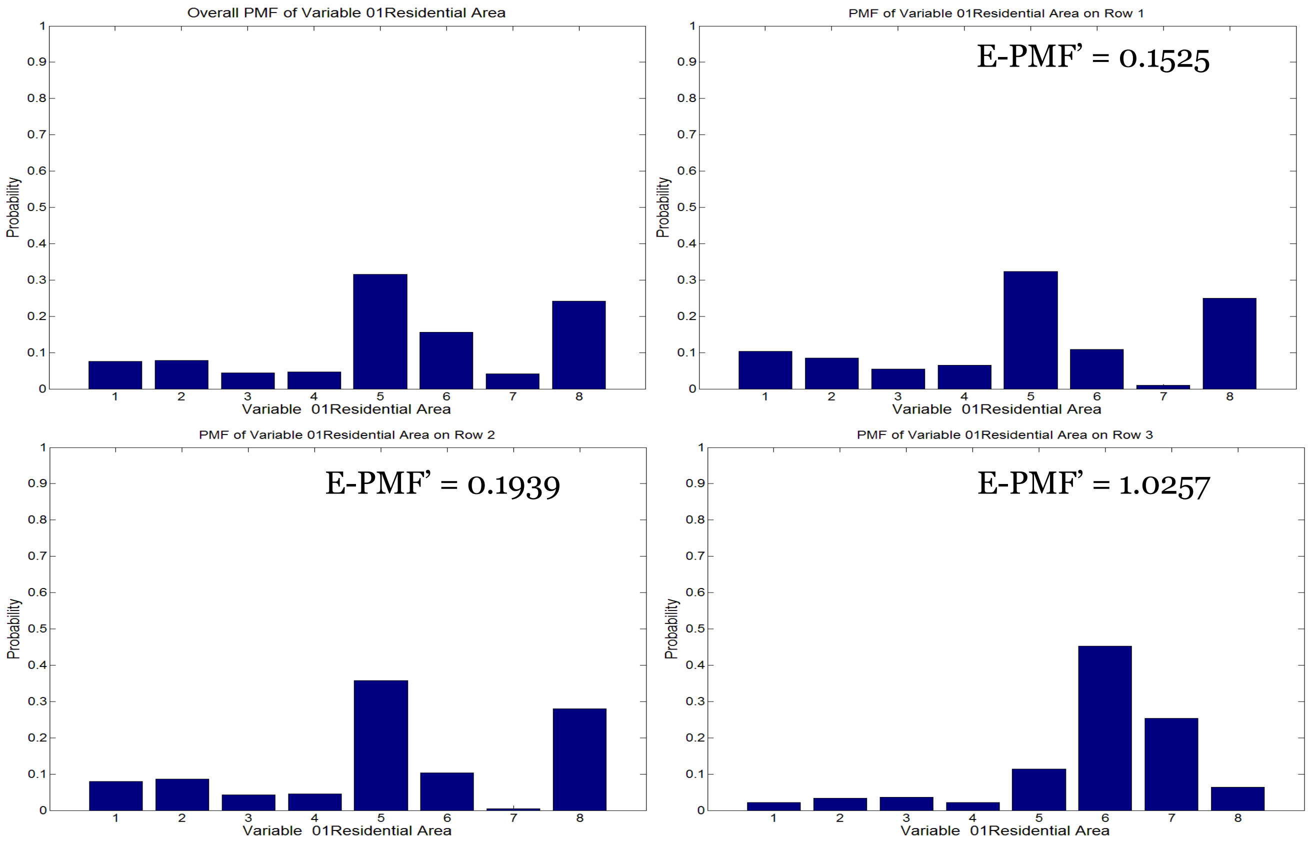
Games to Games time might keep the same travel frequencies even after the Games.

Figure 7-14 Weighted-Euclidean distance PMF test for trip rate changes between the Pre-Games and post-Games time



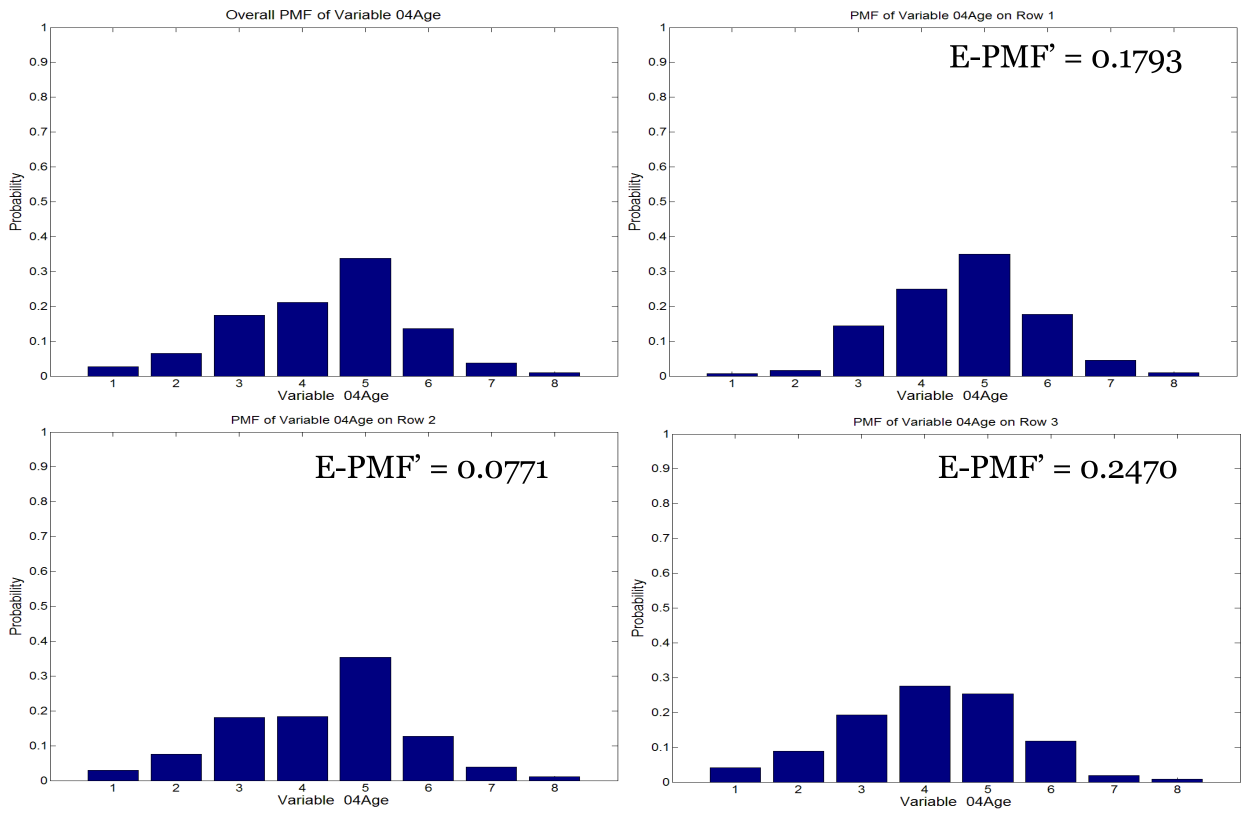
Change of Trip rates between pre-Games and post-Games (Y-axis):
1. Decreased; 2. Unchanged; 3. Increased

Figure 7-15 Comparison of $PMF_{specific\ group=1,\ 2,\ 3}$ and $PMF_{overall}$ of Variable **Residential area**



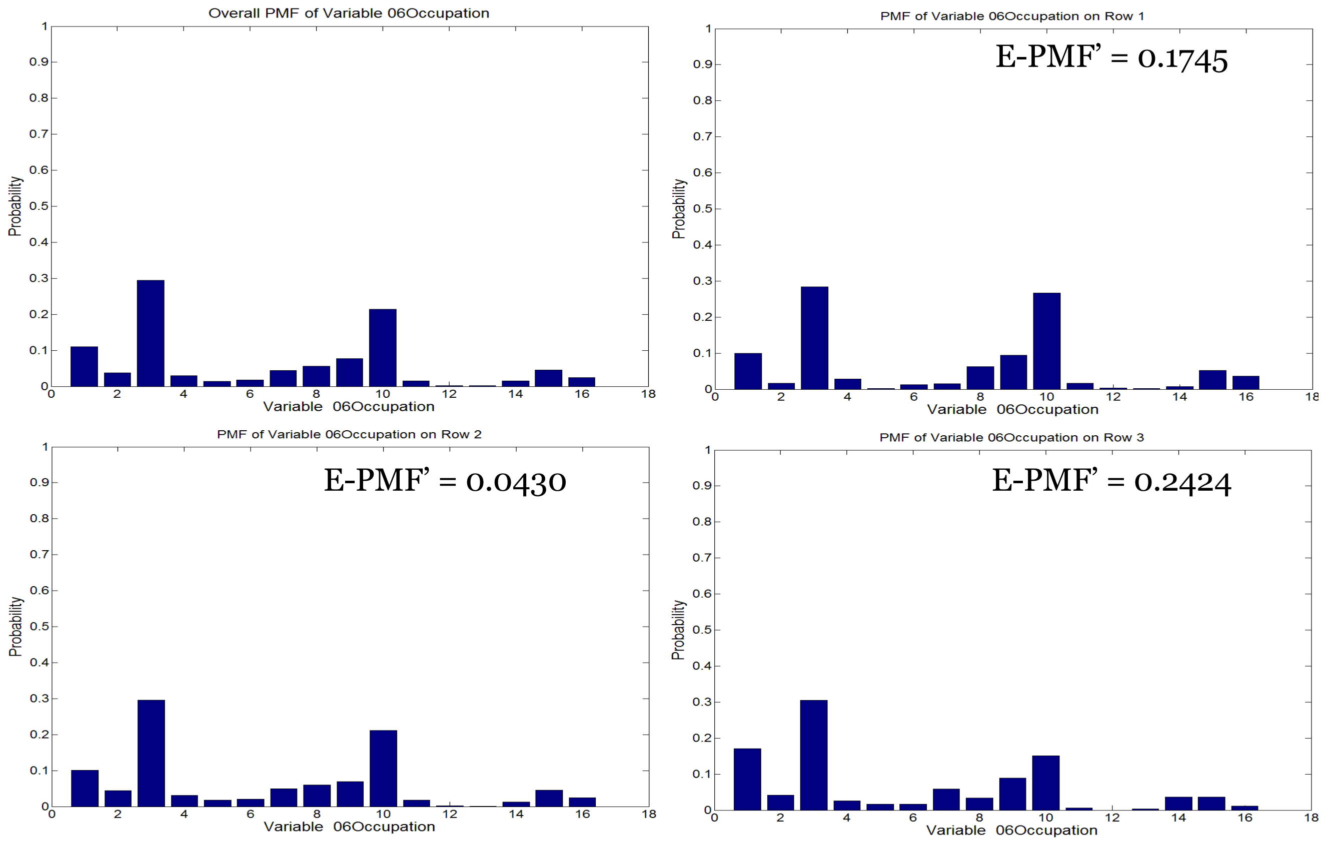
Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

Figure 7-16 Comparison of $PMF_{specific\ group=1,\ 2,\ 3}$ and $PMF_{overall}$ of Variable **Age**



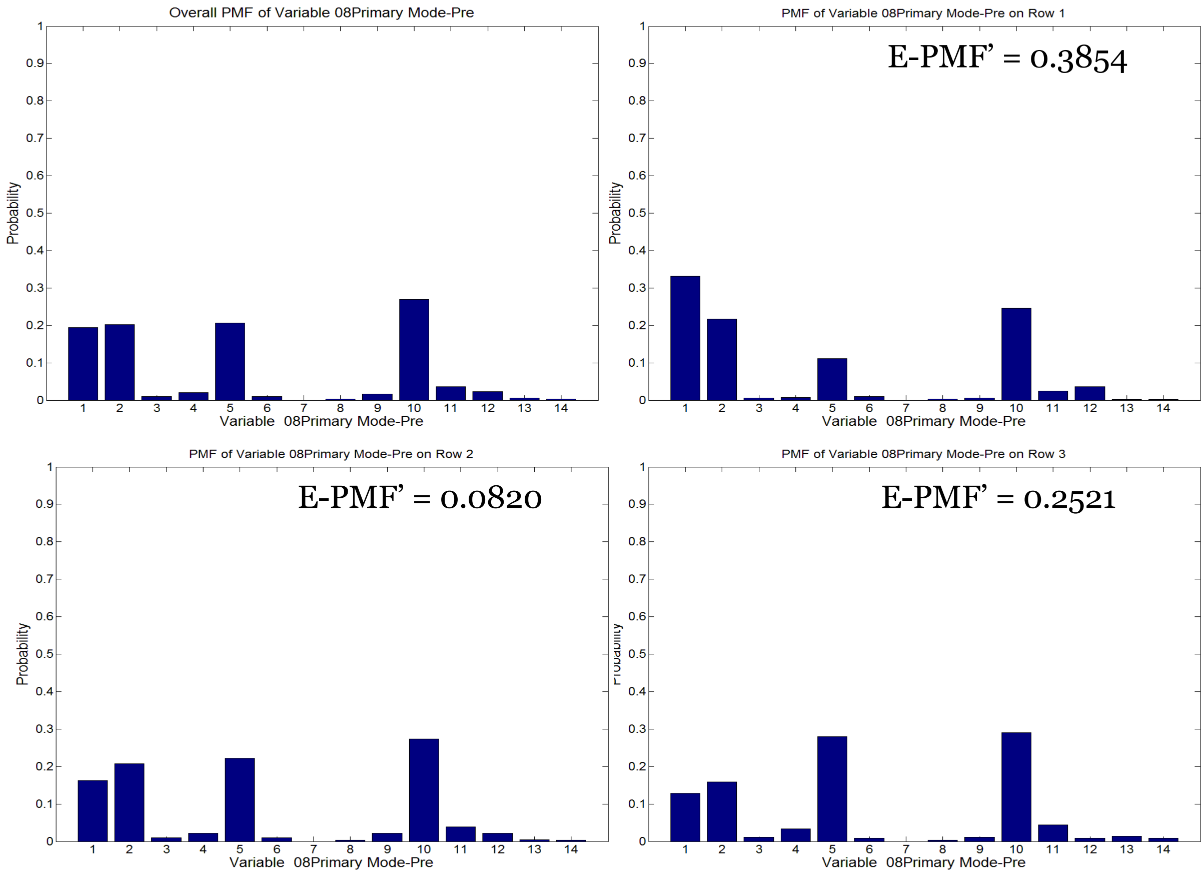
Age (years):
1. 0-14; 2. 15-24; 3. 15-24; 4. 35-44; 5. 45-54; 6. 55-64; 7. 65-74; 8. 75+

Figure 7-17 Comparison of $PMF_{specific\ group=1,2,3}$ and $PMF_{overall}$ of Variable **Occupation**



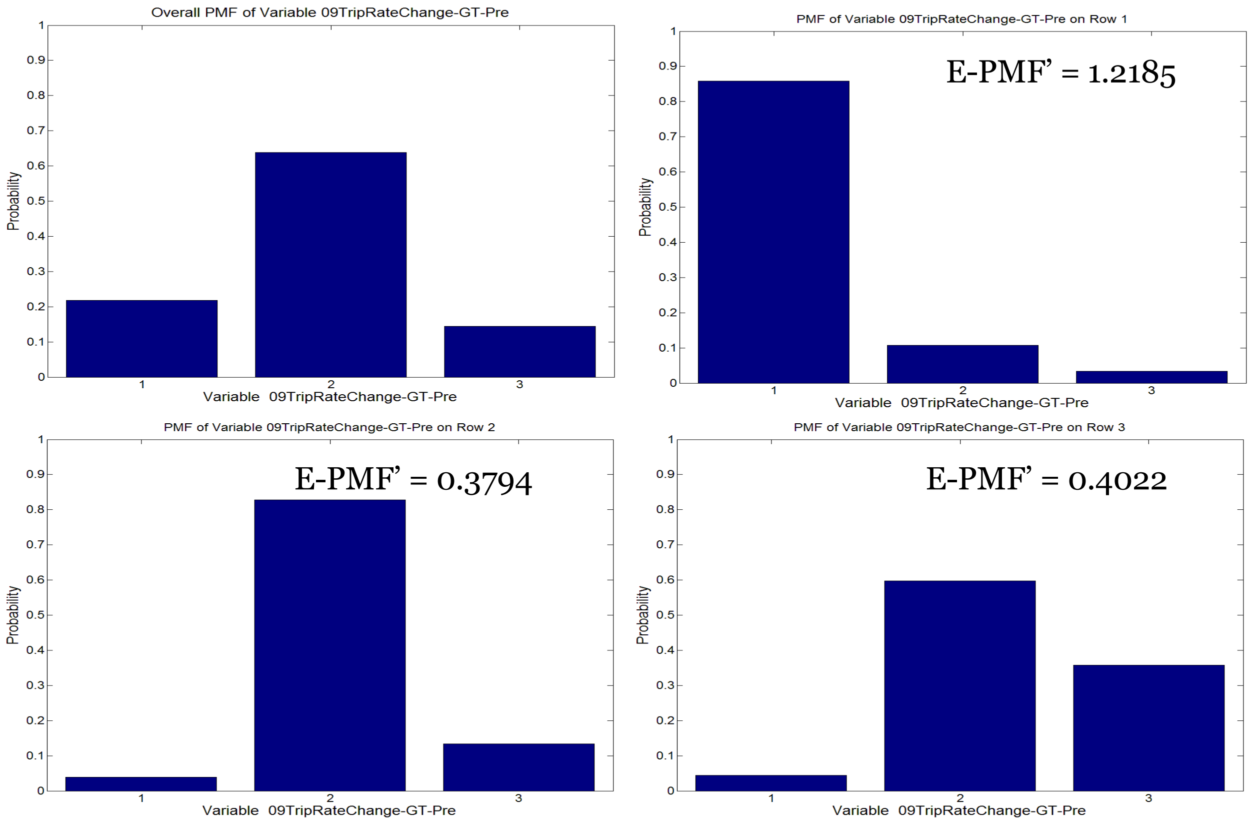
Occupation:
1. Factory/Construction worker; 2. Scientist/Researcher; 3. Office-based staff;
4. Government Official; 5. Heathcare staff; 6. Teacher; 7. Student; 8. Waiter/Waitress;
9. Self-employer; 10. Retired; 11. Driver; 12. Farmer; 13. Soldier/Police;
14. Public bus/Underground/Taxi Driver; 15. Unemployed; 16. Other

Figure 7-18 Comparison of $PMF_{specific\ group=1,2,3}$ and $PMF_{overall}$ of Variable **Pre-Games primary travel mode**



Pre-Games primary travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus; 6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach; 10. Private car (drive); 11. Private car (passenger); 12. Company car (drive); 13. Company car (passenger); 14. Other

Figure 7-19 Comparison of $PMF_{specific\ group=1,2,3}$ and $PMF_{overall}$ of Variable **Trip rate changes between pre-Games and Olympic Games periods**



Change of Trip rates between pre-Games and Games time:
1. Decreased; 2. Unchanged; 3. Increased

7.3.3. Cluster analysis for trip rate changes

In order to better understand and identify the characteristics of residents and their propensity of behaviour change, we apply cluster analysis on the sample data set. According to the preliminary analysis in Sections 7.3.1 and 7.3.2, we found that gender, age, residential area, car accessibility, driving experience and primary travel mode in the pre-Games period might be important for the travellers' change in trip rates. So we used these characters as the test factors for the cluster analysis. Residents with similar combination of characters were grouped into the same cluster and we can get six categories of residents regarding their changes in daily travel frequency as shown in Tables 7-13 ~ 16. As suggested in the research of

Jillian Anable (2005), we give the clusters descriptive labels as below to improve the analysis and understanding:

- 'Office staff': people who worked in offices with fixed working hours and normally drive car.
- 'New car user': people who recently bought a car or just started using car for travel.
- 'Aspiring sustainable traveller': people who used to travel by car but also sometimes by public transport, and appeared friendly and actively to the Games communication on sustainable travelling. From comparison, we find that this group mainly referred to those young men who worked in offices and lived in venue areas.
- 'Car dependent': people who usually travelled by car before the Games.
- 'Carefree traveller': people who normally travelled different from the employers in some aspects, such as time, location, etc. Most of them are retirees or students.
- 'Budget traveller': people who preferred economic travel modes. Most of them are unemployed. As seen from the comparison, they usually travelled by public transport or non-motorized modes such as walk or cycle.

From comparison, we can find that the first three groups are more resistant to change their daily travel frequencies when the Games came, while the other three groups appeared less resistant or more influenced by the Games impacts.

In particular, the 'Office staff' especially the young male staff with higher household income, and the 'New car user' who just altered their daily travel mode from bicycle or public transport to car were less likely to get their travel frequency decreased.

'Aspiring sustainable traveller' seemed to usually keep the same travel frequencies, even though they change their travel patterns more sustainable during Games time in many aspects.

Due to the TDM measures during Games time, the 'Car dependent' had to use some alternatives sometimes, or changed the way of using car. So they might reduce their travel frequencies together with the 'Carefree traveller' and 'Budget traveller' who didn't have to travel as the normal commuters.

However, we need to notice that the Budget travellers' changes in travel frequency might because some of them (e.g. the unemployed) didn't have a fixed travel pattern, rather for the changed circumstance with the Olympic Games.

Table 7-13 Cluster analysis: Change in Trip rate (pre-Games to Games time)

Cluster	No. of cases	% of sample	Games' impact on Trip rate	Descriptive label
			Short-term (pre-Games to Games time)	
1	349	14%	Very low	Office staff
2	677	28%	Very low	New car user
3	211	9%	Very low	Aspiring sustainable traveller
4	349	14%	Moderate	Car dependent
5	734	30%	Moderate	Carefree traveller
6	133	5%	Moderate	Budget traveller

Table 7-14 Personal characteristics of each cluster (Trip rate: pre-Games to Games time)

	Resistive			Less resistive			Sample average
	1. Office staff, 14%	2. New car user, 28%	3. Aspiring sustainable traveller, 9%	4. Car dependent, 14%	5. Carefree traveller, 30%	6. Budget traveller, 5%	
Gender (significant for all clusters)							
Male	76%	48%	67%	76%	38%	37%	54%
Female	24%	52%	33%	24%	62%	63%	46%
Age group (significant for all clusters)							
<25	3%	9%	11%	5%	14%	8%	9%
>=65	0%	0%	0%	3%	14%	3%	5%
Residential area (significant for all clusters)							
Central[1]	34%	26%	0%	23%	27%	22%	24%
Venues[2]	47%	54%	75%	56%	56%	55%	56%
Access to car (significant for all clusters)							
No car	3%	64%	9%	3%	57%	65%	40%
Private	88%	32%	83%	89%	40%	30%	55%
Non-private	8%	4%	8%	8%	3%	5%	5%
Both	1%	0%	0%	0%	0%	0%	0%
Driving Experience: years (significant for all clusters)							
0	9%	73%	13%	15%	89%	79%	56%
<5	15%	7%	27%	12%	2%	4%	9%
>=5	77%	19%	61%	73%	8%	17%	35%
Occupation (significant for all clusters)							
Employers-1[3]	93%	95%	90%	0%	0%	0%	47%
Employers-2[4]	2%	3%	2%	23%	16%	14%	10%
Self--employer	0%	0%	0%	37%	8%	0%	8%
Teacher/Student	5%	2%	8%	3%	13%	0%	6%
Retired	0%	0%	0%	20%	62%	0%	21%
Unemployed	0%	0%	0%	9%	0%	60%	5%
Monthly Income: rmb (significant for all clusters)							
<=3500	14%	30%	15%	29%	34%	54%	29%
>5500	52%	33%	55%	34%	34%	14%	37%
Pre-Games Primary travel mode (significant for all clusters)							
Walk only	0%	20%	0%	0%	39%	42%	19%
Bicycle	0%	44%	0%	0%	29%	26%	22%
Public transport	1%	36%	15%	1%	33%	32%	23%
Drive car	85%	0%	68%	79%	0%	0%	29%
Car passenger	9%	0%	9%	15%	0%	0%	4%

Note: The demographic information listed here is up to June 2008 when the 1st wave of survey started.

1. refer to the districts of Dongcheng, Xicheng, Chongwen and Xuanwu.
2. refer to the districts of Chaoyang and Haidian, where 28 of 29 Olympic venues were located.
3. refer to 'Factory/Construction worker', 'Scientist/Researcher', 'Office-based staff', 'Government Official'.
4. refer to 'Heathcare staff', 'Waitor/Waitress', 'Driver' and 'Public bus/Underground/Taxi Driver'.

Looking at one year after the Games in Tables 7-15 and 16, we find that there were some people continued their pre-Games travel patterns, while some others continued their new travel patterns which they changed during Games time. We can find a similar result from Tables 7-15 and 16 that people who changed during Games time were likely to maintain their changes after the Games, which is similar to that we learned from 7.3.2.

Of the clusters, the 'Office staff' and the 'Aspiring sustainable traveller' were observed to stay with very similar travel frequencies all the times. It's because they had fixed travel demands related to their commuting travel, which were not easy to be affected. On the contrast, the 'Car dependents' were more likely to return with the same daily trip rate after the Games. For the 'New car users', though they appeared ignoring the impacts during Games time, some of them were thought to postpone their car using during Games time and become a new car-user after the Games. So we think that these people were affected by some short-term impact from the Games.

We also note that the 'Carefree travellers' and 'Budget travellers' seemed likely to continue the changes they made during the Games for longer, with decreasing trip rates. These results respond to the discussion in 7.3.2 very well.

Table 7-15 Cluster analysis: Change in Trip rate (pre-Games to post-Games)

Cluster	No. of cases	% of sample	Games' impact on Trip rate		Descriptive label
			Short-term (pre-Games to Games time)	Long-term (pre-Games to post-Games)	
1	522	21%	Very low	Low	Office staff
2	79	3%	Very low	Very low	Aspiring sustainable traveller
3	734	30%	Very low	Very low	New car user
4	278	11%	Moderate	Moderate	Car dependent
5	704	29%	Moderate	Moderate	Carefree traveller
6	133	6%	Moderate	Moderate	Budget traveller

Table 7-16 Personal characteristics of each cluster (Trip rate: pre-Games to post-Games)

	Resistive		**Short-term susceptible**		**Long-term mode switcher**		Sample average
	1. Office staff, 21%	2. Aspiring sustainable traveller, 3%	3. New car user, 30%	4. Car dependent, 11%	5. Carefree traveller, 29%	6. Budget traveller, 5%	
Gender (significant for all clusters)							
Male	74%	85%	49%	73%	37%	37%	54%
Female	26%	15%	51%	27%	63%	63%	46%
Age group (significant for all clusters)							
<25	4%	6%	12%	8%	11%	8%	9%
>=65	0%	0%	0%	3%	14%	3%	5%
Residential area (significant for all clusters)							
Central[1]	22%	20%	25%	24%	26%	22%	24%
Venues[2]	56%	53%	55%	56%	56%	55%	56%
Access to car (significant for all clusters)							
No car	4%	5%	62%	3%	57%	65%	40%
Private	87%	91%	34%	88%	40%	30%	55%
Non-private	9%	4%	4%	9%	3%	5%	5%
Both	1%	0%	0%	0%	0%	0%	0%
Driving Experience: years (significant for all clusters)							
0	9%	6%	72%	19%	89%	79%	56%
<5	19%	13%	8%	12%	2%	4%	9%
>=5	72%	81%	20%	68%	9%	17%	35%
Occupation (significant for all clusters)							
Employers-1[3]	94%	0%	91%	0%	0%	0%	47%
Employers-2[4]	2%	24%	3%	21%	17%	14%	10%
Self--employer	0%	0%	0%	46%	9%	0%	8%
Teacher/Student	4%	0%	6%	7%	9%	0%	6%
Retired	0%	0%	0%	24%	65%	0%	21%
Unemployed	0%	39%	0%	0%	0%	60%	5%
Monthly Income: rmb (significant for all clusters)							
<=3500	15%	25%	28%	30%	34%	54%	29%
>5500	52%	34%	35%	35%	33%	14%	37%
Pre-Games Primary travel mode (significant for all clusters)							
Walk only	0%	0%	19%	0%	40%	42%	19%
Bicycle	0%	0%	42%	0%	29%	26%	22%
Public transport	1%	0%	40%	1%	31%	32%	23%
Drive car	84%	85%	0%	76%	0%	0%	29%
Car passenger	9%	8%	0%	18%	0%	0%	4%
Games-time Primary travel mode (significant for all clusters)							
Walk only	9%	13%	19%	15%	39%	36%	9%
Bicycle	18%	18%	40%	13%	29%	29%	18%
Public transport	23%	14%	34%	18%	26%	27%	23%
Drive car	38%	47%	4%	40%	2%	5%	38%
Car passenger	7%	6%	1%	9%	2%	2%	7%

Note: The demographic information listed here is up to June 2008 when the 1st wave of survey started.
1. refer to the districts of Dongcheng, Xicheng, Chongwen and Xuanwu.

2. refer to the districts of Chaoyang and Haidian, where 28 of 29 Olympic venues were located.
3. refer to 'Factory/Construction worker', 'Scientist/Researcher', 'Office-based staff', 'Government Official'.
4. refer to 'Heathcare staff', 'Waitor/Waitress', 'Driver' and 'Public bus/Underground/Taxi Driver'.

7.3.4. Discussion

From the above comparisons and analyses in Section 7.3, we see that,

1. Residents changed their daily trip rates (number of trips per person per day) during the Olympic Games. The average trip rate reduced significantly during the Olympics, and some of the reduction lasted after the Games finished. This is similar to the result discussed earlier in Section 6.1.

2. During the Games, several groups, identified by their different Gender, Age, Residential area, Car accessibility, Driving experience, Occupation and Primary travel mode changed daily trip rates significantly. Particularly, Age, Residential area, Occupation and Pre-games primary travel mode showed strong correlation with trip rate.

   Gender

   Female travellers were more sensitive to the Travel Demand Management (TDM) measures and reduced their trips more significantly than males during the Olympic Games. In Section 7.3.2, gender didn't show great significance in the Weighted-Euclidean distance PMF test for trip rate change in Figure 7-2. This might be because both females and males had similar proportion of 'changing population', but the degree of change varied. The female 'change travellers' changed more than the male during Games time.

   Age

   People aged 35-44 (Age group =4) appeared most likely to change during the Games, in both increasing and decreasing trends, while those younger (<25 years old) and older (>65 years old) changed less from pre-Games to Games time. This may be due to the particular age group having changing travel demands as their working/living situations changed. Also, tight connections with the community and companies, where most TDM measures were promoted, might encourage them to travel differently during Games time.

Residential area

People living near venues appeared more likely to reduce their trip rates during Games time, while after the Games they were still likely to stay with the decrease in daily travel demands. Seen from Table 7-4, the average trip rate significantly decreased in venue areas (Residential area = 5 and 8) during the Olympic Games and from Figure 7-3 we see that people living in these areas were less likely to increase their daily trip rates during the Games, as many Travel Demand Management (TDM) measures were applied within these areas during the Games, which disrupted residents' normal travelling routines and forced them to consider more carefully before travelling.

Access to car

From the comparison, the daily travel habits of people who had car access were significantly disturbed during Games time. The changes in trip rate for both private vehicle owners and non-private vehicle (government/company) owners were significant as shown in Table 7-5. However, we see from the Weighted-Euclidean distance PMF test in Section 7.3.2 that the difference between people with different types of car ownership was not significant for their changes in trip rates. The difference between these two comparisons showed that there was little correlation between car ownership and whether people changed their trip rates. Among the people who changed their trip rates, those who owned private vehicles changed more significantly than those who didn't.

Driving experience

People with different driving experience also varied in making changes in trip rates. Those who had driving experience between 1-5 years were more likely to stay with their normal travel style during Games time, while people with longer driving experience (5+ years) or without driving licence but with car access might reduce their daily travel demands when the Olympics took place. This implied that those who had more recently acquired a car were more addicted to its use.

Occupation

Due to the summer vacation, the average trip rates of teachers (Occupation=6) and students (Occupation=7) changed significantly. The result of the Weighted-Euclidean distance PMF test in Figure 7-5 shows that students travelled much more during Games time, as there were increasing live activities around and many of them volunteered for the Olympic Games. Meanwhile, Government officials (Occupation=4), Heathcare staff (Occupation=5) and Police (Occupation=13) increased their daily travel demands for obvious reasons. In the contrast, self-employers (Occupation=9), retirees (Occupation=10) and unemployed (Occupation=15) people, who had more flexibilities in daily travel, were more likely to reduce their daily travel amount during the Games. However, office-based staff (Occupation=3) who normally had a fix timetable appeared not likely to make change in their daily trip rates.

Pre-Games primary mode

Due to the wide restriction on car use, regular car users were affected much more than public transport users by the Travel Demand Management (TDM) measures. The comparison results in 7.3.1.7 and 7.3.2 showed that people who normally travelled with car or non-motorized means such as walking and cycling reduced their daily travel frequencies significantly, while public transport passengers were less likely to reduce their amount of daily trips during Games time. Particularly, the drivers who travelled with non-private vehicles (government/company vehicles) showed a great decrease in daily travel volume, due to the strict restriction on government vehicles during Games time.

3. When the Olympic Games finished, people started to revert back to their normal travel routines, although some of them continued the changes they made during Games time. By the analysis of the Weighted-Euclidean distance PMF test, we find that 'Residential area', 'Age', 'pre-Games primary travel means', and 'Trip rate changes between pre-Games and the Olympic Games' show strong correlation with change between pre-Games and post-Games periods.

   Gender

   After the Olympics games, male travellers returned to their original travel demands more quickly than females, and their average rates of increase was higher as well. The women continued to reduce their daily travel demands and maintained the changes they made during the Games further, as shown in Table 7-2. Comparing the difference in their changes during the Games, we find that the male travellers were more likely to keep in their original travel modes. The result is similar to that discussed by Rose & Marfurt (2006) in their research.

   Age

   Over the long term, people aged 35-44 (Age group=4) changed their average trip rate most, while people aged 15-24 (Age group=2) was the only age group that increased their average trip rate after the Games. As discussed in Section 7.3.1.2 and 7.3.2, the 35-44 age group (Age group =4) was more likely to increase or decrease their daily travel demands and the average trip rates decreased between the pre-Games period and Games time as well as post-Games period. It's likely because people at this age were the main working population at a developing stage in their careers. They usually had a high level of activities that demanded travelling. They were more likey to have varying travel demand due to the changes in working/living patterns.

   Residential area

   Residents who lived in venue areas seemed more likely to have a long-term change in their average trip rates after the Olympics. As shown in Table 7-4, people living in venue areas (Districts 5 and 8) had a lasting reduction in their average trip rates when comparing between pre-Games and post-Games. This reduction was not significant in the Weighted-Euclidean distance PMF test.

Access to car

Private car users returned to their pre-Games travel pattern after the Olympics finished, while people with non-private car (government/company car) access or without car access at all kept the same changing trend (reducing) as in Games time as shown in Table 7-5 in Section 7.3.1.4. However, similar to that for the period across pre-Games and Games time, car ownership doesn't show significance in the Weighted-Euclidean distance PMF test for trip rate change between Games time and post-Games periods. It suggests that whether people had the access to car use doesn't affect their trip rate change after the Games. However, among the people who had changed their travel demand after the Games, those who had access to non-private car or without car access might reduce more than the others.

Driving experience

Comparing the trip rate changes by driving experience between Games time and post-Games periods, car users generally slightly increased their travel demands after the Games but still got significant reduction in a long term view. In particular, people with 10-19 years' driving experience and those who lived in household with car access but didn't drive made greater reductions in trip rate than the others. Table 7-6 shows that the average trip rates of people with car access decreased at various degrees, while the people who did not drive and those whose driving experience was between 10-19 years showed great reduction after the Games. But by the Weighted-Euclidean distance PMF test as shown in Figure 7-7, it is hard to find which group of car users had more trip rate changes than others.

Pre-Games primary mode

Comparing by the primary travel mode before the Games, we find that non-motorized travellers and non-private vehicle users had reduced their daily travel demands, while public transport passengers had an increasing average trip rate in post-Games period. In both comparisons of average trip rate and the Weighted-Euclidean distance PMF test, the residents who normally walked or cycled or drove non-private (government/company vehicles) were more likely to continue reducing their travel demands after the Games, while public transport passengers were observed to have more daily trips than before.

Trip rate changes from pre-Games to Games time

As discussed in 7.3.2, people who didn't make trip rate changes during Games time were not likely to change their travel frequency after the Games.

4. The results of cluster analysis for trip rate changes correspond to the comparison of average trip rate as well as the Weighted-Euclidean distance PMF test for trip rate changes. It identifies the specific combination of characteristics of the distinct groups such as the 'Office staff' and 'New car user' were not likely to change while the 'Carefree traveller' and 'Budget traveller' possibly reduced their travel frequencies across the compared periods. The suggestion might be brought to future consideration for policy planning.

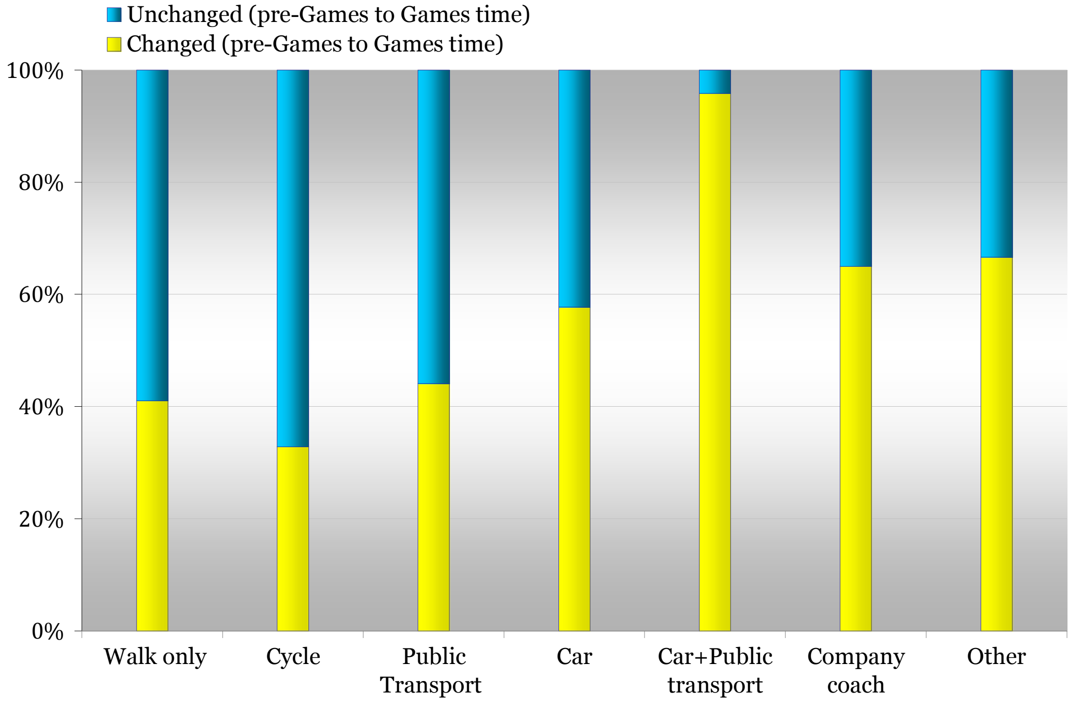
7.4. Changes in travel mode

We learnt in Section 6.1.2 that travellers changed their daily travel mode when the Olympic Games were held. However, the possibility of changing travel modes during or after the Games varied for people with different original primary travel modes. Car users were more likely to change their daily travel mode during the Games than the public transport passengers, due to relevant restrictions. Public transport passengers maintained some changes after the Games finished, while most car users appeared to revert to driving soon after. Section 7.4 looks into residents' changes in primary travel mode in detail to better understand the profile of people who were more likely to alter their daily travel mode across the Games.

7.4.1. Changes in primary travel mode

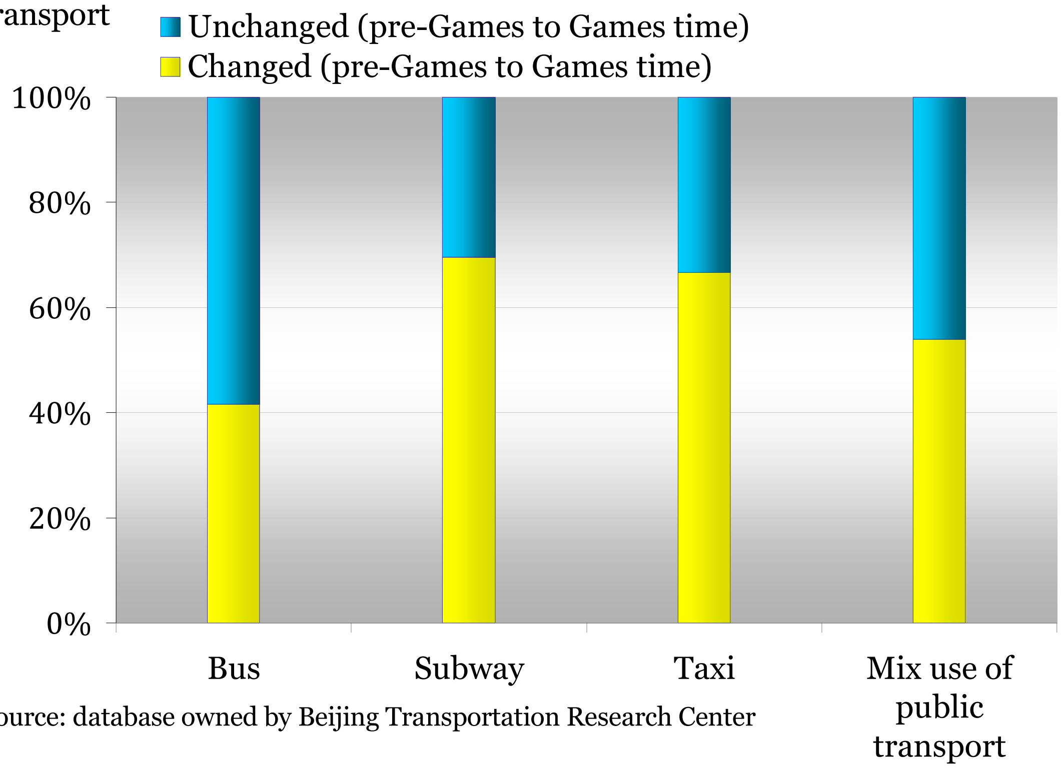
Comparing Figures 7-20~22 for the movements between pre-Games and Games time, we see that 57.8% of car users and 44.1% of public transport passengers altered their travel mode during Games time, while cyclists were least likely to change their travel mode. In particular, the travellers who used to travel by both public transport and car showed a high propensity of mode change. Further comparisons in public transport showed that subway passengers were more likely to change their travel mode than other public transport passengers. There are two possible reasons. Firstly, as mentioned in 4.3, the subway system developed very fast between 2001 to 2007 in Beijing. People travelling with subway might keep trying the new system and change their travel modes together while the overall system was upgrading. Secondly, as discussed in 3.2, the visitors and spectators preferred subway system, so the subway system might become very crowd in certain areas of Beijing. It might make some regular subway passengers to choose alternative modes for travel. Meanwhile, we can also see from the comparison that the bus passengers were most likely to stay with their original primary travel mode. For the car users, people who used non-private cars (government/company cars) were most likely to change during Games time, though travellers in every column of car use exhibited a high possibility of changing mode for daily travel. The reason should be related to the TDM measures during Games time. In particular, the measure which restricted 70% government cars might affect on the non-private car users a lot. These comparisons show a similar changing trend as Figure 6-4 that the car users were more likely to change their travel modes than the public transport passengers, cyclists and pedestrians. However, these figures show the changes at a much higher degree. In order to investigate the movement between different travel modes, we calculate Churn metrics which are thought to be vital and dimension in behaviour change research (Goodwin, 2005) in Table 7-17.

Figure 7-20 Comparison of travel mode from pre-Games to Games time – All modes



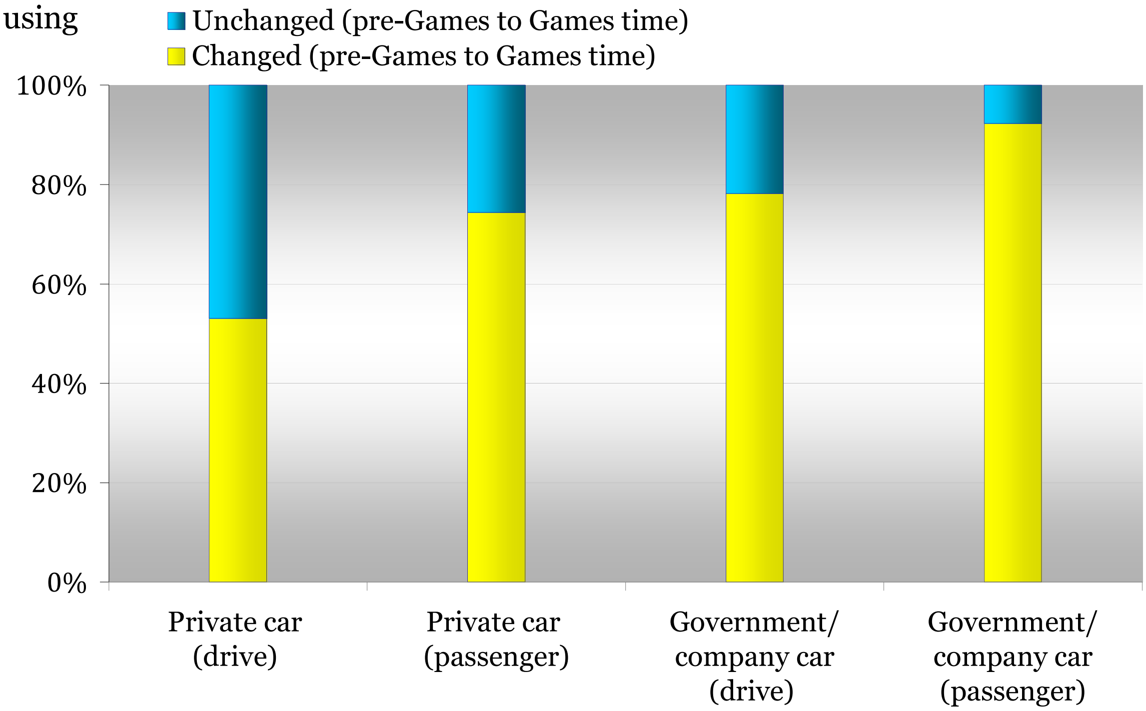
Source: database owned by Beijing Transportation Research Center

Figure 7-21 Comparison of travel mode from pre-Games to Games time – Public transport



Source: database owned by Beijing Transportation Research Center

Figure 7-22 Comparison of travel mode from pre-Games to Games time – Car using



Source: database owned by Beijing Transportation Research Center

By calculating Churn in Table 7-17, we can find that,

1. More than half regular pedestrians, cyclists and bus passengers stayed on their normal travel mode during Games time. They may also change among these three travel modes for some trips, but it was very unlikely for them to use other travel modes such as using car instead.
2. About one third passengers of subway, taxi and company coach stayed with the same travel mode. However, quite a few subway passengers chose to walk and about 8.7% subway passengers choosing mixed public transport during Games time, which normally include at least one stage by subway. It might be due to the coverage of subway network, while the crowd situation in the subway stations could be another reason. Taxi and company coach users preferred bus travelling as an alternative. It is interesting to notice that there was no regular subway passenger using taxi, and no regular taxi passenger using subway during Games time. It may be because taxi

passengers are used to surface transport, and subway passengers usually worry about congestions in the streets.

3. 46.9% of the people who drove private car before the Games still drove during Games time. Meanwhile, 13.8% of them changed to use bike and 14.1% went by bus. Very few of them altered to subway due to the limitation of network coverage and the different travelling environments. It was also noticed that 4.5% of them chose to share car with others.
4. Other car users had significant change in their travel mode during Games time, more than three fourth changed their travel methods. Most of them chose to travel by walk or bus instead. It was because there was very strict measure for non-private cars' using. We can find that 15.4% regular company car passengers changed to sit in private cars during Games time, while more than 30% of them selected walking as the alternative. It might be because a few of their regular trips were within walk distance. They considered walking was even more convenient than public transport if they could not take a lift.

Table 7-17 Changes in primary travel mode from pre-Games to Games time

Pre-Games \ Games time	Walk only	Cycle	Bus	Subway	Taxi	Co. coach	Mixed PT*	Car + PT	Pri-car[1]	Pri-car[2]	G/C car[1]	G/C car[2]	Other
Walk only	58.9%	17.7%	13.5%	0.0%	1.1%	1.1%	0.8%	0.4%	2.5%	2.7%	0.2%	0.6%	0.4%
Cycle	18.5%	66.9%	8.3%	0.2%	0.4%	0.8%	0.4%	0.2%	3.0%	0.8%	0.0%	0.0%	0.4%
Bus	16.8%	12.9%	58.4%	0.6%	1.2%	1.2%	3.4%	0.8%	2.4%	1.0%	0.4%	0.2%	0.8%
Subway	26.1%	13.0%	17.4%	30.4%	0.0%	0.0%	8.7%	4.3%	0.0%	0.0%	0.0%	0.0%	0.0%
Taxi	11.1%	11.1%	33.3%	0.0%	33.3%	11.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Co. coach	15.0%	12.5%	22.5%	0.0%	5.0%	35.0%	2.5%	0.0%	2.5%	0.0%	0.0%	5.0%	0.0%
Mixed PT *	4.0%	8.0%	22.0%	8.0%	8.0%	2.0%	46.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%
Car+PT	12.5%	4.2%	33.3%	4.2%	0.0%	0.0%	8.3%	4.2%	16.7%	8.3%	8.3%	0.0%	0.0%
Pri-car[1]	9.7%	13.8%	14.1%	2.1%	2.1%	0.9%	3.2%	0.3%	46.9%	4.5%	1.2%	0.6%	0.6%
Pri-car[2]	18.9%	13.3%	21.1%	2.2%	3.3%	3.3%	2.2%	2.2%	5.6%	25.6%	0.0%	1.1%	1.1%
G/C car[1]	10.9%	16.4%	7.3%	3.6%	1.8%	0.0%	3.6%	5.5%	16.4%	5.5%	21.8%	5.5%	1.8%
G/C car[2]	30.8%	7.7%	23.1%	0.0%	0.0%	7.7%	0.0%	0.0%	7.7%	15.4%	0.0%	7.7%	0.0%
Other	22.2%	0.0%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	11.1%	0.0%	0.0%	0.0%	33.3%

Co. coach: company coach; Mixed PT *: mixed use of public transport;

Pri-car[1]: drive private car; Pri-car[2]: seated in private car (passenger);
G/C car[1]: drive government /company car; G/C car[2]: seated in government /company car (passenger)
Source: database owned by Beijing Transportation Research Center

From the result in Table 7-17, we see that non-car users appeared to continue travelling without car while some of car users sought changes due to the TDM measures, particularly the Odd-even alternate day-off scheme and restrictions for the government cars. However, we also find that there were few regular car users chose to use subway system when they were not allowed to use car during Games time. It might be because the subway system was still far from satisfied, even compared with buses. The network coverage, connection and design at entrances, as well as marketing communication with the public and organizations require further improvement to be competitive to car and attract travellers. We will try to find out the characteristics of those people who changed and their difference from those who didn't change in following research. With such information, we may make our future plans and communication programs more targeted and effective.

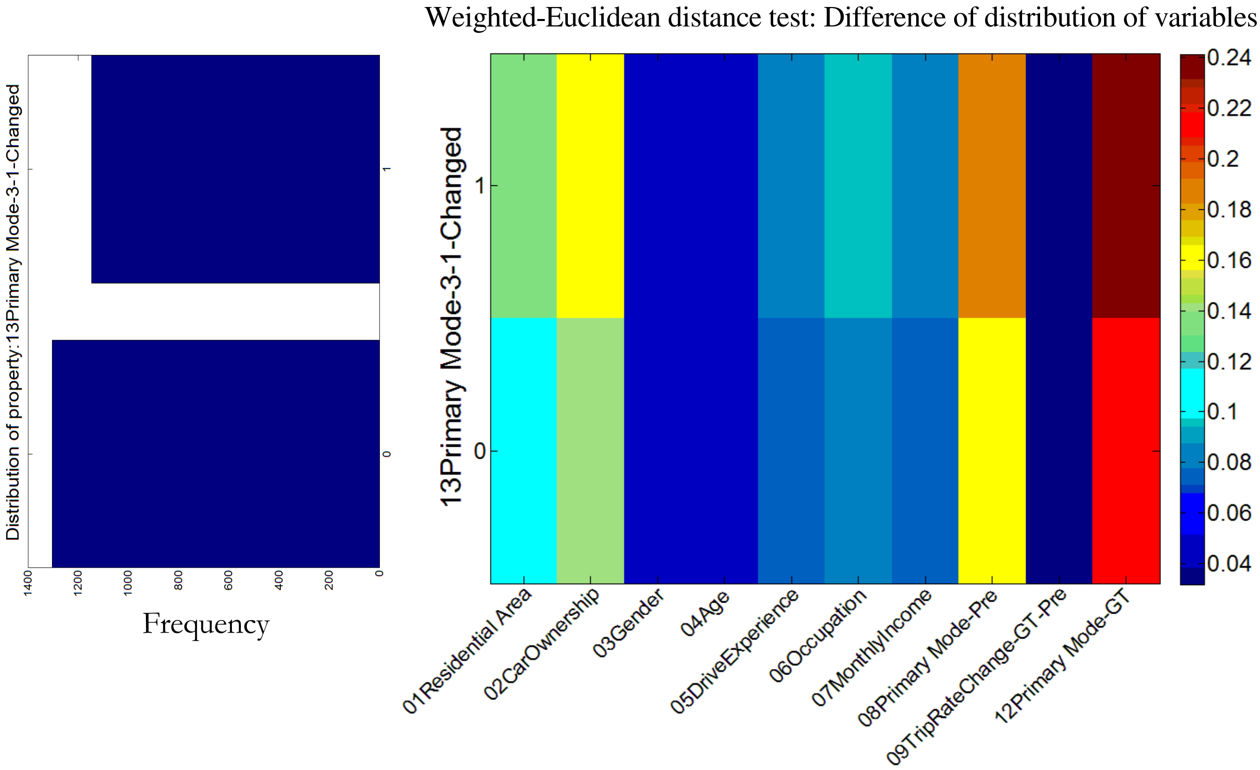
We also need to be careful with using the comparison results here, which might include bias due to the day-to-day variation in different waves of surveys. For example, people might travel for different purposes on different survey days by different travel modes, while in fact they might stick to the same travel method for same purpose travels. Due to the nature of the survey, it is impossible to get a confirmed 'primary travel mode' for each participant. We can only improve the analysis by comparing the journeys with the same purpose, such as commuting trips, to better understand the changes.

7.4.2. Weighted-Euclidean distance PMF test for mode changes

In order to get a better overview for the relationship between mode changes and traveller profiles, we ran the Weighted-Euclidean distance PMF test for mode changes in this section.

From the chart on the left side of Figure 7-23, we see that the travellers who changed their primary travel mode numbered slightly less than those who didn't change during the Olympic Games. By running the Weighted-Euclidean distance PMF test for the residents who did and did not change primary travel mode during the Olympic Games respectively, we find that both of these two groups (Rows 0 and 1 in Figure 7-23) had the same highlighted characteristics when compared with overall travellers, which were 'Car ownership', 'Pre-Games primary travel mode' and 'Games-time primary travel mode'. However, there was no significant difference found for 'Age', 'Gender' and 'Trip rate change between pre-Games and Games time' when compared with overall travellers.

Figure 7-23 Weighted-Euclidean distance PMF test for changes in primary travel modes between pre-Games and Games time

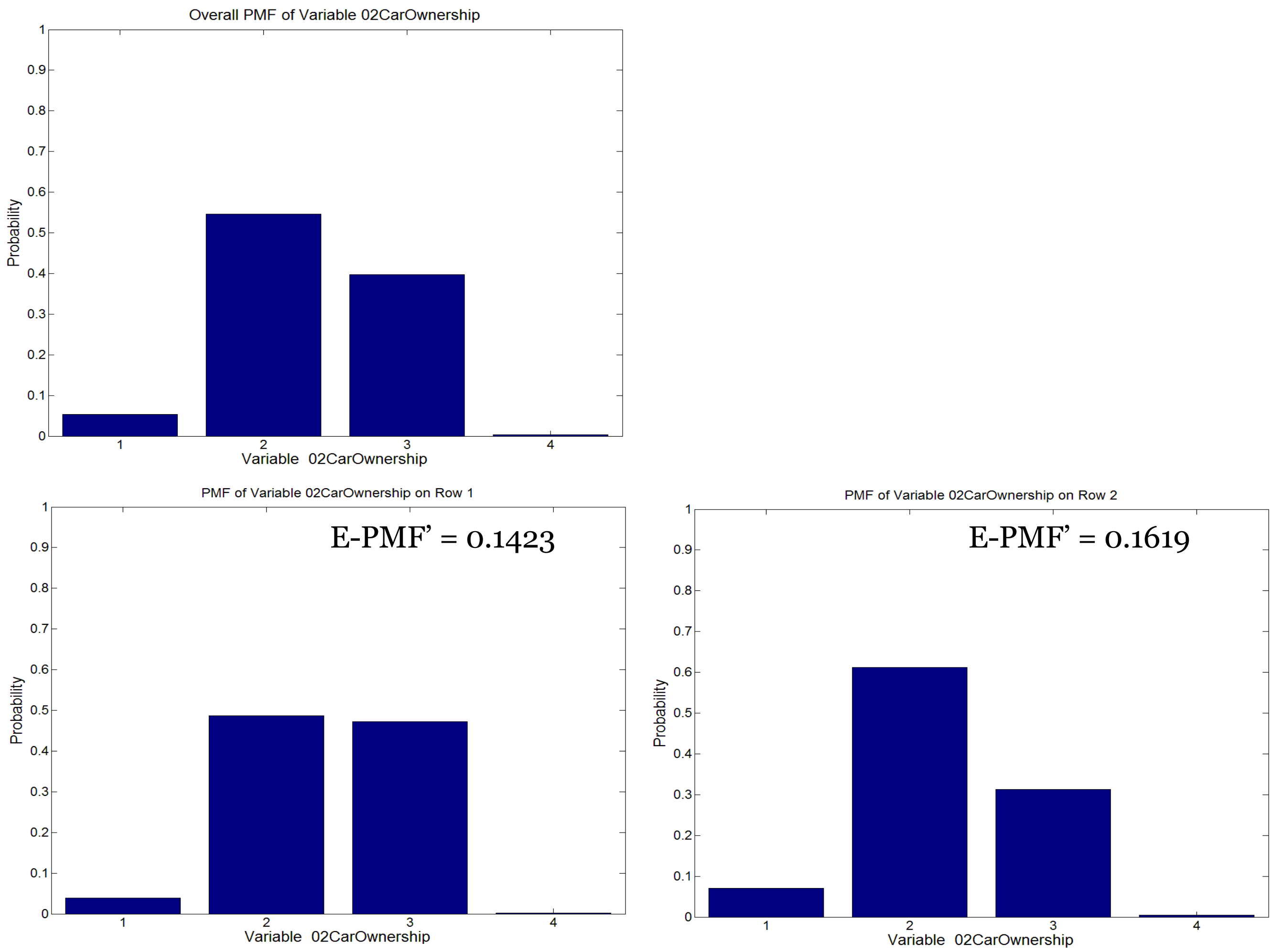


Change of Primary travel mode between pre-Games and Games time (Y-axis):
0. Unchanged; 1. Changed

1. Investigating by car ownership as shown in Figure 7-24, we find that residents who didn't have access to cars (Car ownership=3) were more likely to stay with the same travel mode during Games time, while people who owned private vehicles (Car ownership=2) were much more likely to alter their primary travel modes during the Olympic Games.
2. By pre-Games primary travel mode, we see from Figures 7-25 that non-motorized travellers (pedestrians and cyclists, Pre-Games primary travel mode=1 or 2) and public transport passengers (Pre-Games primary travel mode=5) were more likely to stay with their original primary travel modes during Games time, while car users (Pre-Games primary travel mode=10) changed their travel mode when the Olympics came.
3. From the comparison on Games-time primary travel mode in Figure 7-26, we could find that, the residents were more likely to choose non-motorized

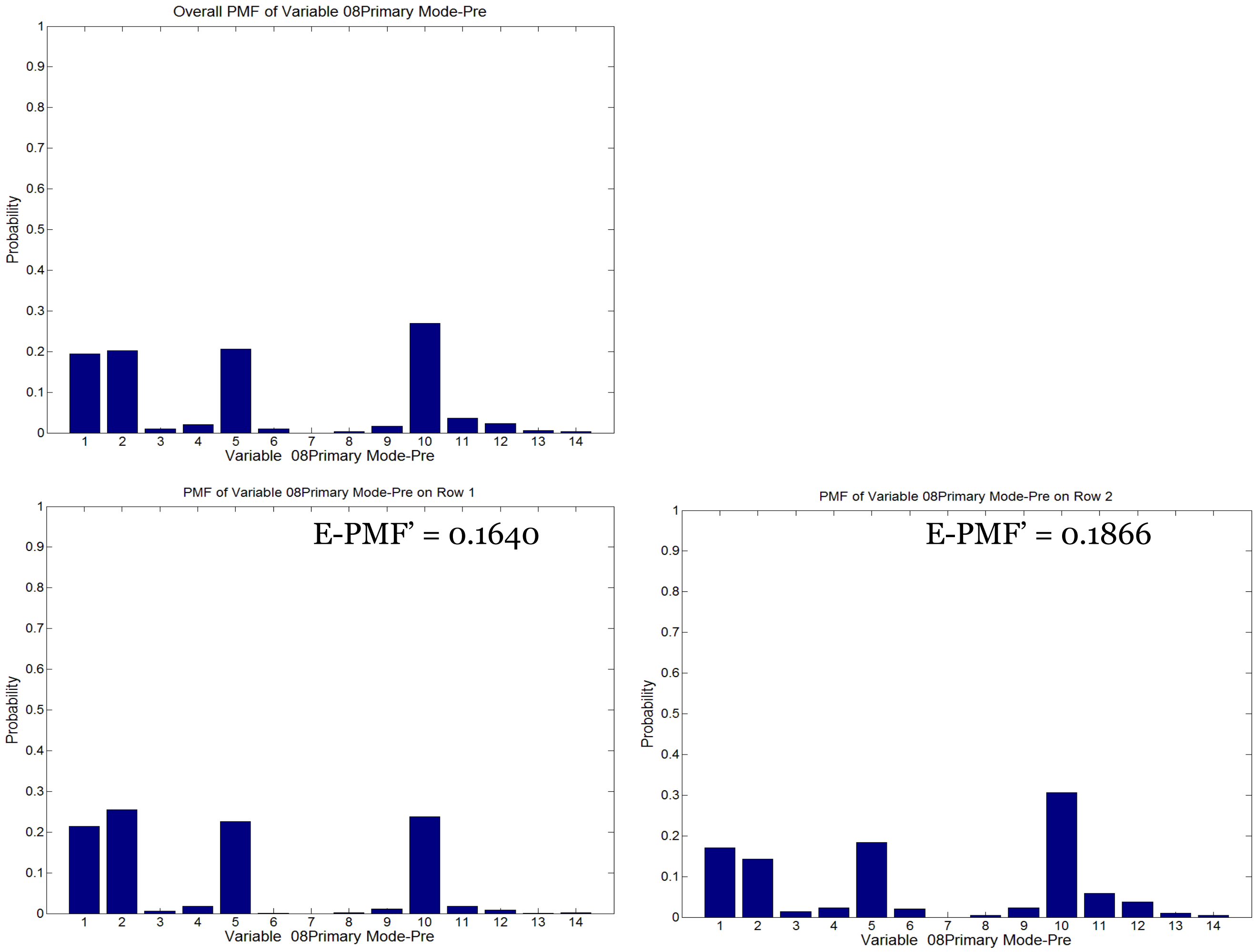
travel mode such as walking and cycling (Games-time primary travel mode =1 or 2) and public transport such as subway, buses and taxi (Games-time primary travel mode =3, 5 or 8) when the Olympic Games were held. The 'changing' travellers were very unlikely to choose driving private car (Games-time primary travel mode =10) as the alternative during Games time. The possibility of sharing cars (Games-time primary travel mode=11 or 13) increased during the Olympic Games.

Figure 7-24 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Car ownership**



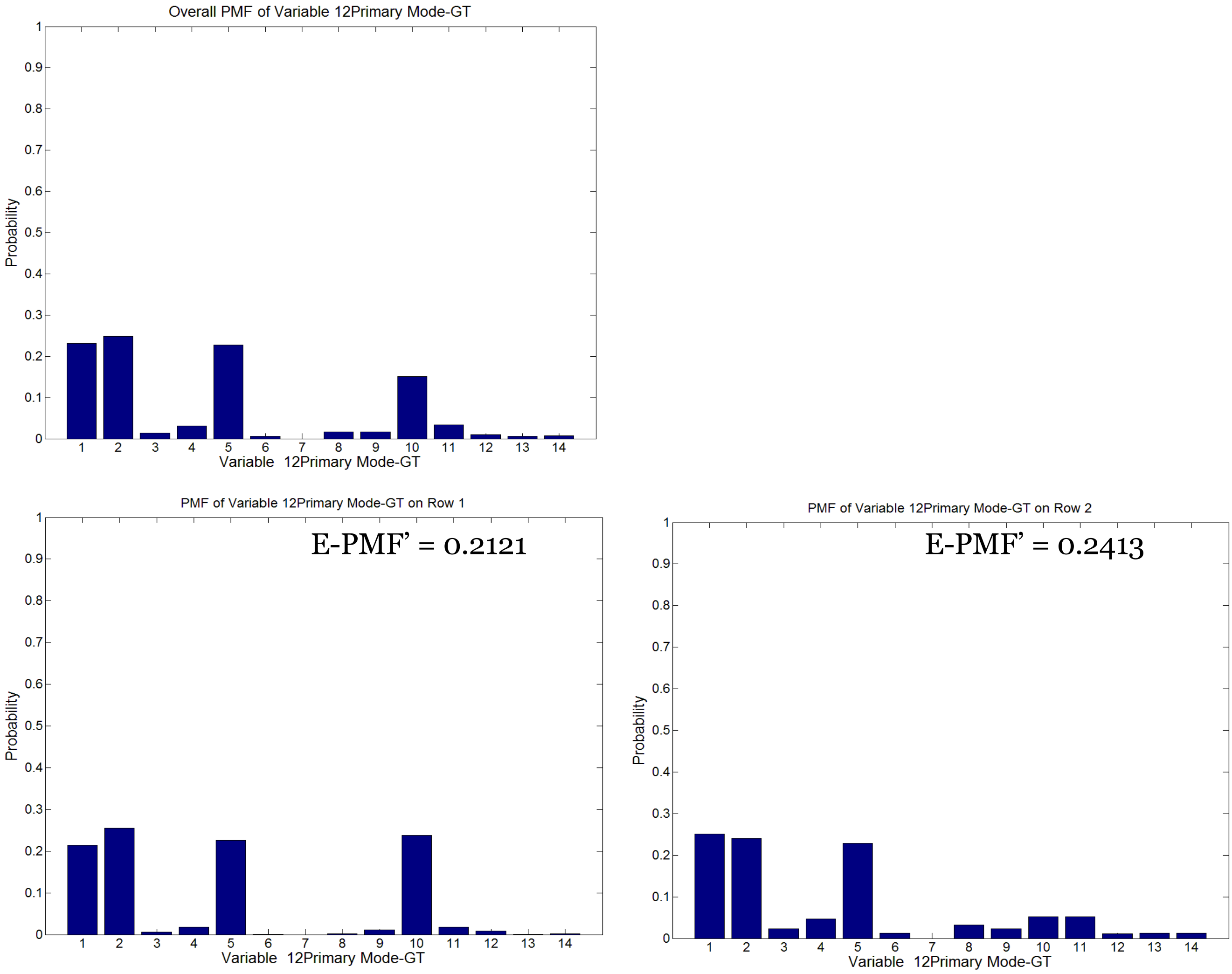
Car ownership
1. Non-private car (government/company car) only; 2. Private car only;
3. No access to car; 4. have access to both non-private car and private cars

Figure 7-25 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Pre-Games primary travel mode**



Pre-Games primary travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus;
6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Company car (drive); 13. Company car (passenger); 14. Other

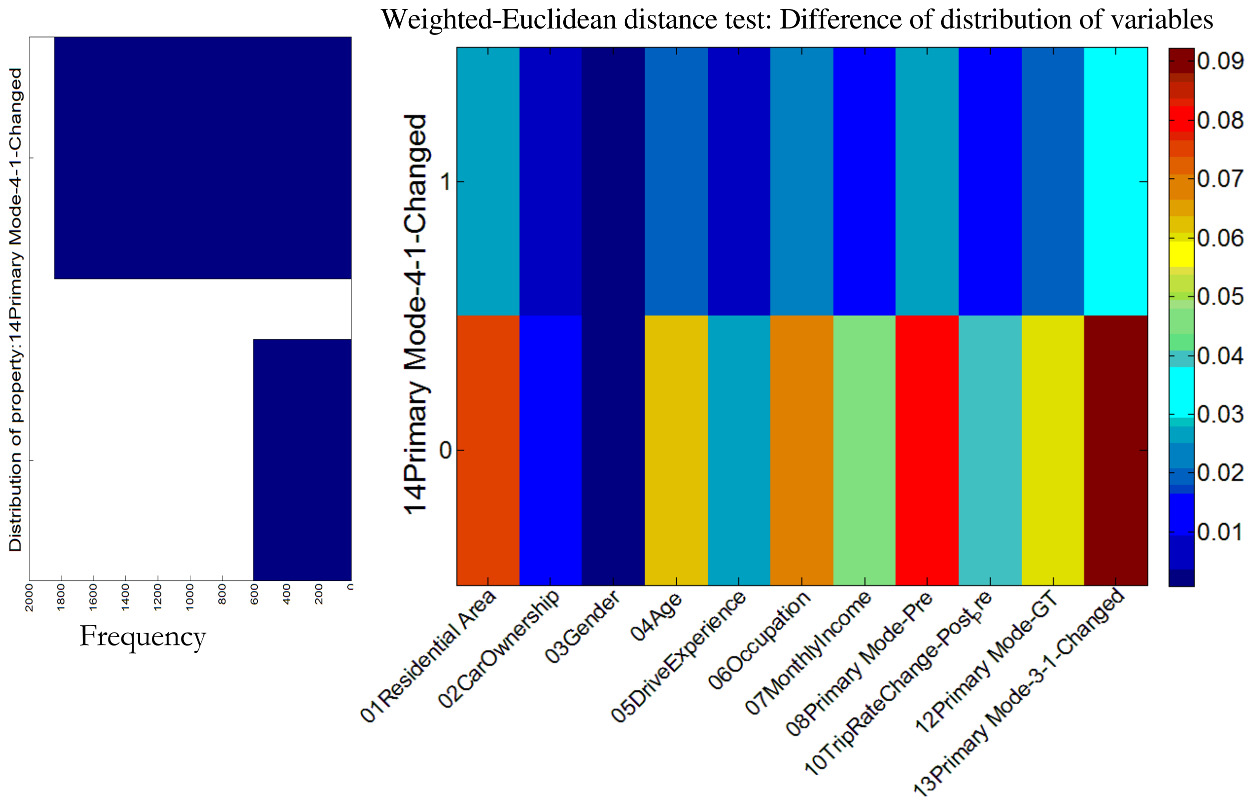
Figure 7-26 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Primary travel mode during the Olympic Games**



Games-time primary travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus;
6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Company car (drive); 13. Company car (passenger); 14. Other

From the chart on the left of Figure 7-27, we see that for longer-term situations, 75.2% of the travellers changed their primary travel modes while only about a quarter of the travellers insisted on their original travel mode before the Olympic Games. Meanwhile, we can also read from Figure 7-24 that there is rarely statistical bias found on any specific factor on the comparisons for residents who did or did not change their travel mode after the Olympic Games (the upper row in Figure 7-27). All E-PMF' values for residents who did change (Row 1) are less than 3%, while those for residents who didn't change (Row 0) are no more than 9.2%. However, we compare the factors which are more highlighted in Figure 7-27, and learn that residents living in venue areas were more likely to move to a new travel mode than people living in other areas after Games time as shown in Figure 7-28. Figure 7-29 shows that travellers whose main travel mode was walking (Pre-games primary travel mode=1) before the Olympic Games were more likely to change to other travel modes after the Games, while regular bus passengers (Pre-games primary travel mode=5) are likely to continue riding the bus, reflecting the result shown in Figure 6-4.

Figure 7-27 Weighted-Euclidean distance PMF test for changes in primary travel modes between pre-Games and post-Games time



Change of Primary travel mode between pre-Games and post-Games (Y-axis):
0. Unchanged; 1. Changed

On the other hand, Figure 7-30 shows that people who changed their primary travel modes during the Olympic Games did not necessary maintain that change after the Games. Some people who didn't change their primary travel modes during Games time did make changes in daily travel modes after the Games, due to the changes in economic situation or car ownership or travel demands, etc.

Figure 7-28 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Residential area**

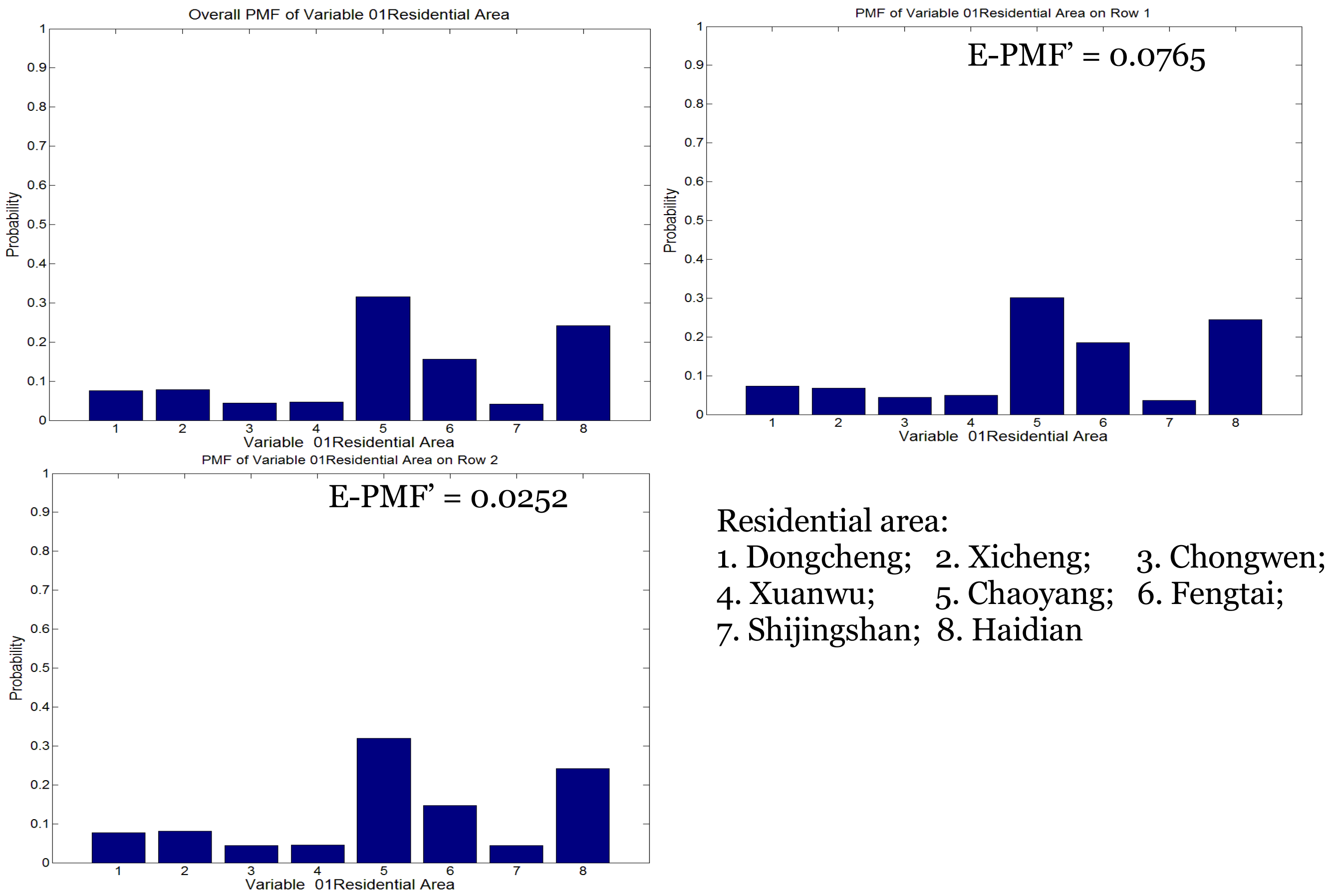
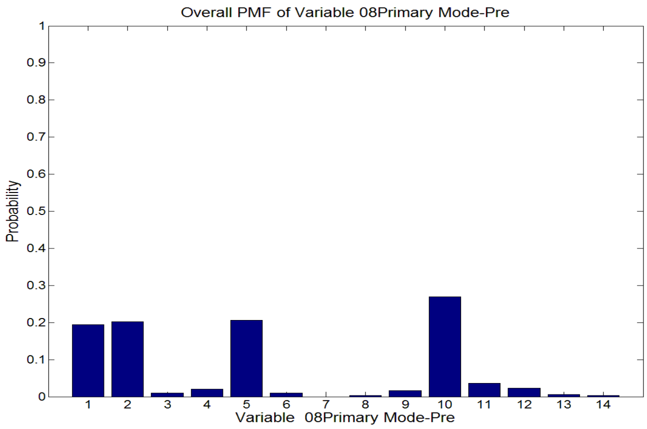
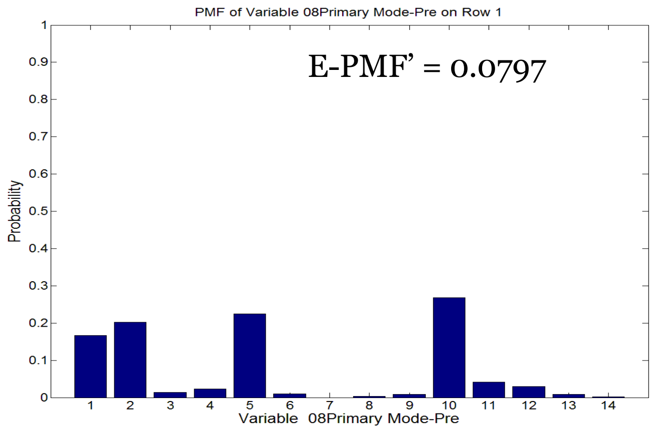
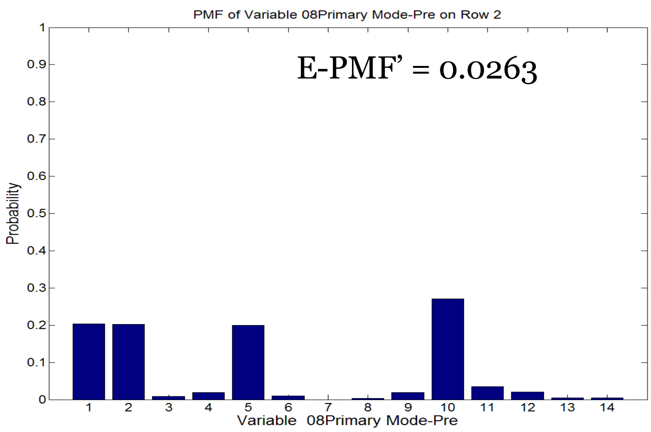


Figure 7-29 Comparison of $PMF_{specific\ group=1,\ 2}$, and $PMF_{overall}$ of Variable **Pre-games primary travel mode**

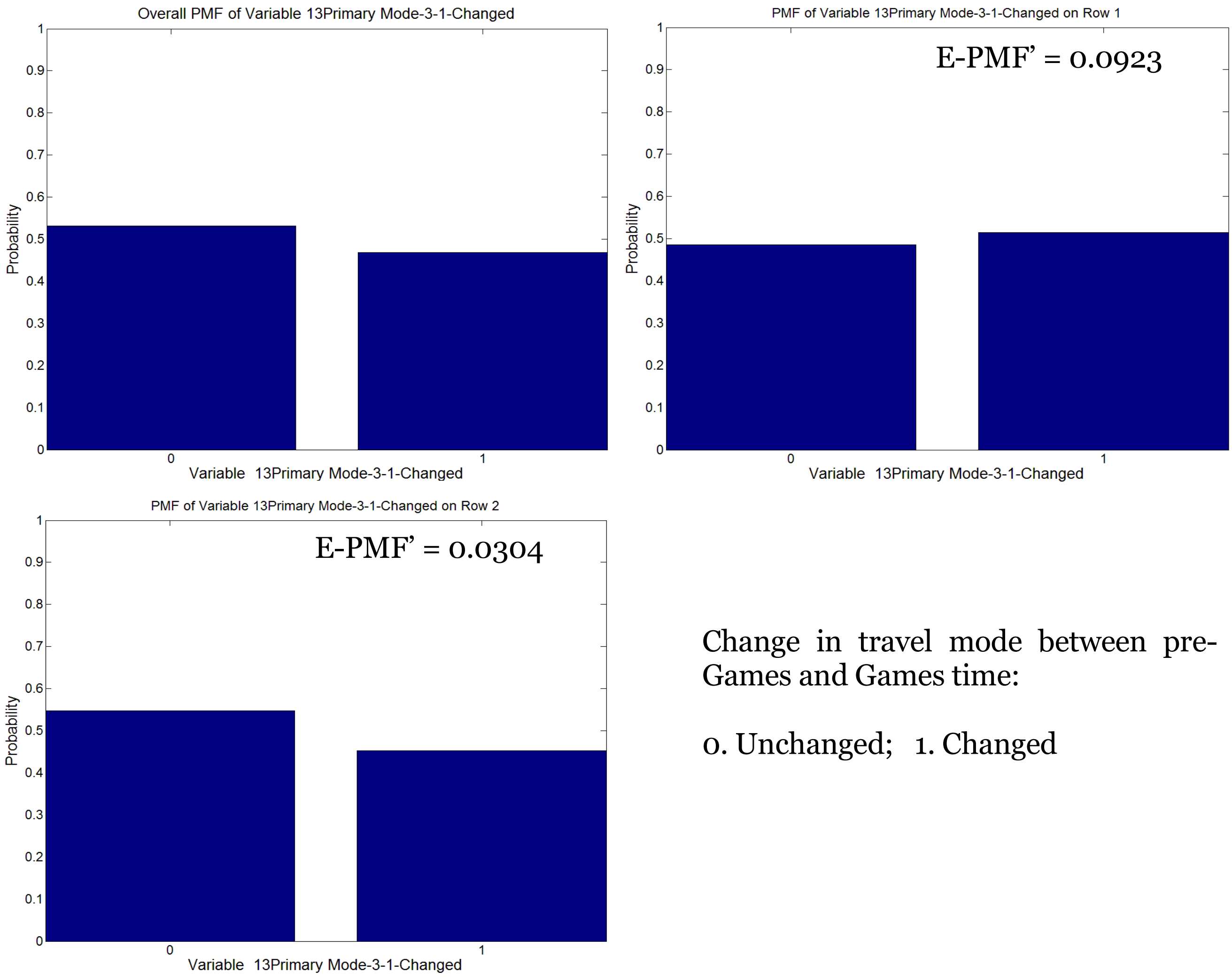






Pre-Games primary travel mode:
1. Walk only; 2. Cycle; 3. Subway;
4. Mix use of public transport; 5. Bus;
6. Car+Public transport 7. Private+Company Cars;
8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Company car (drive); 13. Company car (passenger); 14. Other

Figure 7-30 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Changes in primary travel mode between pre-Games and the Olympic Games time**



7.4.3. Cluster analysis for travel mode changes

To better understand the residents who were more likely to change their primary travel modes during the Olympic Games and after, we applied cluster analysis on the sample data set. Residents were grouped into different clusters by their demographic profiles (including gender, age, residential areas, car accessibility, driving experience, occupation and monthly income), primary travel modes and degree of change.

Look the period between pre-Games and Games time in Tables 7-18 and 19, we can find that the 'New car users' and 'Car dependents' were very unlikely to choose alternative travel modes to instead of car even with the Games' circumstance. In particular, the young female travellers with new car were found very resistive to the change. The 'Car dependents' might turn to share car for travelling, rather using public transport. This is thought to be because these groups were fairly addicted in car using, or convenient car travelling is very desirable for them and hard to get from other travel modes such as public transport at their locations. Unfortunately, such information on their connections to public transport is unavailable for this research.

Similar to the findings in 7.4.1 and 7.4.2, the public transport users and non-motorized travellers were also resistive to changing their travel modes during the Games. As seen in Table 7-19, the 'Budget travellers' and 'Carefree travellers' who usually travelled by walk or public transport before the Games were observed to continue using the same travel methods during Games time.

However, the 'Office staff' and 'Aspiring sustainable travellers' who were found to be resistive to changing their travel frequencies appeared likely to change their travel modes, from car using to public transport or non-motorized travelling such as walking and cycling. In particular, the young gentlemen in these two groups appeared to more active in responding the appeal of 'travel wisely' and chose sustainable alternatives during Games time.

For longer term, we can see from Table 7-20 that the 'Budget travellers', 'New car users' and 'Carefree travellers' (including the retiree and students) were less susceptible to the Games, while the 'Office staff' and 'Aspiring sustainable travellers' might continually affected by the Games and use more sustainable modes for their daily travels. This reflected the results found in 7.4.1 and 7.4.2.

Table 7-18 Cluster analysis: Change in Travel mode (pre-Games to Games time)

Cluster	No. of cases	% of sample	Games' impact on Travel mode	Descriptive label
			Short-term (pre-Games to Games time)	
1	97	4%	Very low	New car owner
2	212	9%	Low	Car dependent
3	134	5%	Low	Budget traveller
4	1144	47%	Low	Carefree traveller
5	695	28%	High	Office staff
6	168	7%	Very high	Aspiring sustainable traveller

Table 7-19 Personal characteristics of each cluster (Change in Travel mode: pre-Games to Games time)

	Resistive or Less susceptible				Susceptible		Sample average
	1. New car owner, 4%	2. Car dependent, 9%	3. Budget traveller, 5%	4. Carefree traveller, 47%	5. Office staff, 28%	6. Aspiring sustainable traveller, 7%	
Gender (significant for all clusters)							
Male	33%	79%	40%	42%	68%	67%	54%
Female	67%	21%	60%	58%	32%	33%	46%
Age group (significant for all clusters)							
<25	15%	5%	7%	10%	8%	11%	9%
>=65	4%	2%	3%	8%	0%	4%	5%
Residential area (significant for all clusters)							
Central[1]	28%	22%	19%	28%	21%	23%	24%
Venues[2]	64%	52%	57%	55%	56%	63%	56%
Access to car (significant for all clusters)							
No car	22%	1%	67%	62%	20%	6%	40%
Private	70%	90%	28%	34%	72%	88%	55%
Non-private	6%	8%	4%	3%	8%	7%	5%
Both	2%	0%	0%	0%	1%	0%	0%
Driving Experience: years (significant for all clusters)							
0	67%	12%	78%	84%	24%	25%	56%
<5	10%	14%	4%	4%	17%	12%	9%
>=5	23%	74%	18%	13%	59%	63%	35%
Occupation (significant for all clusters)							
Employers-1[3]	38%	0%	0%	39%	98%	0%	47%
Employers-2[4]	7%	22%	16%	11%	1%	20%	10%
Self--employer	7%	42%	0%	5%	0%	24%	8%
Teacher/Student	20%	5%	0%	8%	1%	13%	6%
Retired	27%	13%	0%	37%	0%	27%	21%
Unemployed	1%	9%	58%	0%	0%	9%	5%
Monthly Income: rmb (significant for all clusters)							
<=3500	23%	27%	55%	33%	18%	28%	29%
>5500	53%	35%	14%	32%	48%	38%	37%
Pre-Games Primary travel mode (significant for all clusters)							
Walk only	38%	0%	43%	33%	0%	0%	19%
Bicycle	31%	0%	28%	41%	1%	0%	22%
Public transport	31%	4%	30%	25%	27%	4%	23%
Drive car	0%	83%	0%	0%	62%	67%	29%
Car passenger	0%	11%	0%	0%	6%	20%	4%
Games-time Primary travel mode (significant for all clusters)							
Walk only	0%	0%	36%	36%	6%	36%	23%
Bicycle	0%	0%	34%	42%	15%	33%	28%
Public transport	11%	4%	28%	22%	42%	31%	26%
Drive car	39%	75%	1%	0%	28%	0%	16%
Car passenger	27%	14%	1%	0%	6%	0%	4%

Note: The demographic information listed here is up to June 2008 when the 1st wave of survey started.

1. refer to the districts of Dongcheng, Xicheng, Chongwen and Xuanwu.
2. refer to the districts of Chaoyang and Haidian, where 28 of 29 Olympic venues were located.
3. refer to 'Factory/Construction worker', 'Scientist/Researcher', 'Office-based staff', 'Government Official'.
4. refer to 'Heathcare staff', 'Waitor/Waitress', 'Driver' and 'Public bus/Underground/Taxi Driver'.

Table 7-20 Cluster analysis: Change in Travel mode (pre-Games to post-Games)

Cluster	No. of cases	% of sample	Games' impact on Travel mode		Descriptive label
			Short-term (pre-Games to Games time)	Long-term (pre-Games to post-Games)	
1	133	5%	Low	Very low	Budget traveller
2	677	28%	Very low	Very low	New car user
3	550	22%	Low	Low	Retiree
4	211	9%	Low	Low	Student
5	527	22%	High	High	Office staff
6	352	14%	Very high	Very high	Aspiring sustainable traveller

Table 7-21 Personal characteristics of each cluster (Change in Travel mode: pre-Games to post-Games)

	Resistive and Less susceptible				Long-term mode switcher		Sample average
	1. Budget traveller, 5%	2. New car user, 28%	3. Retiree, 22%	4. Student, 9%	5. Office staff, 23%	6. Aspiring sustainable traveller, 14%	
Gender (significant for all clusters)							
Male	37%	49%	35%	42%	74%	76%	54%
Female	63%	51%	65%	58%	26%	24%	46%
Age group (significant for all clusters)							
<25	10%	11%	0%	10%	8%	6%	9%
>=65	10%	8%	11%	3%	0%	3%	5%
Residential area (significant for all clusters)							
Central[1]	22%	25%	25%	32%	22%	23%	24%
Venues[2]	55%	56%	58%	49%	56%	56%	56%
Access to car (significant for all clusters)							
No car	65%	62%	56%	62%	4%	3%	40%
Private	30%	34%	41%	35%	87%	89%	55%
Non-private	5%	4%	3%	3%	9%	8%	5%
Both	0%	0%	0%	0%	1%	0%	0%
Driving Experience: years (significant for all clusters)							
0	79%	71%	90%	85%	9%	16%	56%
<5	4%	8%	1%	8%	19%	12%	9%
>=5	17%	21%	9%	7%	72%	72%	35%
Occupation (significant for all clusters)							
Employers-1[3]	0%	98%	0%	0%	93%	0%	47%
Employers-2[4]	14%	2%	9%	37%	2%	22%	10%
Self--employer	0%	0%	7%	11%	0%	37%	8%
Teacher/Student	0%	0%	0%	52%	5%	4%	6%
Retired	0%	0%	83%	0%	0%	19%	21%
Unemployed	60%	0%	0%	0%	0%	9%	5%
Monthly Income: rmb (significant for all clusters)							
<=3500	54%	28%	32%	40%	15%	29%	29%
>5500	14%	35%	36%	27%	53%	34%	37%
Pre-Games Primary travel mode (significant for all clusters)							
Walk only	42%	19%	43%	25%	0%	0%	19%
Bicycle	26%	43%	27%	32%	0%	0%	22%
Public transport	32%	38%	29%	44%	1%	1%	23%
Drive car	0%	0%	0%	0%	83%	78%	29%
Car passenger	0%	0%	0%	0%	9%	15%	4%
Games-time Primary travel mode (significant for all clusters)							
Walk only	36%	20%	44%	21%	9%	15%	23%
Bicycle	29%	41%	27%	34%	18%	14%	28%
Public transport	27%	33%	24%	36%	23%	17%	26%
Drive car	5%	4%	2%	3%	38%	42%	16%
Car passenger	2%	1%	2%	2%	8%	8%	4%
Post-Games Primary travel mode (significant for all clusters)							

Walk only	17%	20%	25%	15%	16%	21%	20%
Bicycle	23%	22%	19%	25%	22%	20%	21%
Public transport	27%	27%	27%	35%	27%	26%	28%
Drive car	29%	23%	23%	18%	29%	26%	25%
Car passenger	2%	5%	3%	6%	4%	6%	4%

Note: The demographic information listed here is up to June 2008 when the 1st wave of survey started.

1. refer to the districts of Dongcheng, Xicheng, Chongwen and Xuanwu.
2. refer to the districts of Chaoyang and Haidian, where 28 of 29 Olympic venues were located.
3. refer to 'Factory/Construction worker', 'Scientist/Researcher', 'Office-based staff', 'Government Official'.
4. refer to 'Heathcare staff', 'Waitor/Waitress', 'Driver' and 'Public bus/Underground/Taxi Driver'.

7.4.4. Discussion

From the above comparisons and analysis, we find that:

1. Residents might change their primary travel modes during the Olympic Games, but not many of them kept the changes after the Games. This is similar to the result discussed earlier in Section 6.2.

2. During Games time, residents with different demographic characteristics were found to be different in changing their primary travel modes. Specifically, 'Car ownership', 'Pre-games and 'Games time primary travel modes' appeared more correlated with the change in primary travel modes. People who normally used cars were disturbed more than those who didn't for daily travels.

   Access to car

   The residents who had car access were more likely to change their primary travel modes than those without car access during Games time. Particularly, people who owned private cars were more likely to alter their Games time travel mode than others. It should be because of the wide restriction on car use during the Olympic Games, as well as the schemes to encourage sustainable travel means as mentioned in Chapter 4.

   Pre-Games primary mode

   The normal private car users were more likely to change their primary travel mode during the Games, while public transport users, especially bus passengers, might prefer to stay with their original travel methods.

Meanwhile, pedestrians and cyclists appeared not likely to change their travel mode during the Olympic Games too. Both comparative analysis in Section 7.4.1 and the result of the Weighted-Euclidean distance PMF test in Section 7.4.2 support these findings, which likely resulted from the restriction on car use and public transport promotions during Games time.

Games time primary mode

The Weighted-Euclidean distance PMF test demonstrates that travellers prefer public transport or non-motorized travel means during Games time. Meanwhile, car share became more popular than before.

3. Looking over the long-term, more than three quarters of the residents were observed to make certain change in their primary travel modes as shown in Figure 7-27. However, it was not necessarily connected to their changes during the Games. From the Weighted-Euclidean distance PMF test, we find that the 'Residential area' and 'pre-Games primary travel means' showed certain correlation with residents' changing situations between pre-Games and post-Games periods.

   Residential area

   Investigating the changes one year after the Olympics Games, residents living in Zone 2, 5 and 8 were more likely to change their primary travel mode than others as shown in Figure 7-28. As tested earlier in Figure 7-27, the difference between those who changed their primary travel mode and the overall resident in the sample data set was very small. However, people living in the venue areas (Residential zone=2, 5, and 8) were found to be slightly more likely to change than those living in other area after the Games. It may be because the Olympic Games brought a lot of infrastructure developments in these areas and many transport facilities were created, which impacted the residents' daily travel pattern over the long term.

   Pre-Games primary travel means

Comparing pre-Games primary travel means, we find from the analysis in Figures 7-20~22 and the Weighted-Euclidean distance PMF test that bus passengers were less likely to change their travel mode while car users and pedestrians were slightly more likely to change their travel mode in the long-term comparisons. There were two possible reasons for this phenomenon: 1) Beijing residents had more activities and increasing travel demands in daily life as the economy developed. It was difficult to satisfy the transport needs by walking. 2) After the Olympic Games, some restrictions on car use carried on, such as the 'One day off a week' scheme that restricted the use of cars for one weekday every week. As a result, car users might consider other travel modes instead.

Primary travel mode change between Games time and pre-Games

The 'Primary travel mode change between Games time and pre-Games' was significant in the Weighted-Euclidean distance PMF test. However, when looking into the detailed comparison in Figure 7-30, we find that people who changed during the Olympic Games were observed not to change in the longer term, and vice versa. It indicated that people who didn't change primary travel modes did not necessarily stay with the same travel modes after the Games, while those who did change might return to their pre-games travel modes.

4. The results of cluster analysis for the primary travel mode change corresponded to descriptive analysis and the Weighted-Euclidean distance PMF test for primary travel mode change discussed above. It indicated the specific combination of factors of the distinguish groups who were or were not likely to change during Games time, among which 'Residential area', 'Car ownership' were more effective than the others. For the long-term view, cluster analysis identified a group who altered to subway from driving cars during Games time and maintained the change after the Games (Groups 3 and 5 in Table 7-19. Gender=1, Age=4, Residential area=5, Access to car=2,

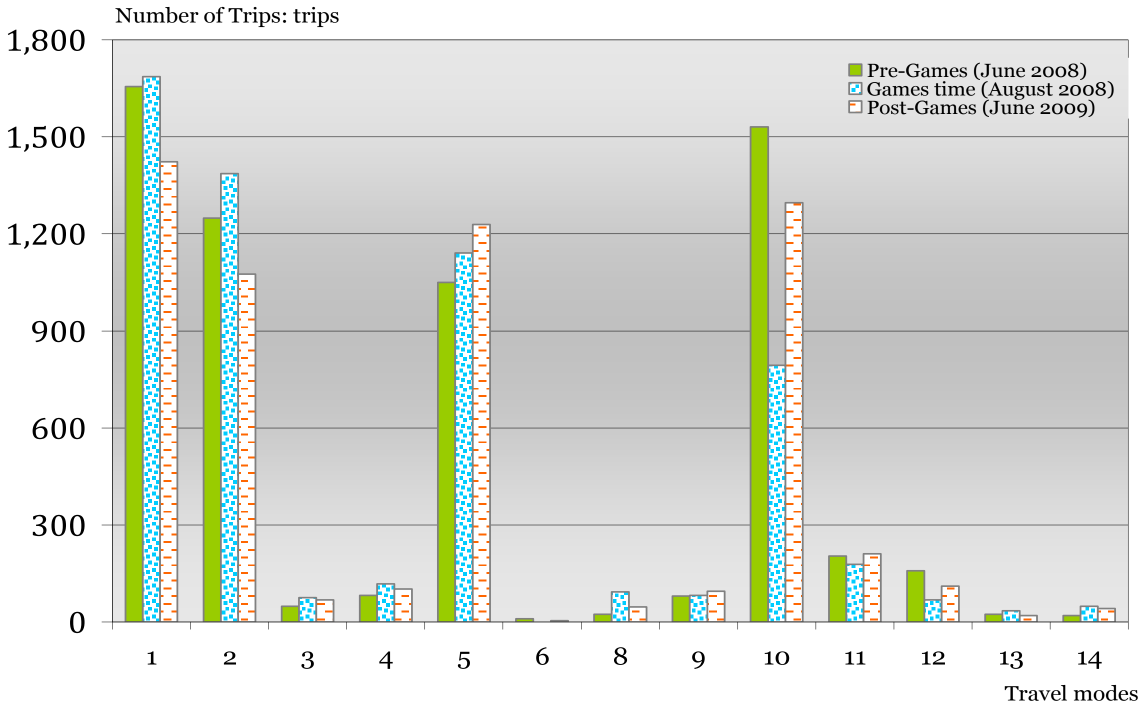
Driving experience=2, Occupation=4 or 11, primary travel mode-pre Games=10).

7.5. Changes in commuting trips

7.5.1. Changes in commuting trips

In Section 6.5.1, we found that the change in mode share for commuting was much sharper than that for overall trips, especially in the reduction of car use during the Olympic Games. This is also evident from the comparisons for the sample data set in Figure 7-31 and 32. Commuting trips by bus increased by 7.0% from pre-Games to Games time, while the overall mode share for bus only increased by 2.9% at the same time. Meanwhile, commuting trips by driving private cars decreased by 12.9%, while the overall mode share for driving private cars only decreased by 11%. Public transport was more popular for commuting trips than cars during the Games, but the phenomenon appeared to turn back after the Games and the mode share of car driving for work rebounded.

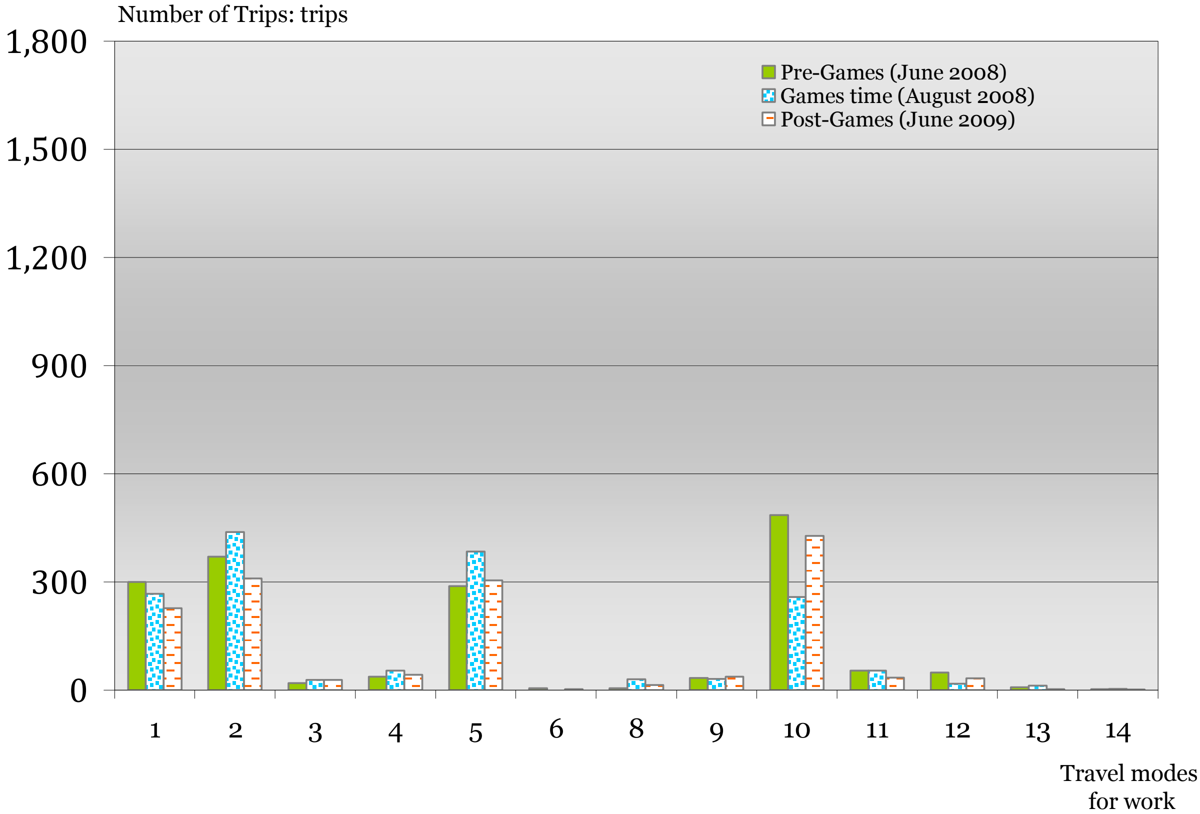
Figure 7-31 Trips by primary travel modes in different waves of the surveys (sample data set)



Travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus; 6. Car+Public transport
7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Company car (drive); 13. Company car (passenger); 14. Other

Note: Trips of 'Walk only' are counted only when they form complete trips (i.e. walking all the way), not when they are part of trips using other modes of transport.
Source: database owned by Beijing Transportation Research Center

Figure 7-32 Commuting trips by travel modes in different waves of the surveys (sample data set)



Travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus; 6. Car+Public transport
7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Company car (drive); 13. Company car (passenger); 14. Other

Note: Trips of 'Walk only' are counted only when they form complete trips (i.e. walking all the way), not when they are part of trips using other modes of transport.
Source: database owned by Beijing Transportation Research Center

In Table 7-22, we can see the detailed changes of commuting trips of Beijing residents during Games time. It can be seen that,

1. People made significantly fewer changes to their commuting travel, compared to the overall travels. Comparing Tables 7-17 and 7-20, we find the changes for overall travels during Games time were significantly less than those for commuting travels, showing people usually use the same travel method for work unless necessary change is required.
2. Most non-motorized travellers and public transport passengers didn't change their commuting travel methods during Games time. In particular, over 80% of the people who cycled to work kept using bikes for commuting during Games time.
3. Many car users selected alternative travel methods such as bus and bicycle during Games time. In particular, most regular government/company car users changed their commuting travel modes to public transport or car sharing. We also see that company coach is a very important alternative for regular government/company car sharers.

In Sections 7.5.2 and 7.5.3, the individual travel behaviour changes in mode choice for commuting trips across the compared period: pre-Games, Games time and post-Games are investigated with the Weighted-Euclidean distance PMF test and cluster analysis, aiming to identify who might be more likely to make such changes for their commutes.

Table 7-22 Changes in commute travel mode from pre-Games to Games time

Games time / Pre-Games	Walk only	Cycle	Bus	Subway	Taxi	Co. coach	Mixed PT*	Car + PT	Pri-car1	Pri-car2	G/C car¹	G/C car²	Other
Walk only	73.5%	13.1%	5.0%	0.4%	1.9%	0.0%	0.4%	0.0%	2.3%	0.4%	0.4%	1.2%	1.5%
Cycle	9.9%	80.2%	6.1%	0.0%	0.0%	1.1%	0.4%	0.0%	2.3%	0.0%	0.0%	0.0%	0.0%
Bus	4.6%	13.2%	71.7%	0.0%	2.0%	0.7%	3.3%	0.0%	3.3%	0.7%	0.7%	0.0%	0.0%
Subway	30.8%	0.0%	23.1%	38.5%	0.0%	0.0%	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Taxi	0.0%	0.0%	0.0%	0.0%	75.0%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Co. coach	4.5%	13.6%	18.2%	0.0%	0.0%	59.1%	0.0%	0.0%	4.5%	0.0%	0.0%	0.0%	0.0%
Mixed PT *	0.0%	7.7%	26.9%	3.8%	3.8%	0.0%	57.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Car+PT	33.3%	0.0%	33.3%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pri-car¹	5.2%	12.4%	17.9%	3.6%	2.8%	1.2%	3.6%	0.0%	44.2%	6.0%	1.6%	1.2%	0.4%
Pri-car²	6.9%	10.3%	31.0%	0.0%	6.9%	0.0%	0.0%	0.0%	6.9%	34.5%	0.0%	3.4%	0.0%
G/C car¹	0.0%	17.2%	17.2%	3.4%	3.4%	0.0%	6.9%	0.0%	17.2%	3.4%	10.3%	20.7%	0.0%
G/C car²	0.0%	16.7%	33.3%	0.0%	0.0%	33.3%	0.0%	0.0%	0.0%	16.7%	0.0%	0.0%	0.0%
Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%

Co. coach: company coach; Mixed PT *: mixed use of public transport;
Pri-car¹: drive private car; Pri-car²: seated in private car (passenger);
G/C car¹: drive government /company car; G/C car²: seated in government /company car (passenger)

7.5.2. Weighted-Euclidean distance PMF test for travel modes for commuting trips

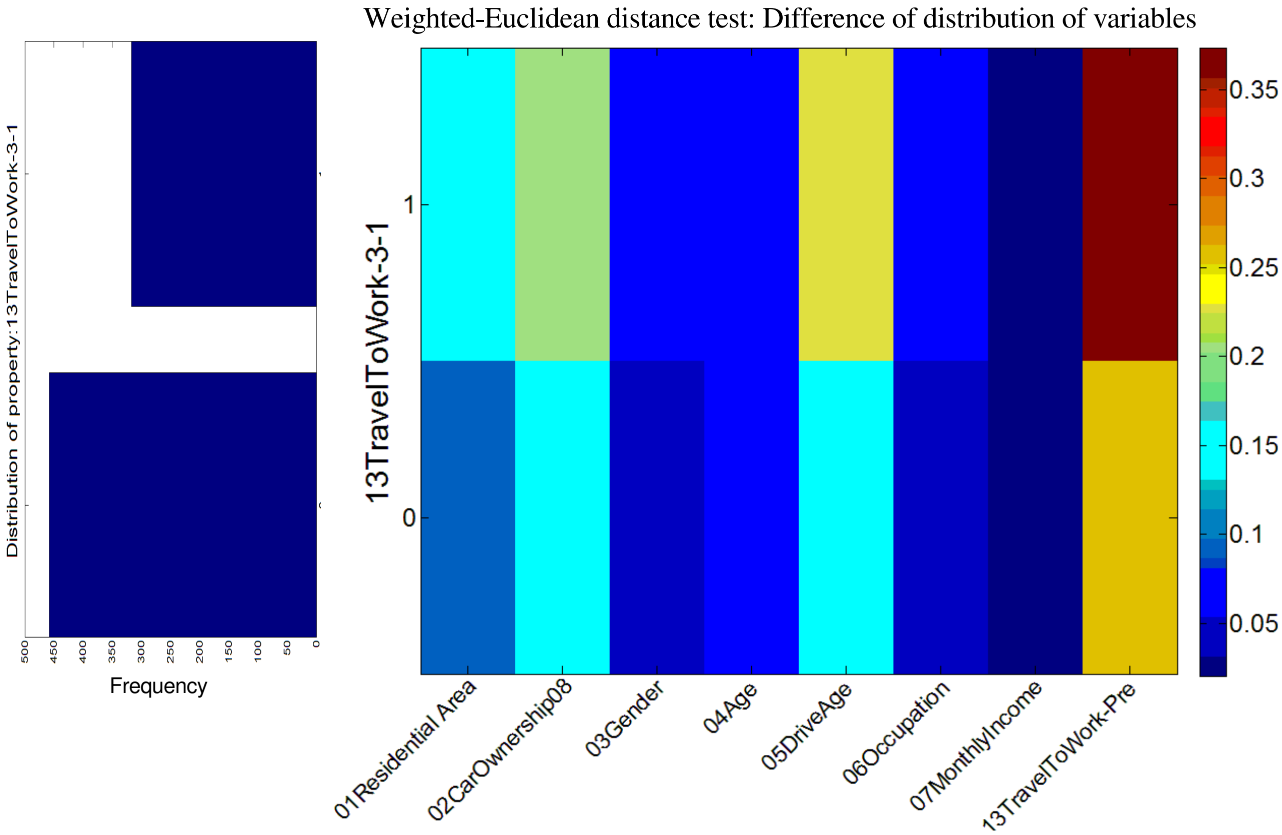
From the chart on the left of Figure 7-33, we learn that fewer travellers changed their travel modes for work than those who didn't during the Olympic Games. By the Weighted-Euclidean distance PMF test, we find that whether the residents changed their commuting travel modes was significantly impacted by their 'Car ownership', 'Driving experience' and 'Pre-Games travel mode for work'. Meanwhile, 'Gender', 'Age', 'Occupation' and 'Monthly income' didn't show much effect on their mode change for commuting trips.

1. Investigating by car ownership, as shown in Figure 7-34, we find that residents who owned private vehicles (Car ownership = 2) were more likely

to alter their commuting travel mode during Games time than people who didn't (Car ownership = 3).

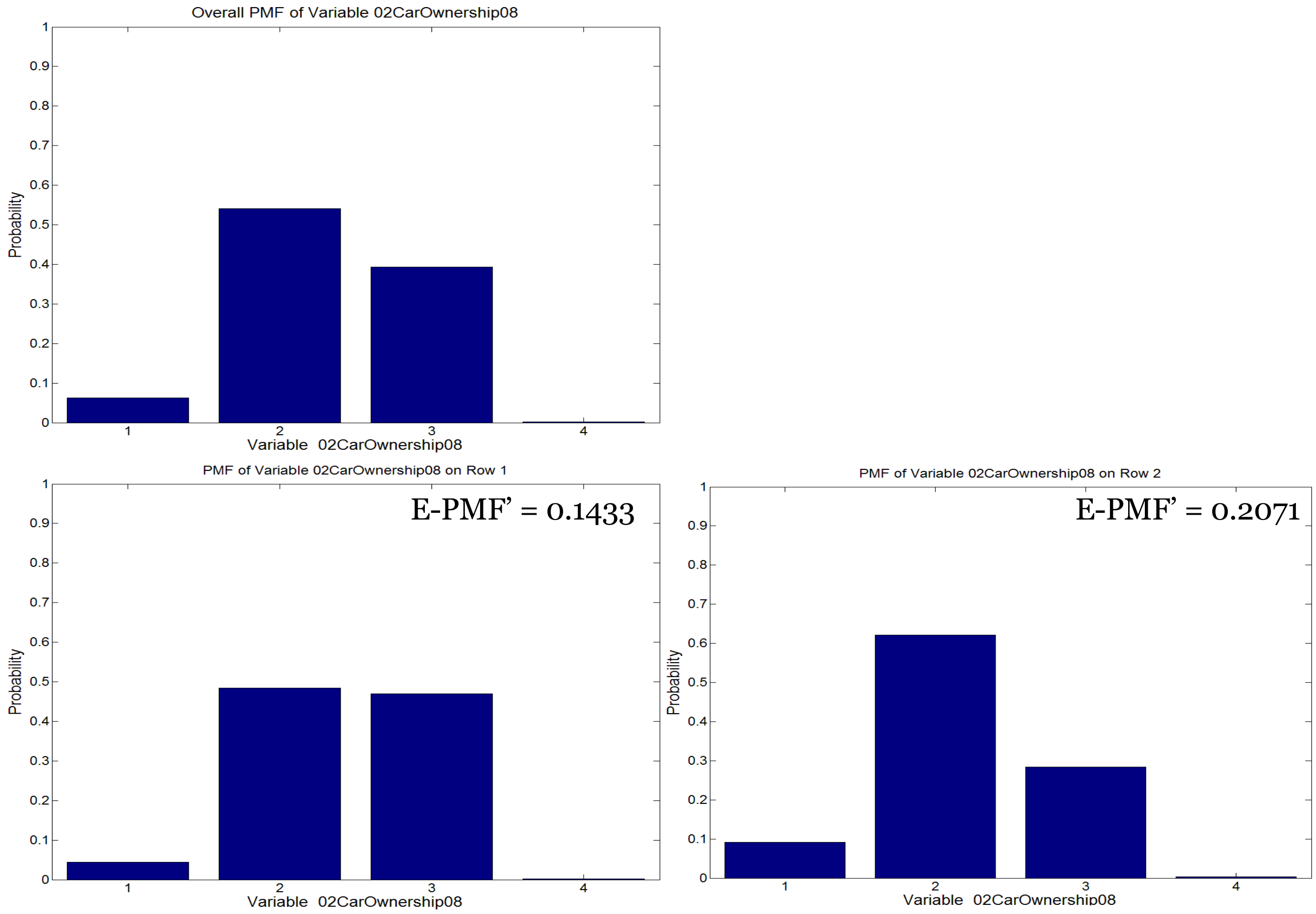
2. By Driving experience, we see from Figure 7-35 that peope who had access to cars in the household but don't drive (Drive experience = 0) were less likely to change their commuting travel mode, while car users with 5-10 years' driving experience (Driving experience = 2) were more likely to choose other travel means for work when the restrictions were applied.
3. By pre-Games commuting travel mode, we see from Figures 7-36 that cyclists (Pre-Games travel mode for work = 2) and bus passengers (Pre-Games travel mode for work = 5) were more likely to stay with the same commuting travel modes as pre-Games time, while subway passengers (Pre-Games travel mode for work = 3) and car users (Pre-Games travel mode for work = 10, or 11, or 12, or 13) were found to prefer changing their commuting travel mode when the Olympics took place.

Figure 7-33 Weighted-Euclidean distance PMF test for the changes in travel modes for work between pre-Games and Games time



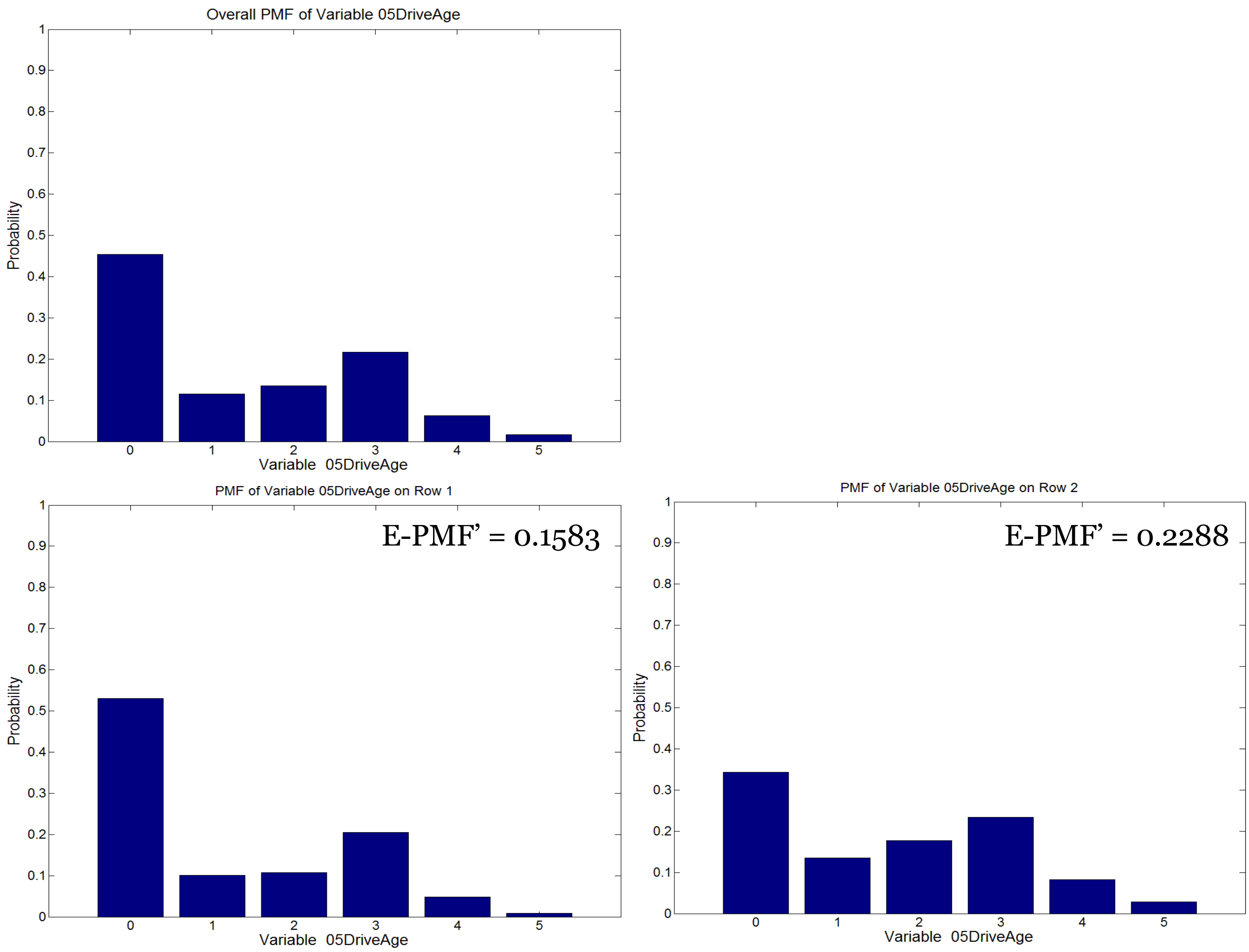
Change of travel mode for work between pre-Games and Games time (Y-axis):
0. Unchanged; 1. Changed

Figure 7-34 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Car ownership**



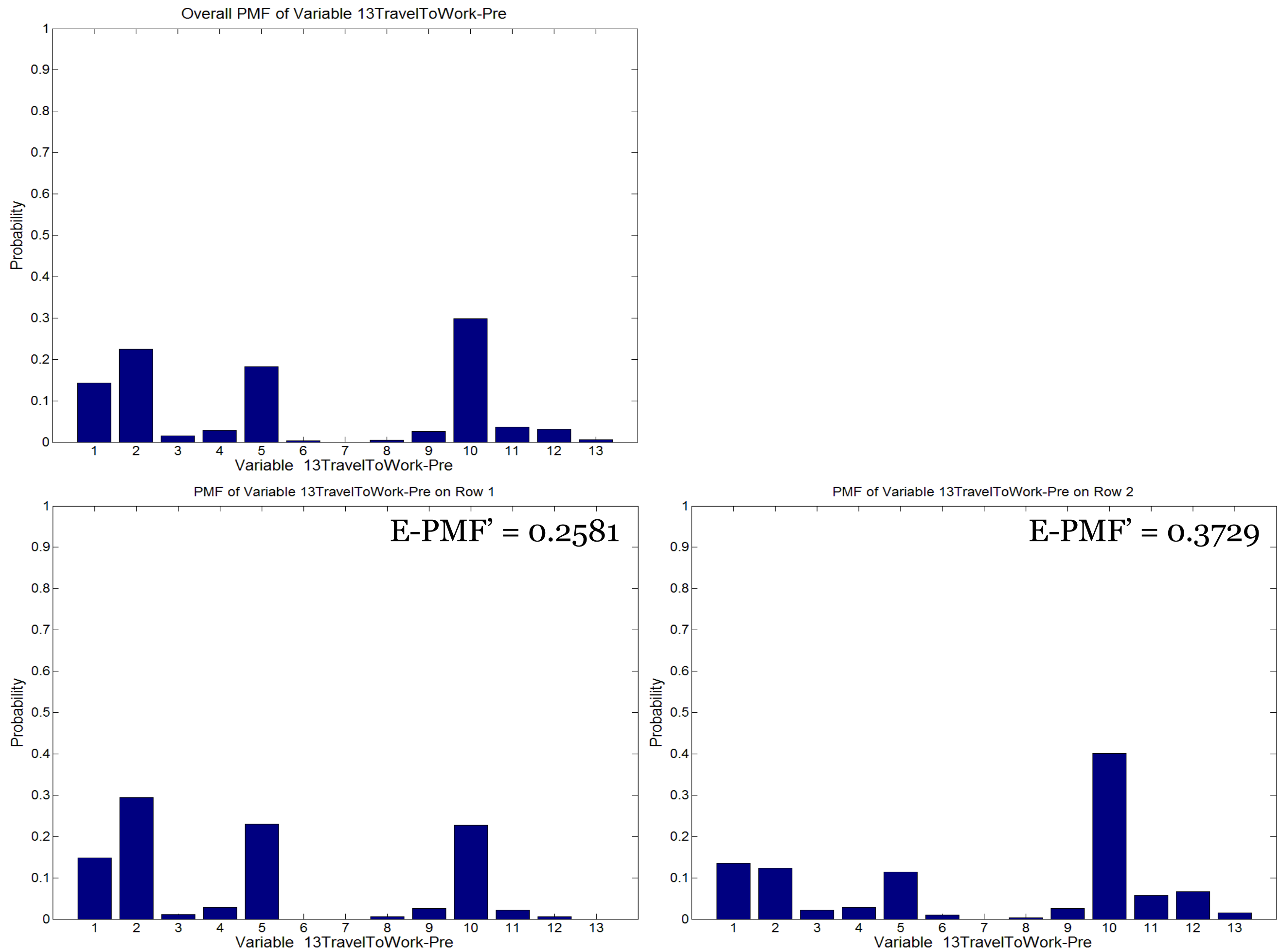
Car ownership
1. Non-private car (government/company car) only; 2. Private car only;
3. No access to car; 4. have access to both non-private car and private cars

Figure 7-35 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Driving experience**



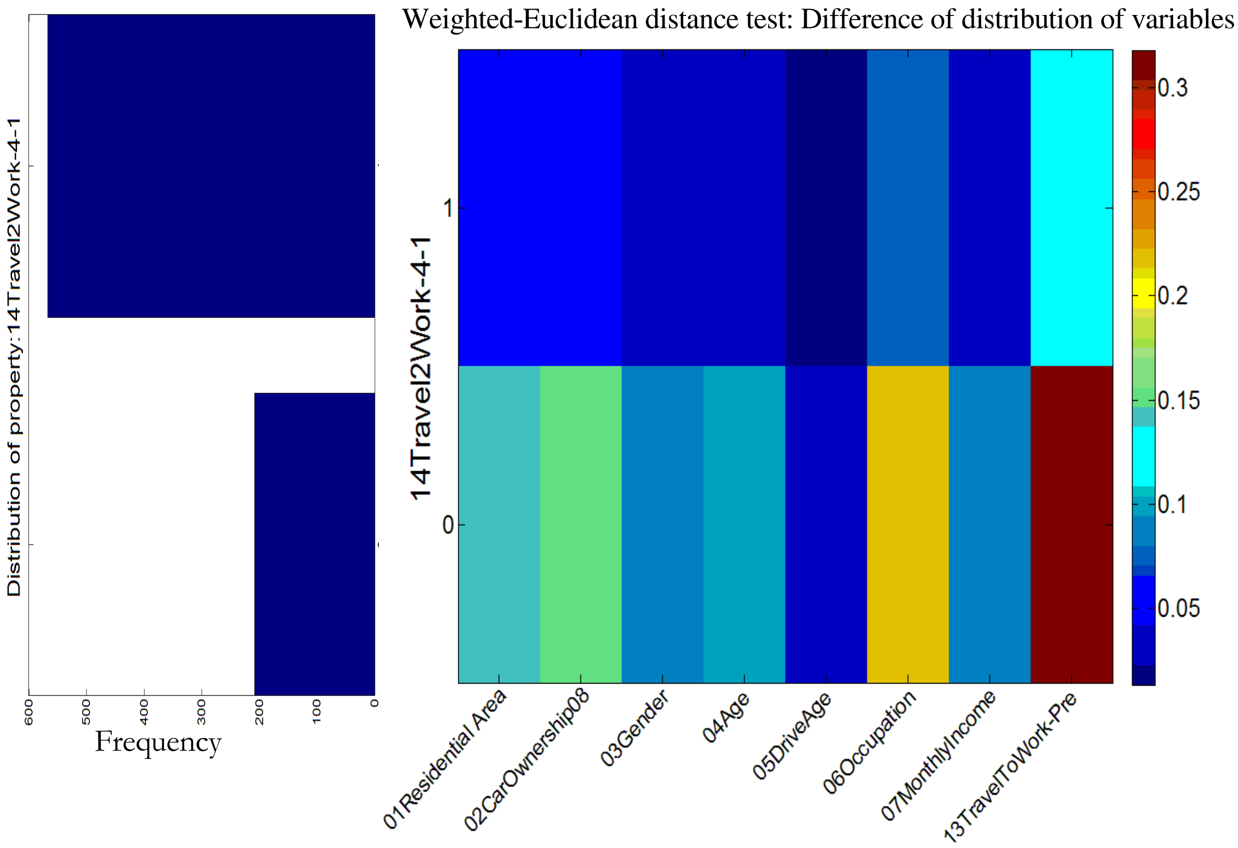
Driving experience (years):
0. Not drive; 1. <5; 2. >=5, <10; 3. >=10, <20; 4. >=20, <30; 5.>=30

Figure 7-36 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Pre-Games travel mode to work**



Pre-Games primary travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus;
6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Company car (drive); 13. Company car (passenger)

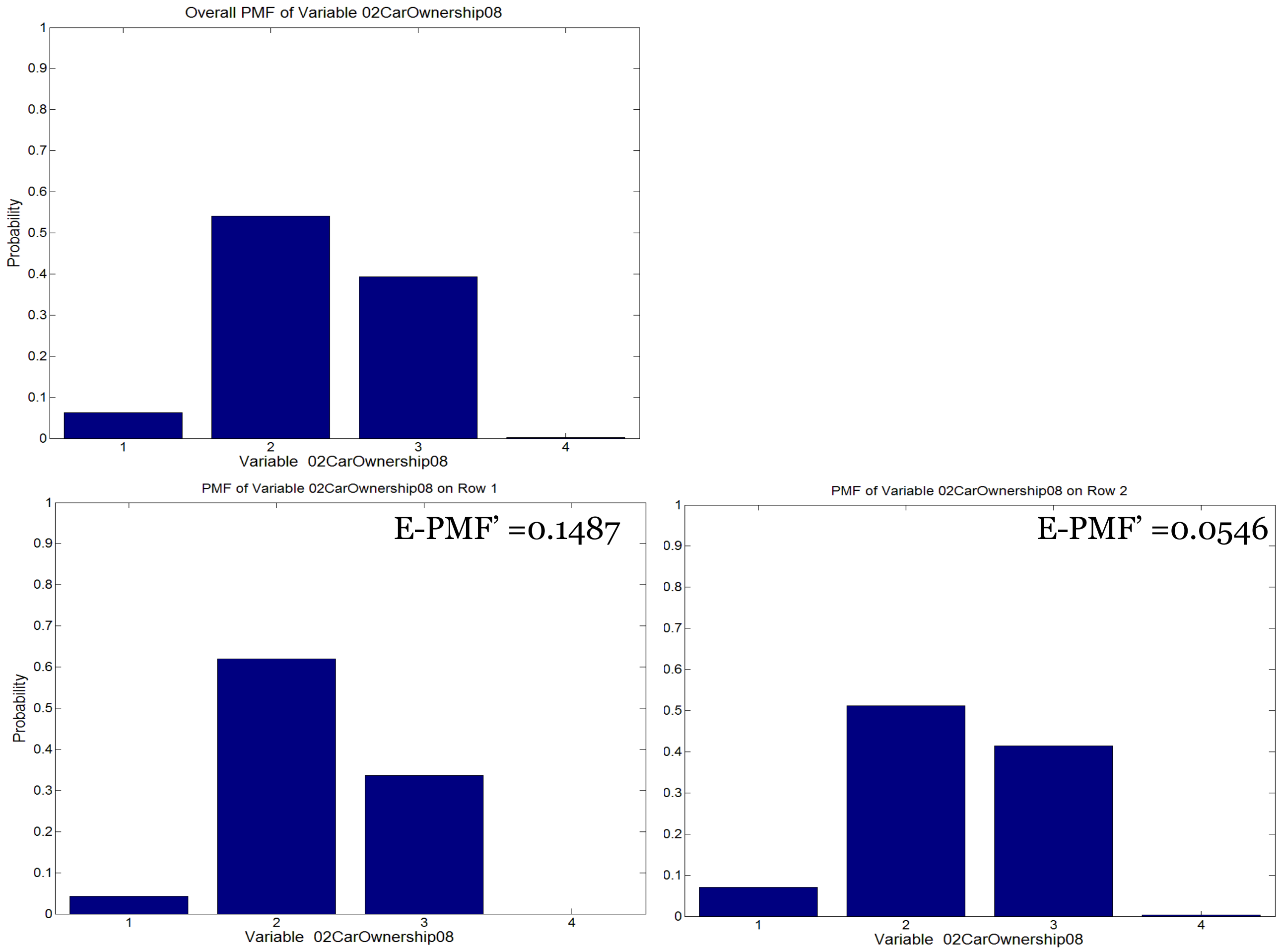
Figure 7-37　Weighted-Euclidean distance PMF test for the changes in travel modes for work between pre-Games and post-Games time



Change of travel mode for work between pre-Games and post-Games (Y-axis): 0. Unchanged;　1. Changed

Figure 7-37 is the map of the Weighted-Euclidean distance PMF test for longer-term changes in commuting travel modes. We find that when comparing the longer-term situations, more travellers showed changes in their travel mode for commuting. However, residents who did change their commuting travel modes after the Olympic Games (the upper row in Figure 7-37) don't show any significant difference on compared characters (X-Axis) when compared with the overall resident. As seen from Figure 7-34, residents who didn't change their travel mode after the Olympic Games (the lower row in Figure 7-37) were significantly different from the overall travellers on 'Car ownership', 'Occupation' and 'Pre-games commuting travel mode'.

Figure 7-38 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Car ownership**



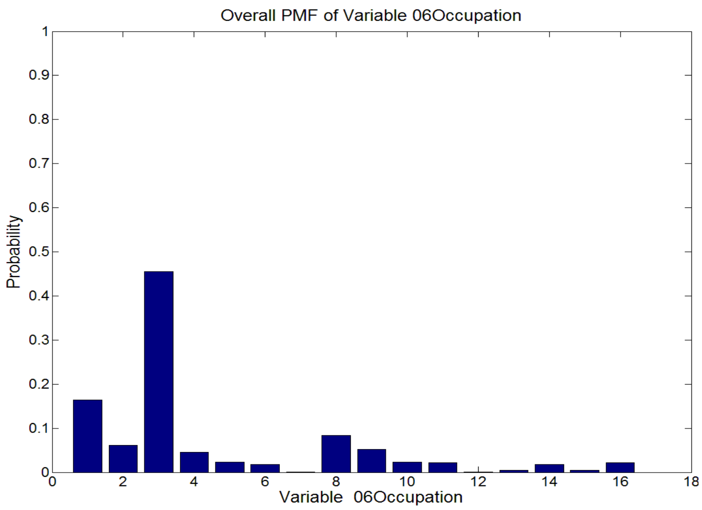
Car ownership
1. Non-private car (government/company car) only; 2. Private car only;
3. No access to car; 4. have access to both non-private car and private cars

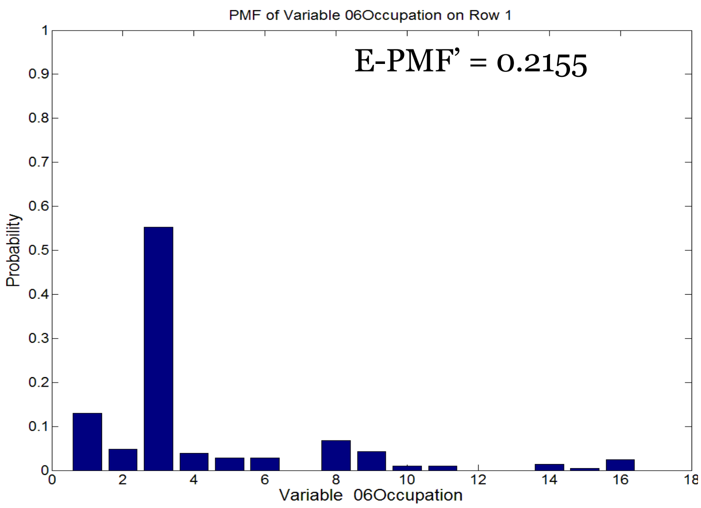
Investing by car ownership, we see from Figure 7-38 that people who owned private vehicles (Car ownership=2), were unlikely to change their travel mode for work after the Games, while residents who had non-private vehicles (government/company cars) only or had no access to car use (Car ownership = 1 or 3) seemed more likely to change their ways of commute after the Olympic Games.

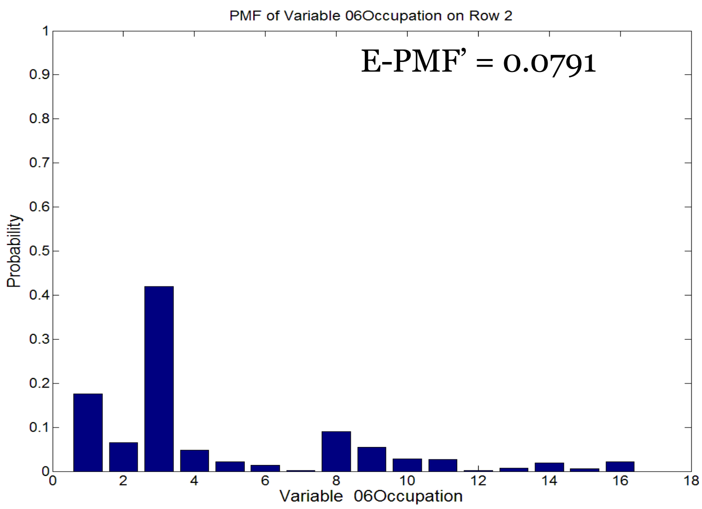
By occupation, as seen from Figure 7-39, office-based staff (Occupation = 3) were more likely to stick to their original commutes after the Games.

When comparing by their pre-Games commuting mode in Figure 7-40, we find that cyclists and private car users (pre-Games commuting travel mode = 2 or 10) were more likely to have the same commuting travel modes between pre-Games and post-Games, while non-private car users (pre-Games commuting travel mode=12) might possibly change their travel means for work after the Games.

Figure 7-39 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Occupation**

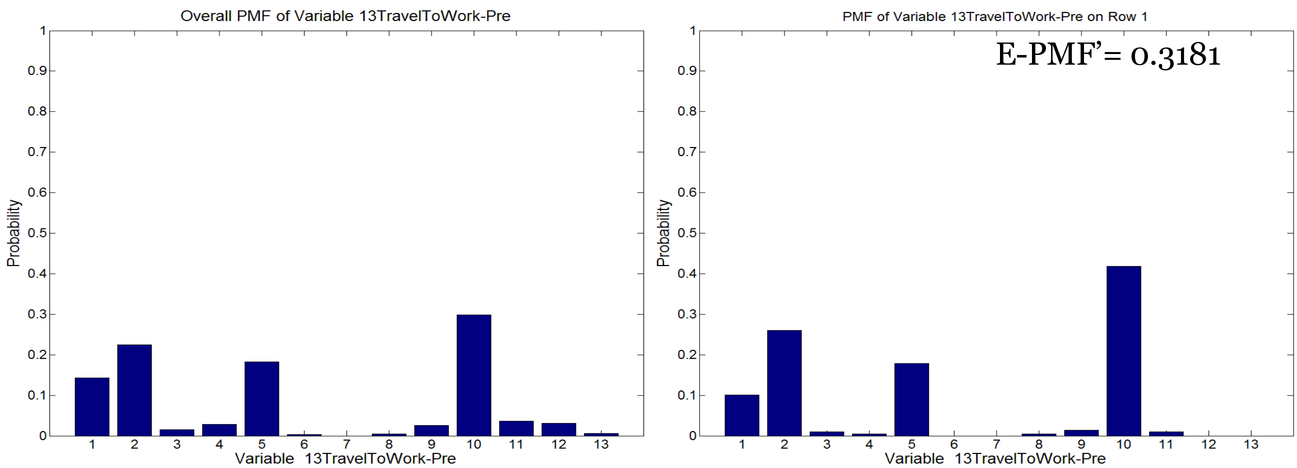


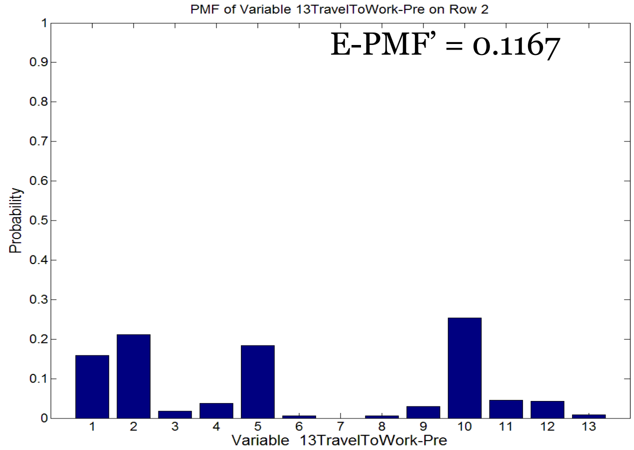




Occupation:
1. Factory/Construction worker;
2. Scientist/Researcher;
3. Office-based staff; 4. Government Official;
5. Heathcare staff; 6. Teacher; 7. Student;
8. Waitor/Waitress; 9. Self-employer;
10. Retired; 11. Driver; 12. Farmer;
13. Soldier/Police;
14. Public bus/Underground/Taxi Driver;
15. Unemployed

Figure 7-40 Comparison of $PMF_{specific\ group=1,\ 2,}$ and $PMF_{overall}$ of Variable **Pre-Games travel mode to work**





Pre-Games travel mode to work:

1. Walk only; 2. Cycle; 3. Subway;
4. Mix use of public transport; 5. Bus;
6. Car+Public transport
7. Private+Company Cars;
8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Non-private car (drive);
13. Non-private car (passenger); 14. Other

7.5.3. Cluster analysis for changes in travel modes for work

Reading the results of cluster analysis on the mode changes for commuting trips in Tables 7-23 and 24, we learn the following:

From pre-Games to Games time, the commuting travel modes changed similarly to the overall travel modes as discussed in 7.4.3. The 'New car users' as well as the public transport users including the 'Budget traveller' and 'Carefree traveller' were not affected by the Olympic Games' impacts a lot. However, the 'Car dependent' made more changes in their commuting travel compared to their normal travels. Some of them started taking company coach for work while some shared cars. It's because some of this group used non-private cars for work which were strictly restricted. They had to use alternatives for work. Also, some of them might hope to respond to the government's appeal of travel wisely.

The 'Office staff' and 'Aspiring sustainable travellers' were found likely to change their commuting travel modes, from car using to sustainable travel modes such as public transport or non-motorized methods during Games time.

Table 7-23 Cluster analysis: Change in Commuting travel mode (Pre-Games to Games time)

Cluster	No. of cases	% of sample	Games' impact on Commuting travel mode Short-term (pre-Games to Games time)	Descriptive label
1	26	3%	Very low	Budget traveller
2	321	41%	Low	New car user
3	114	15%	Low	Carefree traveller
4	40	5%	High	Car dependent
5	250	32%	High	Office staff
6	24	3%	Very high	Aspiring sustainable traveller

Table 7-24 Personal characteristics of each cluster (Commuting travel mode: pre-Games to Games time)

	Resistive or Less susceptible			**Susceptible**			Sample average
	1. Budget traveller, 3%	2. New car user, 41%	3. Carefree traveller 15%	4. Car dependent, 5%	5. Office staff, 32%	6. Aspiring sustainable traveller, 3%	
Gender (significant for all clusters)							
Male	35%	50%	45%	85%	74%	88%	59%
Female	51%	61%	48%	25%	11%	27%	41%
Age group (significant for all clusters)							
<25	4%	8%	6%	0%	3%	4%	5%
>=55	4%	7%	11%	5%	6%	4%	7%
Residential area (significant for all clusters)							
Central[1]	15%	22%	25%	35%	24%	42%	24%
Venues[2]	69%	55%	52%	48%	53%	46%	54%
Access to car (significant for all clusters)							
No car	19%	65%	68%	3%	4%	17%	39%
Private	73%	30%	29%	80%	89%	71%	54%
Non-private	8%	4%	4%	18%	8%	13%	6%
Both	0%	1%	0%	0%	0%	0%	0%
Driving Experience: years (significant for all clusters)							
0	46%	70%	74%	5%	10%	13%	45%
<5	8%	9%	7%	13%	16%	13%	11%
>=5	46%	21%	19%	83%	73%	75%	43%
Occupation (significant for all clusters)							
Employers-1[3]	77%	95%	0%	0%	95%	0%	73%
Employers-2[4]	12%	3%	61%	38%	3%	38%	15%
Self--employer	4%	0%	11%	48%	0%	33%	5%
Teacher/Student	8%	2%	1%	0%	2%	4%	2%
Retired	0%	0%	14%	0%	0%	8%	2%
Monthly Income: rmb (significant for all clusters)							
<=3500	19%	26%	33%	13%	14%	21%	22%
>5500	38%	34%	25%	53%	52%	38%	39%
Pre-Games Commuting travel mode (significant for all clusters)							
Walk only	42%	19%	33%	0%	0%	0%	14%
Bicycle	31%	45%	39%	0%	0%	0%	25%
Public transport	27%	36%	27%	8%	1%	0%	21%
Company coach	0%	0%	0%	0%	7%	8%	3%
Drive car	0%	0%	0%	83%	81%	79%	33%
Car passenger	0%	0%	0%	10%	10%	13%	4%
Games time Commuting travel mode (significant for all clusters)							
Walk only	0%	19%	27%	0%	4%	21%	14%
Bicycle	0%	47%	40%	0%	18%	21%	32%
Public transport	23%	35%	32%	5%	26%	58%	30%
Company coach	12%	0%	0%	8%	6%	0%	3%
Drive car	50%	0%	1%	68%	38%	0%	17%
Car passenger	15%	0%	0%	20%	9%	0%	5%

Note: The demographic information listed here is up to June 2008 when the 1st wave of survey started.
1. refer to the districts of Dongcheng, Xicheng, Chongwen and Xuanwu.
2. refer to the districts of Chaoyang and Haidian, where 28 of 29 Olympic venues were located.
3. refer to 'Factory/Construction worker', 'Scientist/Researcher', 'Office-based staff', 'Government Official'.
4. refer to 'Heathcare staff', 'Waitor/Waitress', 'Driver' and 'Public bus/Subway/Taxi Driver'.

For longer term, we can see the details for clusters in Tables 7-25 and 7-26 that, the 'Car dependents' will use car again after the Games, while the 'Office staff' and 'Aspiring sustainable traveller' may continue their changes during Games time for longer.

Table 7-25 Cluster analysis: Change in Commuting travel mode (pre-Games to post-Games)

Cluster	No. of cases	% of sample	Games' impact on Commuting travel mode		Descriptive label
			Short-term (pre-Games to Games time)	Long-term (pre-Games to post-Games)	
1	25	3%	Low	Very low	New car user
2	277	36%	Very low	Very low	Budget traveller
3	108	14%	Low	Very low	Carefree traveller
4	160	21%	High	Very low	Car dependent
5	63	8%	High	High	Office staff
6	142	18%	Very high	Very high	Aspiring sustainable traveller

Table 7-26 Personal characteristics of each cluster (Commuting travel mode: pre-Games to post-Games)

	Resistive		**Short-term susceptible**		**Long-term mode switcher**		Sample average
	1. New car user, 3%	2. Budget traveller, 36%	3. Carefree traveller, 14%	4. Car dependent, 21%	5. Office staff, 8%	6. Aspiring sustainable traveller, 18%	
Gender (significant for all clusters)							
Male	36%	51%	44%	65%	87%	70%	59%
Female	64%	49%	56%	35%	13%	30%	41%
Age group (significant for all clusters)							
<25	4%	6%	5%	8%	2%	3%	5%
>=55	4%	7%	12%	5%	5%	6%	7%
Residential area (significant for all clusters)							
Central[1]	16%	23%	24%	21%	38%	25%	24%
Venues[2]	72%	54%	52%	54%	46%	54%	54%
Access to car (significant for all clusters)							
No car	16%	64%	70%	23%	10%	4%	39%
Private	72%	31%	27%	72%	75%	87%	54%
Non-private	12%	5%	3%	5%	16%	8%	6%
Both	0%	0%	0%	1%	0%	0%	0%
Driving Experience: years (significant for all clusters)							
0	44%	73%	77%	25%	8%	8%	45%
<5	12%	8%	6%	17%	10%	17%	11%
>=5	44%	19%	18%	58%	83%	75%	43%
Occupation (significant for all clusters)							
Employers-1[3]	68%	95%	0%	92%	0%	95%	73%
Employers-2[4]	16%	4%	59%	4%	40%	3%	15%
Self--employer	8%	0%	10%	1%	41%	0%	5%
Teacher/Student	8%	1%	1%	3%	0%	2%	2%
Retired	0%	0%	15%	0%	3%	0%	2%
Monthly Income: rmb (significant for all clusters)							
<=3500	16%	27%	35%	16%	14%	15%	22%
>5500	44%	33%	24%	51%	48%	46%	39%
Pre-Games Commuting travel mode (significant for all clusters)							
Walk only	48%	22%	34%	0%	0%	0%	14%
Bicycle	32%	50%	42%	3%	0%	0%	25%
Public transport	20%	27%	24%	29%	5%	2%	21%
Company coach	0%	0%	0%	6%	3%	6%	3%
Drive car	0%	0%	0%	57%	81%	80%	33%
Car passenger	0%	0%	0%	5%	11%	13%	4%
Games-time Commuting travel mode (significant for all clusters)							
Walk only	0%	22%	29%	3%	6%	4%	14%
Bicycle	0%	52%	43%	18%	8%	16%	32%
Public transport	20%	26%	29%	43%	27%	28%	30%
Company coach	8%	0%	0%	7%	5%	3%	3%
Drive car	56%	0%	0%	28%	41%	36%	17%
Car passenger	16%	0%	0%	3%	13%	13%	5%

Post-Games Commuting travel mode (significant for all clusters)							
Walk only	12%	13%	17%	0%	14%	14%	11%
Bicycle	24%	29%	26%	0%	24%	44%	25%
Public transport	24%	30%	29%	3%	25%	42%	26%
Company coach	0%	3%	0%	8%	0%	0%	3%
Drive car	40%	23%	28%	83%	33%	0%	33%
Car passenger	0%	1%	1%	8%	3%	0%	2%

Note: The demographic information listed here is up to June 2008 when the 1st wave of survey started.

1. refer to the districts of Dongcheng, Xicheng, Chongwen and Xuanwu.
2. refer to the districts of Chaoyang and Haidian, where 28 of 29 Olympic venues were located.
3. refer to 'Factory/Construction worker', 'Scientist/Researcher', 'Office-based staff', 'Government Official'.
4. refer to 'Heathcare staff', 'Waitor/Waitress', 'Driver' and 'Public bus/Subway/Taxi Driver'.

7.5.4. Discussion

From the above comparisons and analysis in Section 7.5, we find that,

1. The proportion of people who changed their commuting travel modes among the overall commuters was less than that of people who changed their primary travel modes among the whole sample set during the Olympic Games as well as after the Games when compared with pre-Games period. It showed that people were more likely to stick into their original travel modes for work. The comparison in Sections 6.5 and 7.5.1 also show that the changes in mode share of commuting trips were much sharper than the change in overall trips. This difference indicates that commuters who made changes in travel modes used to have higher trip rates (number of trips per person per day), which reflects the previous discussion. As discussed in Section 7.3.1.7, travellers using private cars were more likely to reduce their daily travel demand during Games time. On the other hand, commuters who used private cars for going to work before the Games were more likely to choose another travel mode for commuting as shown in Figure 7-33. Thus, we find that travellers who used private cars for work and have higher trip rates (number of trips per person per day) were more likely to change their commuting travel modes during Games time. However, investigating the overall changes in travel mode during the Games, it was easier for travellers to choose a new alternative for other trip purpose, rather than for work.
2. During Games time, commuters with different demographic characteristics were found to behave differently in changing their travel means for work.

Particularly, the characters of 'Car ownership', 'Driving experience', and 'Pre-games travel mode for work' appeared more closely connected to their changing situation in commuting travel modes.

Car ownership

The commuters who owned cars were more likely to be impacted by the Olympic Games and changed their travel modes for work, while those who didn't seem to prefer their original travel mode for work. This is similar to the results discussed in Section 7.3.

Driving experience

The group with 5-10 years driving experience is more likely to change its commute travel mode than others: while those had no driver's licence looked to have less likelihood of making changes in the way of travelling to work. The comparison in Section 7.4 as well as Figure 7-33 also points out the people who normally used public transport or cycling for work were less likely to change their travel modes.

Pre-Games travel mode for work

We see from the result of the Weighted-Euclidean distance PMF test that travellers who biked or bussed to work appeared much less likely to change their travel modes, while car users were found to make changes in the way of going to work during Games time.

3. Looking at the long-term, we see that the 'Car ownership', 'Occupation', and 'pre-Games travel mode to work' were more correlated with residents' changing situations between pre-Games and post-Games periods. The results showed that people with private cars were unlikely to change their travel means for work in a long-term view.

Car ownership

Investigating the changes one year after the Olympics Games, residents who owned private cars were less likely to change in the long term while residents who had non-private vehicles (government/company cars) only or had no access to car use seemed more likely to choose a new travel means to go to work after the Olympic Games.

Occupation
People who had fixed working schedules such as office-based staff were less likely to change in the long-term view. They were more likely to stick to their original life styles, including working and travelling.

Pre-Games travel mode for work
Similar to the finding in the comparison by car ownership, travellers who used private cars for work were significantly less likely to change in the year following the Olympic Games, while people travelling to work by walking, cycling and non-private cars were observed to be more likely to change than the private car users.

4. The cluster analysis described in Section 7.5.3 reflects the result found in above discussion. The groups identified by the cluster analysis also showed the people who owned private cars and had 5-10 years driving experience were more likely to make change in travel mode for work during the Games while people who lived outside the venue areas and without car access and normally travel by bike or bus might stick to their original commuting ways during Games time. The cluster analysis also show that it was hard for the people who were doing office-based work or were used to drive private cars to work to make a change in travel mode for work in the long-term comparisons.

7.6. Discussion

This chapter investigated the difference between people who made travel behaviour changes and identified who might be more likely to change vs. not during the Olympic Games and after, by applying descriptive analysis, the Weighted-Euclidean distance PMF test, and cluster analysis on the sample data set which recorded the travel behaviours of people in pre-Games, Games time and post-Games continually. Our efforts demonstrate:

1. Residents changed their daily trip rates (number of trips per person per day), primary travel mode, as well as commuting travel mode significantly during the Olympic Games. However, it was observed from the comparisons that the changes in trip rates might last for longer term after the Games, while those in travel mode might not. Section 7.3.2 shows that people who made changes in trip rates during Games time might keep these changes after the Games, while those who didn't change might not change even after the Games. Meanwhile, as discussed in Section 7.4.2, there is no evidence found for the connection between residents' change in primary travel modes during Games time and after Games. Games' impact has little lasting effect on the residents' choice on travel modes.

2. People with different demographic characteristics made different changes in trip rates and travel modes when the Olympic Games took place. For trip rate, 'Age', 'Residential area', 'Occupation' and 'Pre-games primary travel mode' were strongly correlated to the related changes. People aged 35-44, travellers living in the venue areas, teachers and students, as well as car users were more likely to make changes in their daily travel demands. For travel modes, 'Car ownership', 'Pre-games and Games time primary travel modes' were found effective predictors in the related changes. Commonly, people who owned car or normally used car for travelling were affected significantly during Games time, due to vehicle restrictions and traffic control. They were more likely to, forced or voluntarily, change to an alternative mode of travel. Meanwhile, bus passengers and the non-motorized travellers, such as pedestrians and cyclists, seemed to prefer staying with their previous travel modes during Games time. On the other hand, from the Weighted-Euclidean distance PMF test, we found that the 'changers' during Games time would like to choose public transport or non-

motorized travel means as the alternatives. Car sharing became more popular than before.

3. Investigating long term, we find that in general, residents started to go back to their normal travel patterns when the Games finished. But the movements in trip rate and travel mode rebounded differently. First of all, the proportion of people who changed their daily trip rates were less than that of people who didn't change, while there were more people who changed their travel modes in the long term. Secondly, people were observed to possibly continue some changes they made in trip rates during Games time for longer term, while the analysis also showed that the people who changed their travel modes during the Games did not necessarily continue the alternative travel means after the Games.

   On trip rate, 'Residential area', 'Age', 'pre-Games primary travel means' and 'Trip rate changes between pre-Games and the Olympic Games' showed strong correlation with the residents' changing situations between pre-Games and post-Games periods. As discussed in Section 7.3.4, many people continued to decrease their daily travel demands after the Games, especially those people who lived in the venue areas or non-private car users and non-motorized travellers. On the other hand, male travellers, people aged between 15-24, and public transport passengers were more likely to change back immediately when the Games finished. The people who didn't make trip rate changes during Games time were not likely to change their travel frequency after the Games.

   On travel mode, 'Residential area', 'Age', 'pre-Games primary travel means' showed certain connection with the residents' long-term movement between pre-Games and post-Games periods. As discussed in Section 7.4.4, the people living in the venue areas and the normal car users and pedestrians were found more likely to change than the others. It was because the Olympic Games brought a lot of development and improvements in infrastructure and transportation, which impacted the residents' daily travel pattern longer term.

4. Residents behaviour proved more resistant in their travelling for work. The results showed that people were less likely to change their travel mode for work than their travel modes for other purposes.

   During Games time, the changing situation of travellers was found to be correlated with 'Car ownership', 'Driving experience' and 'Pre-games travel mode for work'. Travellers who owned cars, had 5-10 years of driving experience, and were used to driving private car for work were more likely to change their commuting travel modes during Games time, while those who travelled by bike or bus to work appeared much less likely to change their travel modes.

   Viewing a long-term movement, the analysis showed that people with private cars and used private car for work or those who worked in offices were unlikely to change their travel means for work.

Chapter 8

DATA ANALYSIS: CAR USERS AND PUBLIC TRANSPORT PASSENGERS

As discussed in the previous chapters, various Travel Demand Management (TDM) measures were launched in Beijing to help smooth transport operation during the 2008 Olympic Games. However, people with various backgrounds or travel needs changed or maintained their daily travel patterns in different ways during the Olympic Games period and after. It was widely discussed in previous studies that, people's opinions might be tied to the effects of TDM measures. On one hand, people's choices on travel methods do not directly rely on the service level or the facilities of the transport system, but on psychological factors such as beliefs, attitudes, and habits that may be influenced by the service level and related policies (Fishbein & Ajzen, 1975; Ajzen & Fishbien, 1980; Ajzen, 1991; Verplanken & Aarts, 1999; Fujii & Kitamura, 2003). On the other hand, different 'travel changing' incentives of the TDM actions for different groups of travellers and their propensity to respond caused the effectiveness for various measures to vary significantly (Meyer, 1999; Beijing Transportation Research Center, 2008b). In investigating the connection between the residents' opinions towards the TDM measures undertaken in Beijing during the Olympic Games, and their consequent behaviour changes in daily travel through 2008 and 2009, a supplementary survey was undertaken in Beijing as mentioned in Section 5.1, which investigated 1,864 car users and 3,460 public transport users. This chapter analyzes the impacts of the Travel Demand Management (TDM) measures on the travel behaviour changes of public transport passengers and car users.

8.1. Studied data set

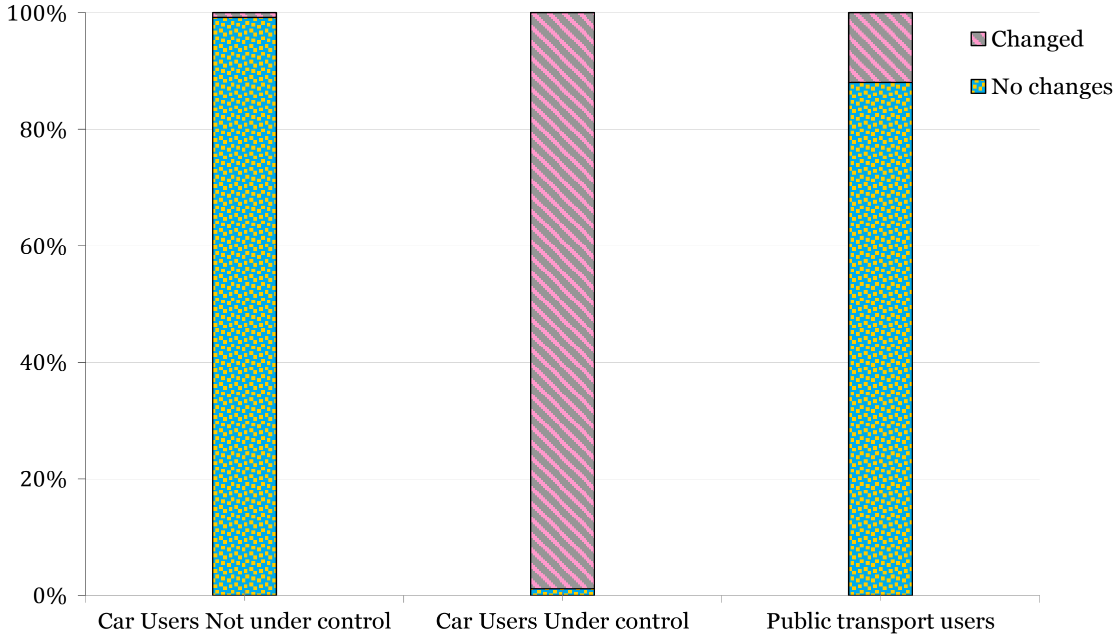
The studied data set in this chapter used the supplementary survey results, which was described in Table 5-2. The main purpose of the survey was to understand

Beijing residents' subjective feeling towards the Olympic related TDM measures, and support the evaluation and assessment for relevant transport policy planning and operation. In this supplementary survey, 1,864 car users and 3,460 public transport passengers took the interview in car parking (for car users) or public bus/subway stations (for public transport users) and provided their opinions towards the Olympic Games-related TDM measures as well as the information on their behaviour changes during Games time. This survey emphasized on the difference between car users and public transport passengers. However, due to the nature of this survey's location, design and interviewees, its results were with significant limitation and bias in interpreting an overall travel pattern of residents. There are two main reasons: 1) the survey interviewed actual travellers using certain specific travel mode at specific transport facilities such as parking or stations. They might be more active in travelling during Games time and make less change in this special period of time; 2) as the survey collected people's subjective feeling and what they said, rather than recorded actual travel diary such as what was done in main surveys discussed in previous chapters, there was non-commitment bias of interviewees. People might talk about their travel patterns which are different from what they actually behaved. We need to try to deduce the bias in this study and use such information on attitudes and intentions which disconnected from the actual behaviour to interpret the results from the main household survey. So we focus on comparing car users and public transport passengers with the survey results in this chapter, rather than comparing it to the analysis for overall residents in previous chapters.

8.2. Different changes in Games time travel patterns

In this supplementary survey, we find that car users had significantly different travel patterns on the days their vehicles were banned by the Odd-even alternate day-off scheme during Games time, while they used similar means for travelling on those days their cars were allowed, as shown in Figure 8-1 and Table 8-1. Public transport users had certain changes on their daily travel patterns as well, which was bigger than the car users on the days without controls. Only 0.9% of the car users indicated that they had changed their travel patterns during Games time when their cars were allowed to the road, while 98.8% of the car users altered their main travel means and 1.2% stayed the same when their vehicles were prohibited. On the other hand, 88.0% of the public transport users continued their ordinary travel pattern during Games time. We can see this result appeared very different from what was shown in Figure 7-20, because of the limitation and bias discussed in Section 8.1. However, we can see that car users were more likely to change their travel modes than public transport users during the Olympic Games, which was similar to the comparison in Chapter 7.

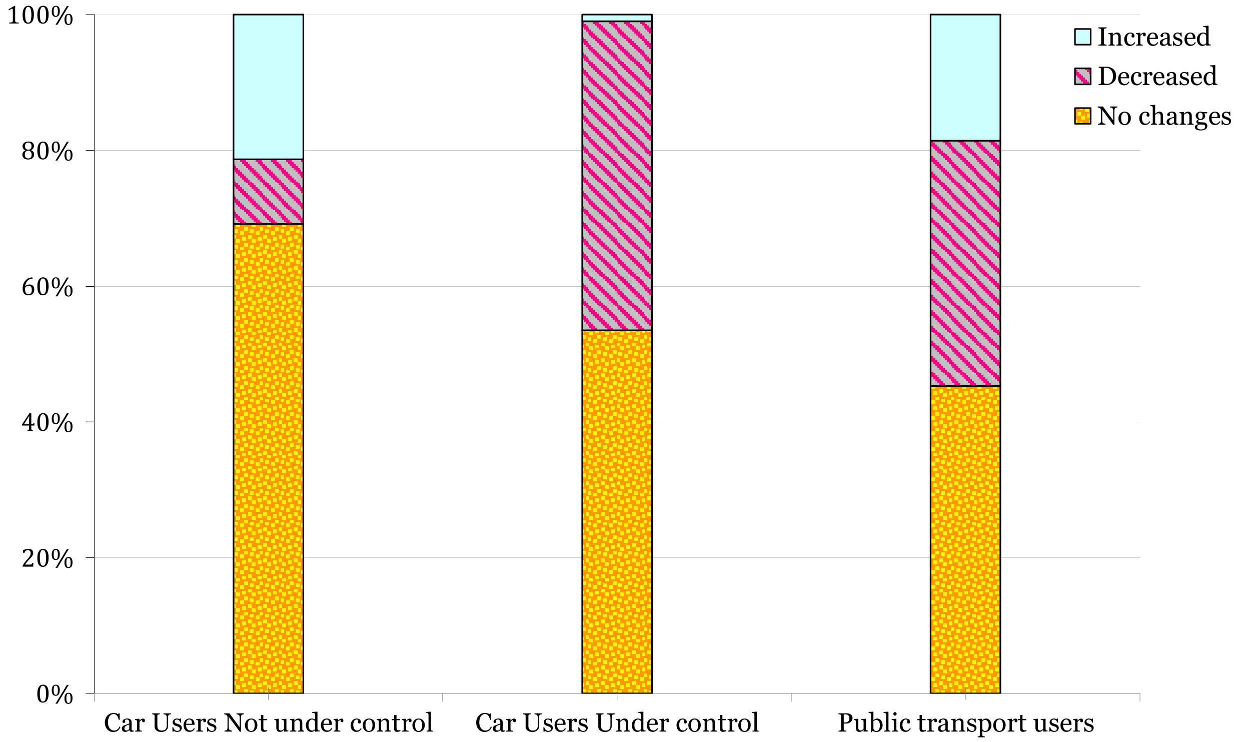
Figure 8-1 Comparison of main travel modes before and during Games time



Source: Database owned by Beijing Transportation Research Center

On trip rate, car users and public transport users changed in different ways as well, but in similar trend as that for travel mode to a certain degree. As compared in Figure 8-2, car users were likely to keep travelling at the same times during days when their vehicles were not under control: about 69.2% of them stated that they neither increased nor decreased daily travel times during that period. However, due to the limitation of car use on certain days, 21.3% of the car users increased their daily travel on the days when their cars were allowed. On the days when their cars were limited by the Odd-even alternate day-off scheme, rarely did car users increase their daily travel, while 54.5% of them reduced the travel times and the rest kept the same. Only 1.0% of all car users increased their daily trips when their cars were not allowed for the roads. On the other hand, public transport users seemed likely to reduce their travel demands during Games time. Though 45.3% of public transport users stated that they had their daily travel at the same frequencies, 36.1% of them reduced their daily travel demands during the Games. We find from the comparisons that both car users and public transport users reduced their travel demands during Games time. However, car users travel demands reduced significantly on the control days and rescheduled certain travels to the days not under control.

Figure 8-2　Comparison of trip rate before and during Games time



Source: Database owned by Beijing Transportation Research Center

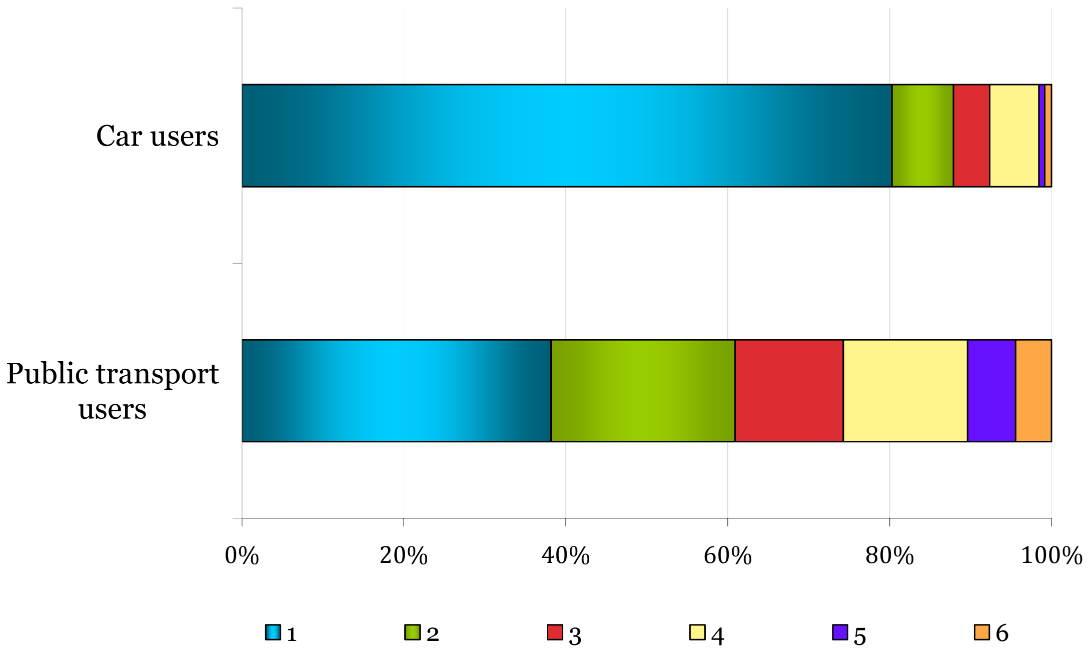
Table 8-1 Chi-squared tests for mode changes

Travellers	Compared periods	Chi²	Sig (2-sided)
Car users	Pre Games compared with Games time (Under control)	821.825[a]	<0.0001
	Pre Games compared with Games time (Not Under control)	16.070[b]	0.007
Public transport users	Pre Games compared with Games time	67.173[c]	<0.0001

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 207.50.
b. 8 cells (66.7%) have expected count less than 5. The minimum expected count is 1.00.
c. 4 cells (22.2%) have expected count less than 5. The minimum expected count is 2.50.
Source: Database owned by Beijing Transportation Research Center

Figure 8-3 shows that car users and public transport users have significantly different opinions on the effectiveness of the Travel Demand Management (TDM) measures. In general, the Odd-even alternate day-off scheme was heavily effective on car users, while public transport users were impacted by other factors, including companies offering different work hours, shops changing business hours, temporary road closures and vacation encouragement. 80.3% of all car users thought the Odd-even alternate day-off scheme was the most effective measure on their daily travels during Games time, while only 38.2% of public transport users felt this impact. Meanwhile, nearly half of the public transport users thought ‘alter work hours’, ‘change business hours of shops’ and ‘temporary road closures’ were more effective than the other measures on their daily travel patterns.

Figure 8-3 Effectiveness of TDM measures



1. Odd-even alternative day-off 2. Alter work hours 3. Changes on business hours of shops
4. Temporary road closure 5. Vacation encouragement 6. Government appeal and public call

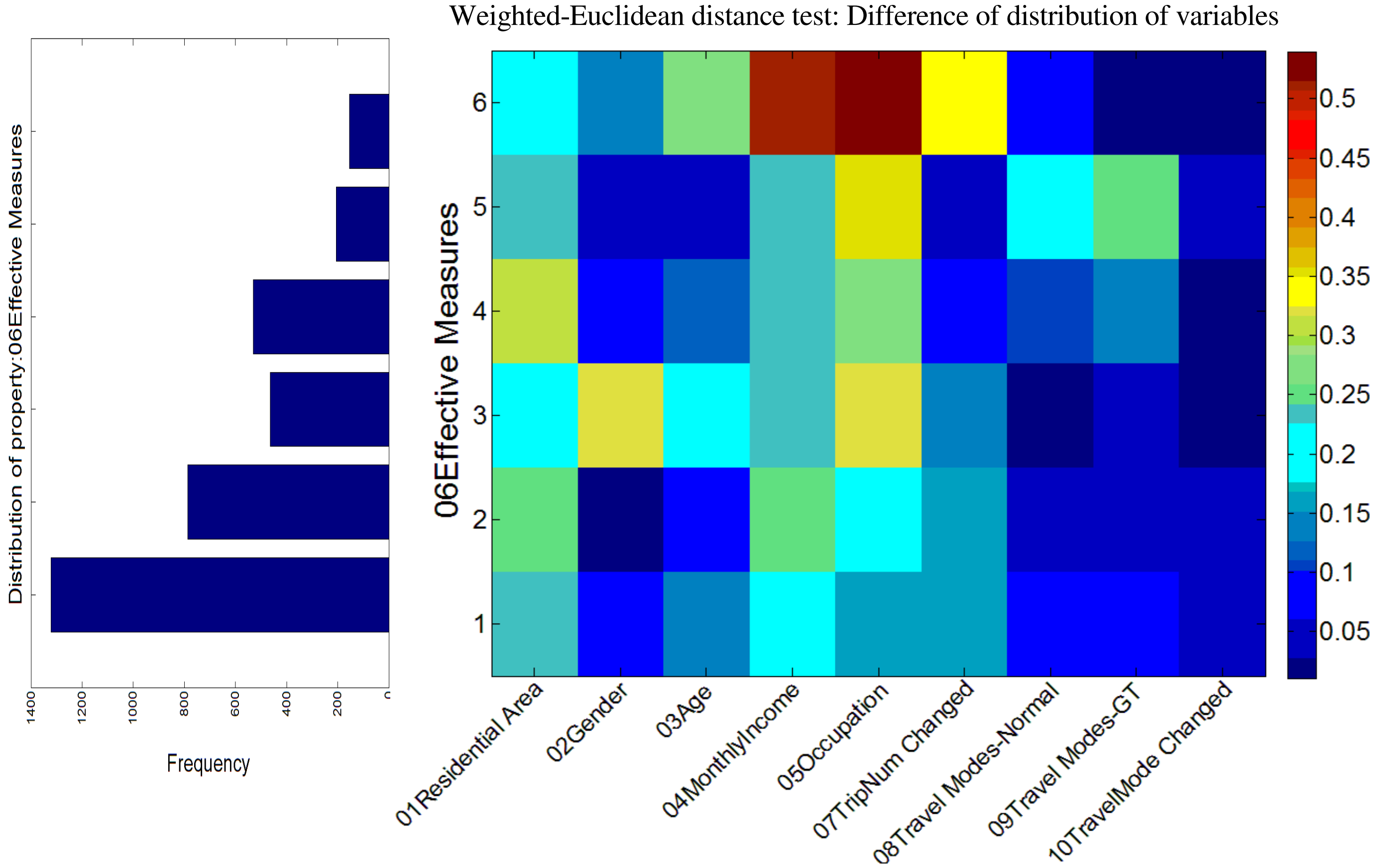
Source: Database owned by Beijing Transportation Research Center

In order to investigate whether some people might have significantly different attitudes on the impacts of Travel Demand Management (TDM) measures from others, we performed the Weighted-Euclidean distance PMF test on the attitudes of effectiveness of TDM measures and travellers' demographic characters for both car users and public transport users below. Sections 8.2 and 8.3 will explore the significant characteristics of people with different opinions on these Travel Demand Management (TDM) measures.

8.3. Public transport users' attitudes on TDM measures

As shown in Figure 8-4, for public transport users, the 'Odd-even alternate day-off scheme' was also one of the most important measures, but travellers' choices appeared more spread out. 'Altered work hours', 'changing business hours of shops' and 'temporary road closures' were also very effective measures impacting people's choice of means for daily travel. Figure 8-4 is the result of the Weighted-Euclidean distance PMF test for public transport users on their opinions on TDM measures, showing that the public transport users with different backgrounds might have different opinions on the effectiveness of TDM measures, which was different from the car users. In particular, the differences between specific groups were mostly highlighted on 'Residential area' and 'Monthly income', followed by 'Gender' and the 'Changes of trip rates'.

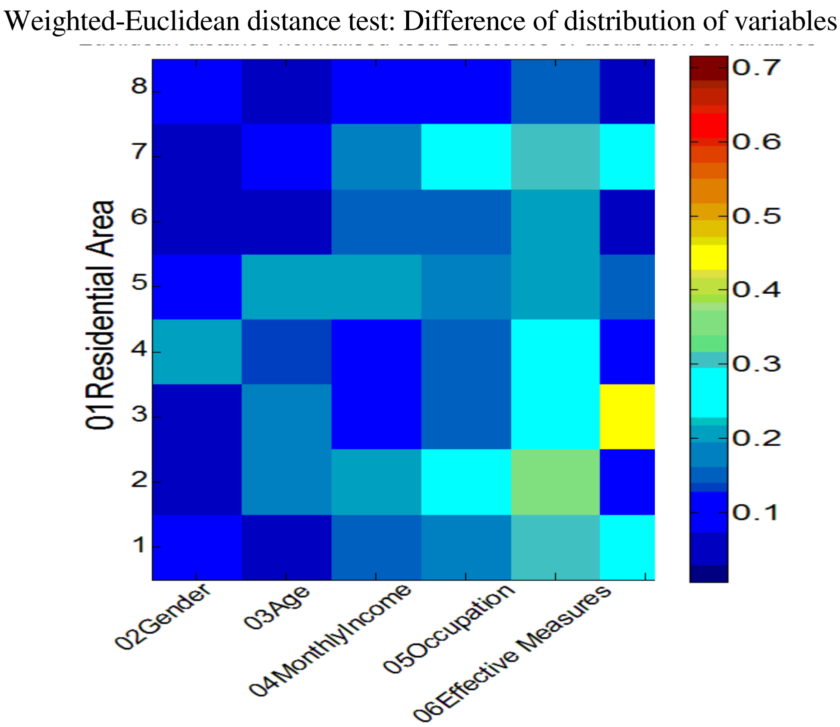
Figure 8-4 Weighted-Euclidean distance PMF test for Attitudes on the effectiveness of TDM measures of public transport users



Effective measures (Y-axis):
1. Odd-even alternate day-off 2. Alter work hours 3. Changes on business hours of shops
4. Temporary road closure 5. Vacation encouragement 6. Government appeal and public call

Firstly, in order to clarify if there was significant concentration in any zones for the demographic characters such as Gender, Age, Monthly income and Occupation, we apply the Weighted-Euclidean distance PMF test for public transport users by residential area. As shown in Figure 8-5, there was no highlight point, which implied that the significances found below in residential area were not due to the differences existing in demographic characteristics.

Figure 8-5 Weighted-Euclidean distance PMF test for Residential area of public transport users



Residential area (Y-axis):

1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;

5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

Figures 8-6 ~ 8-12 show the comparisons for highlighted points in Figure 8-4. As the smallest group (Row 6) in Figure 8-4 includes more than 3% people of all public transport users in the studied sample, the following discussion would take all groups into account to analyze.

1) For those travellers choosing the Odd-even alternate day-off scheme as the most effective measure (Row 1 in Figure 8-4), their Monthly income, Residential area and Trip number changed appeared significantly

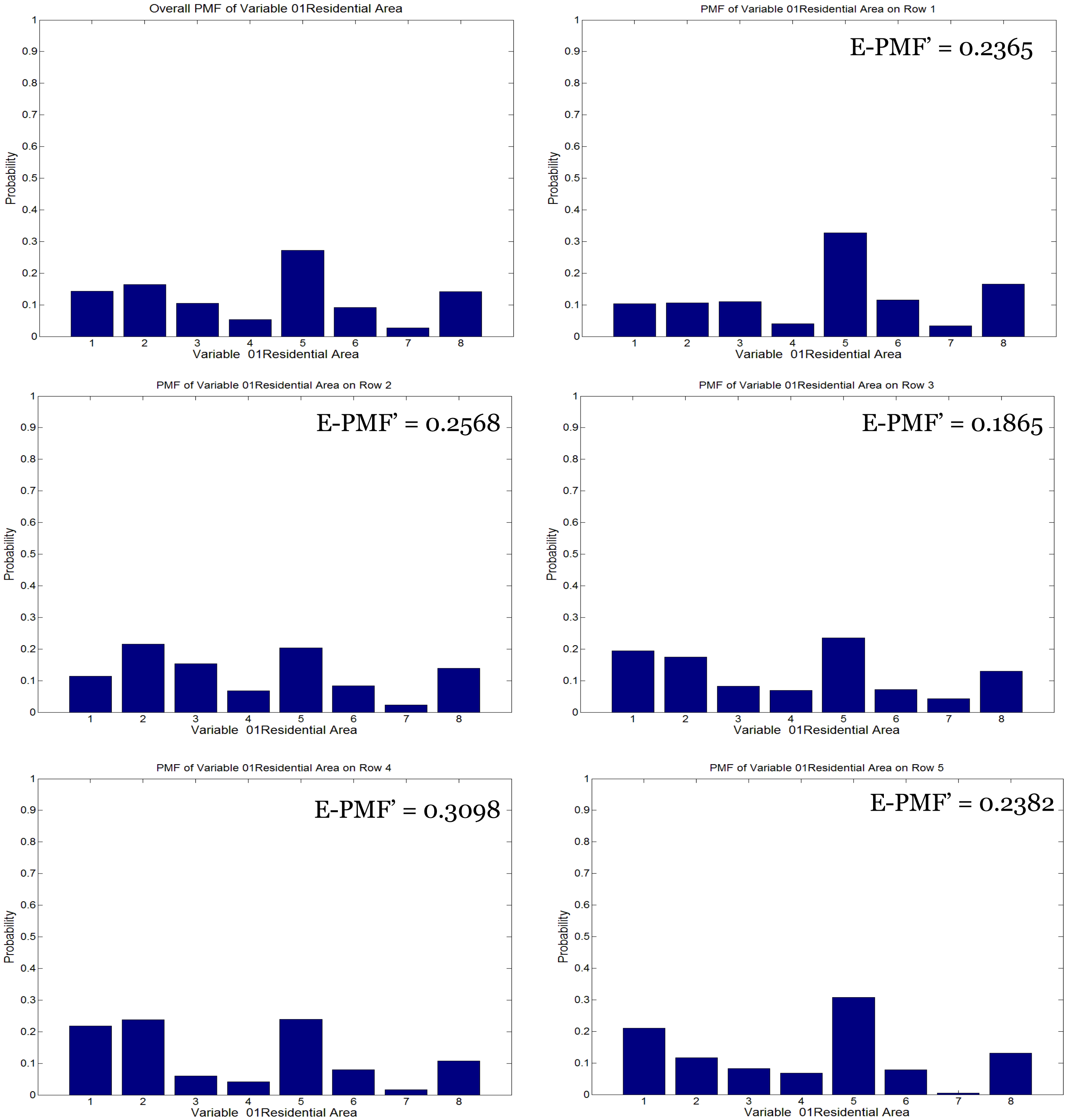
different from others. As compared in Figures 8-6, 8-9 and 8-11, they were normally higher income and living around venue areas. They were more likely than others to increase their daily travel frequencies, because a lot of them believed that the Odd-even alternate day-off scheme was able to cut off certain car use to free the space on the roads.

2) For the travellers who believe 'Alter work hours' provided the most impact to their daily travel (Row 2 in Figure 8-4), they earned a lower income than the people selecting the 'Odd-even alternate day-off scheme' and are more concentrated in Zone 2, 3, and 4, where a lot of local Beijing residents lived and government offices are located. As people in this group were mostly focussed on optimizing their travel schedules, other than changing travel demands, their travel frequencies appeared more likely to stay the same as before as seen from Figure 8-11.
3) For travellers who thought 'Change business hours of shops' was most effective to them (Row 3 in Figure 8-4), their Gender, Monthly income and Occupation seemed very different from the others as shown in Figure 8-4. As compared in Figure 8-7, female residents were more likely to acknowledge this impact than males, because the women did more shopping and were more sensitive to this. Meanwhile, people with lowest income (monthly income=1) were more impacted by this measure than others, as shown in Figure 8-9. On the comparison for the occupation in Figure 8-10, Professional staff (Occupation=3) and Private enterprise owners (Occupation=4) were less impacted by the change of shop's business hours, while normal agency staff (Occupation = 5) and students (Occupation = 8) stated to be more effected.
4) Travellers who were concerned with 'Temporary road closure' most (Row 4 in Figure 8-4) appeared significantly different in Residential area, Monthly income and Games time travel method. People living in areas such as Zones 1 and 2, which were crowded with official accommodation sites and Olympic lanes, were more sensitive to this measure. From Figure 8-12, we also see that people using public buses for travelling were more affected by this measure than those travelling by subway. Some

temporary road closure might cause the bus journeys to become much longer.

5) Travellers who chose ‘Vacation encouragement’ as the most effective measure appeared to concentrate in Zone 1, where many government offices and stated-owned companies are located. From Figure 8-9, we see that travellers with lower income might be more likely to consider vacations. Figure 8-10 shows that Government officials (Occupation=2) and Stated-owned company staff (Occupation=9) were more likely to take vacations during Games time, which properly reflect the significance found in residential areas.
6) Facing the government’s appeal and public call, people responded differently as well. As compared in Figures 8-6~10, people living in Zone 1 were more likely to take this into consideration. It might be because Zone 1 was heavily concentrated with government offices and stated-owned companies. They did a lot of work in communicating and educating their employers with the government’s appeal on sustainable travel styles during Games time. This was also reflected in Figure 8-10, that the Government officials (Occupation=2) were more likely to respond. Meanwhile, students (Occupation=8) and the retired people (Occupation=11) were also very positive on this measure, which is also evident in the comparison by age in Figure 8-8. Figure 8-7 shows that males were more likely to pay attention to this measure.

Figure 8-6 Comparison of $PMF_{specific\ group=1,\ 2,\ 3,\ 4,\ 5,}$ and $PMF_{overall}$ of Variable **Residential area** for public transport users



Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

Figure 8-7 Comparison of $PMF_{specific\ group=3,\ 6,}$ and $PMF_{overall}$ of Variable **Gender** for public transport users

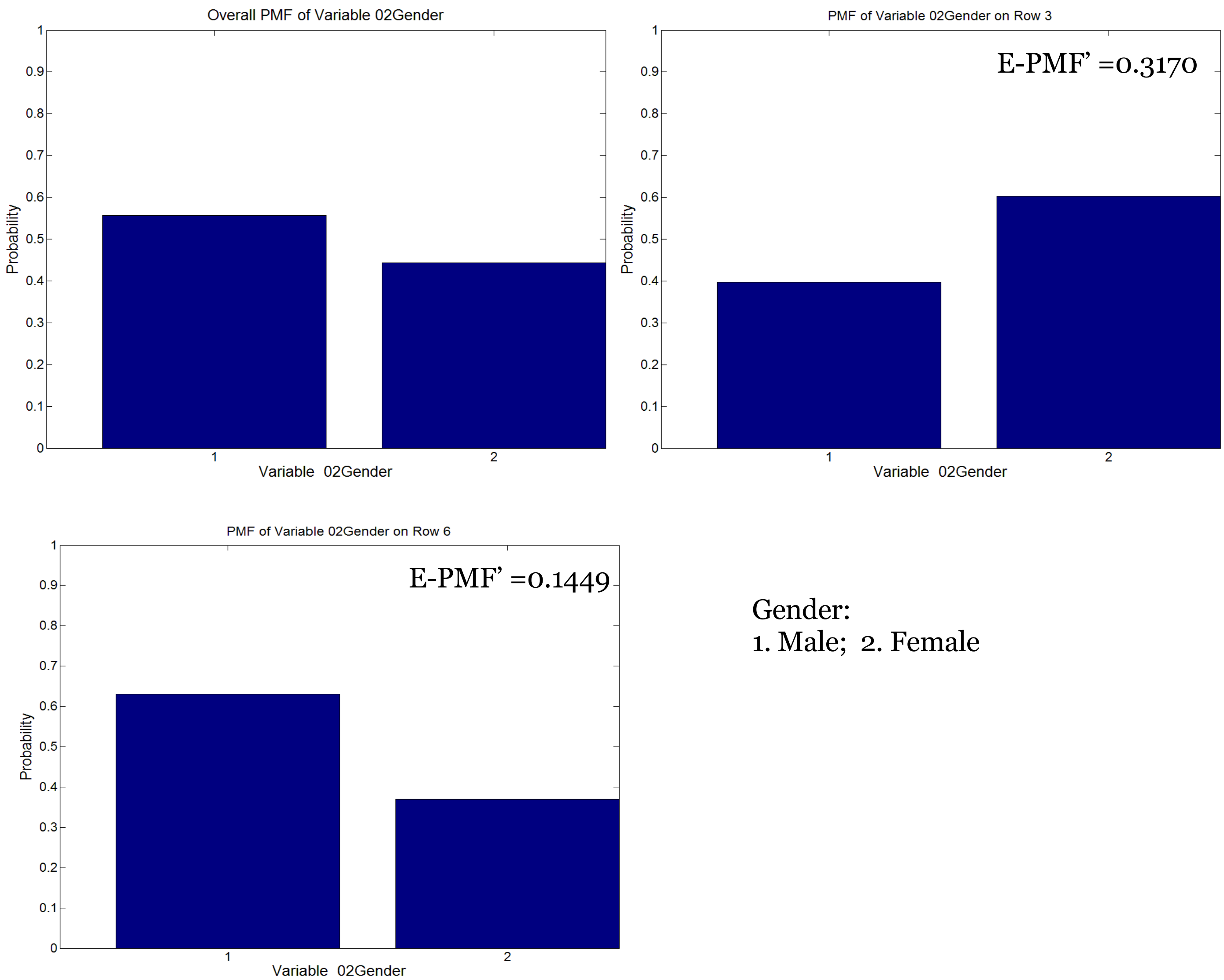
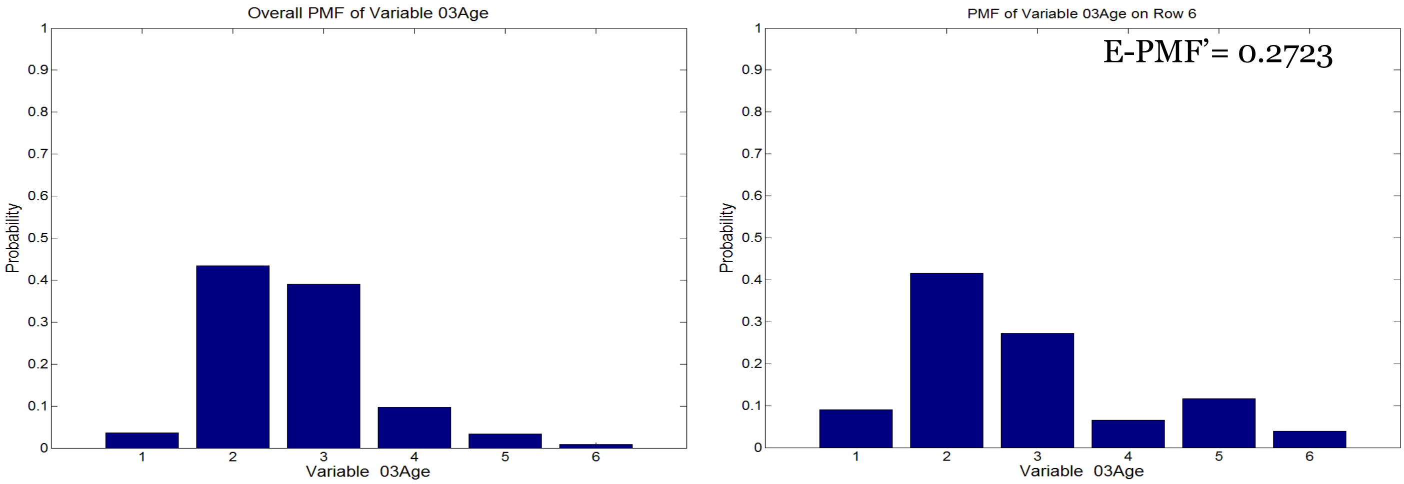
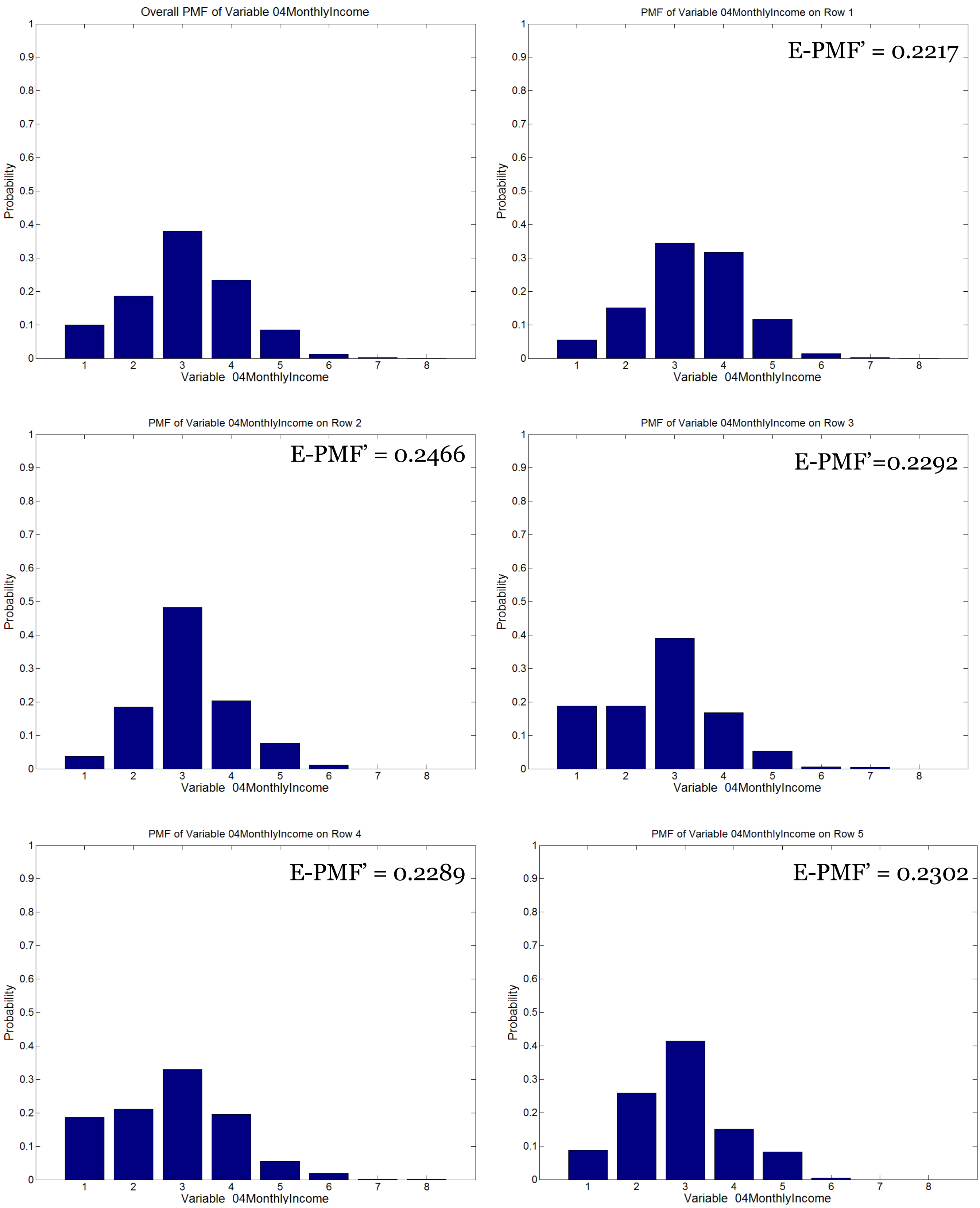


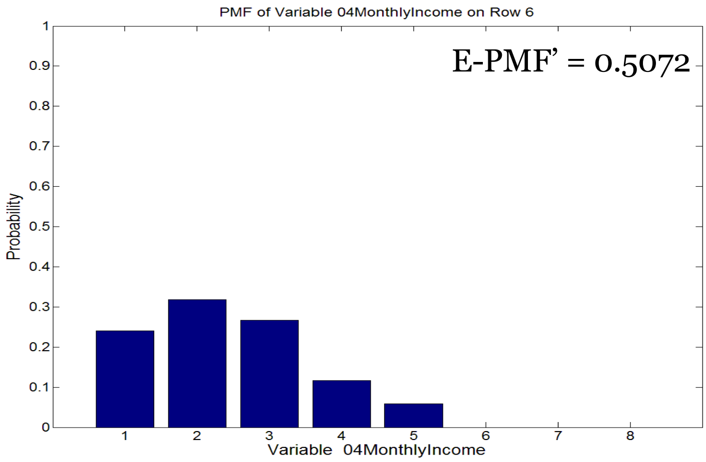
Figure 8-8 Comparison of $PMF_{specific\ group=6}$ and $PMF_{overall}$ of Variable **Age** for public transport users



Age (years):
1. 0-14; 2. 15-24; 3. 25-34; 4. 35-44; 5. 45-54; 6. 55-64; 7. 65-74; 8. 75+

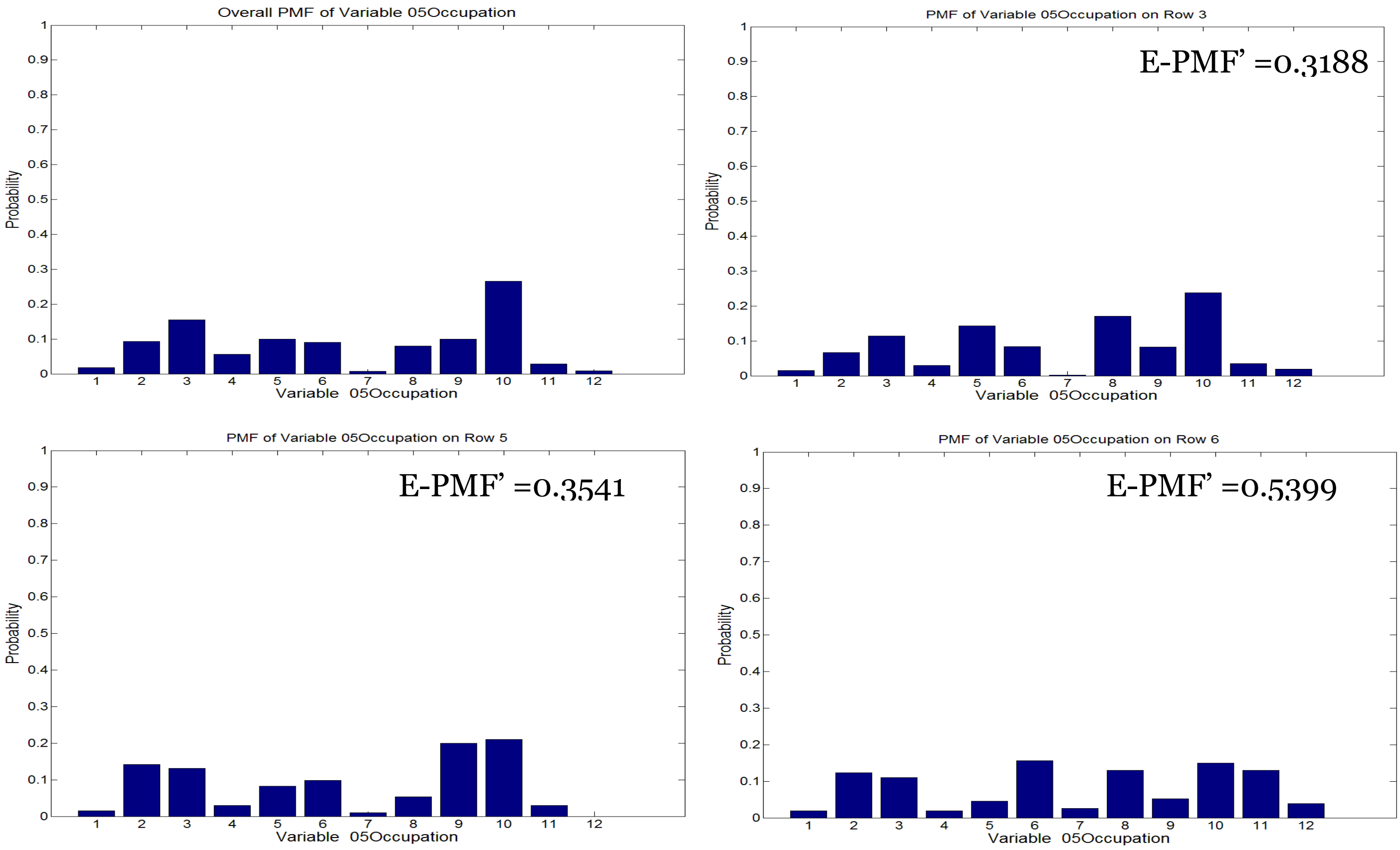
Figure 8-9 Comparison of $PMF_{specific\ group=1,\ 2,\ 3,\ 4,\ 5,\ 6}$ and $PMF_{overall}$ of Variable **Monthly income** for public transport users





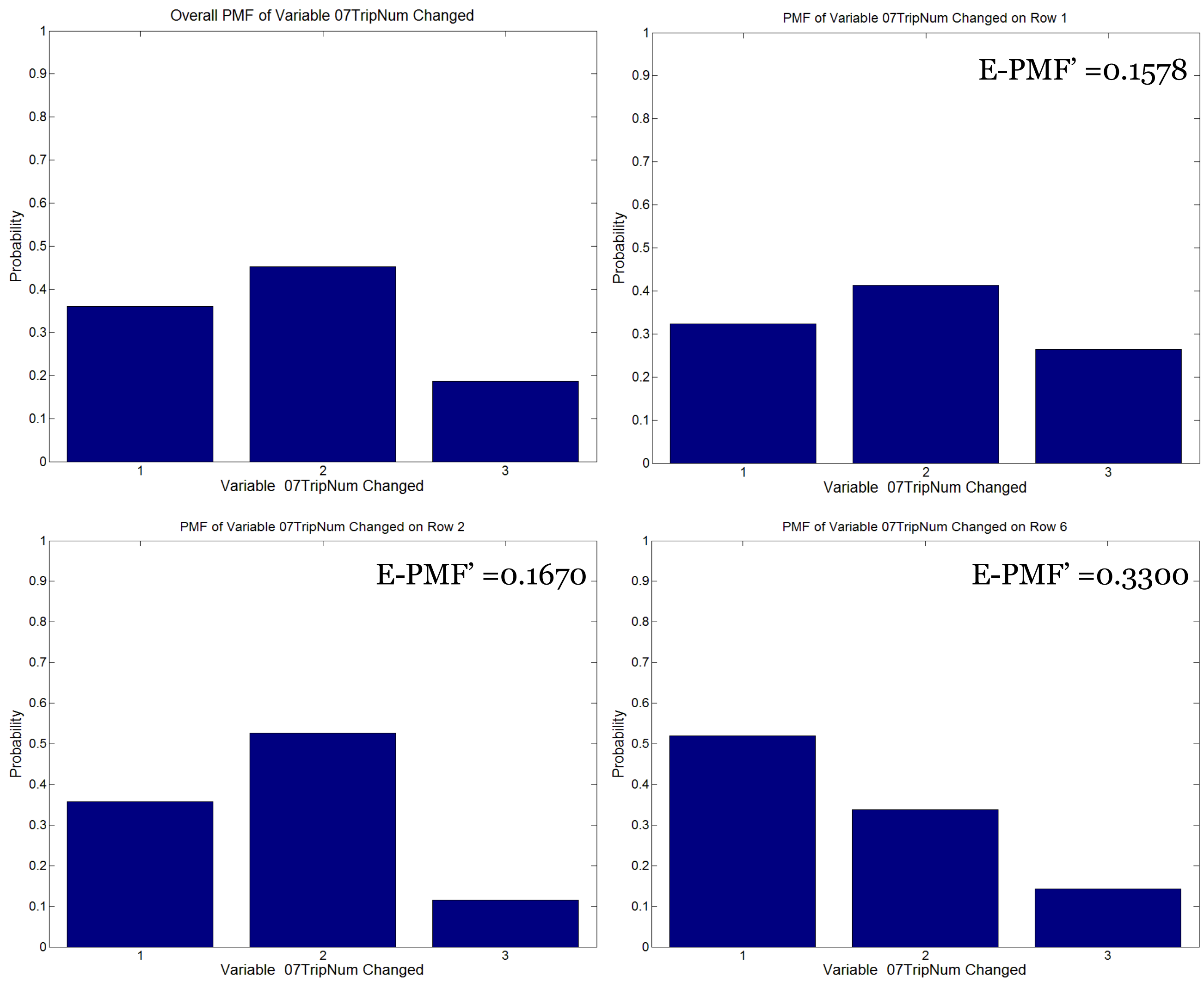
Monthly income (RMB):
1. <1500; 2. 1501-2500;
3. 2501-3500; 4. 3501-5500;
5. 5501-10000; 6. 10001-20000;
7. 20001-30000; 8. >30001

Figure 8-10 Comparison of $PMF_{\text{specific group}=3,5,6}$ and PMF_{overall} of Variable **Occupation** for public transport users



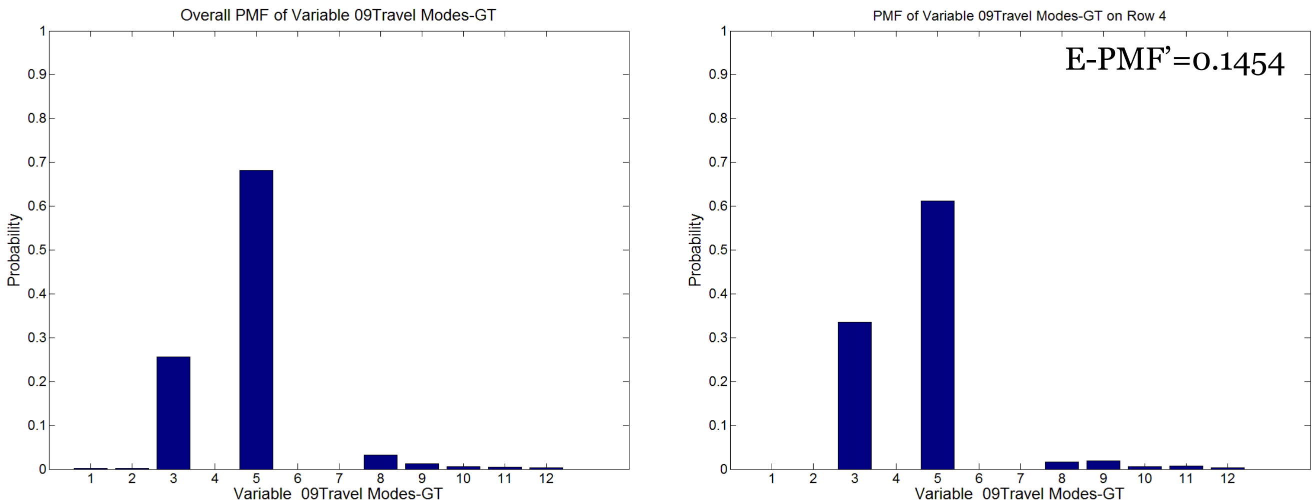
Occupation:
1. Factory/Construction worker; 2. Scientist/Researcher; 3. Office-based staff;
4. Government Official; 5. Heathcare staff; 6. Teacher; 7. Student; 8. Waiter/Waitress;
9. Self-employer; 10. Retired; 11. Driver; 12. Farmer; 13. Soldier/Police;
14. Public bus/Underground/Taxi Driver; 15. Unemployed

Figure 8-11 Comparison of $PMF_{specific\ group=1,\ 2,\ 6}$ and $PMF_{overall}$ of Variable **Trip number changed** for public transport users



Change of Trip rates of public transport users between pre-Games and Games time:
1. Decreased; 2. No change; 3. Increased

Figure 8-12 Comparison of $PMF_{specific\ group=4}$ and $PMF_{overall}$ of Variable **Primary travel mode during Games time** for public transport users



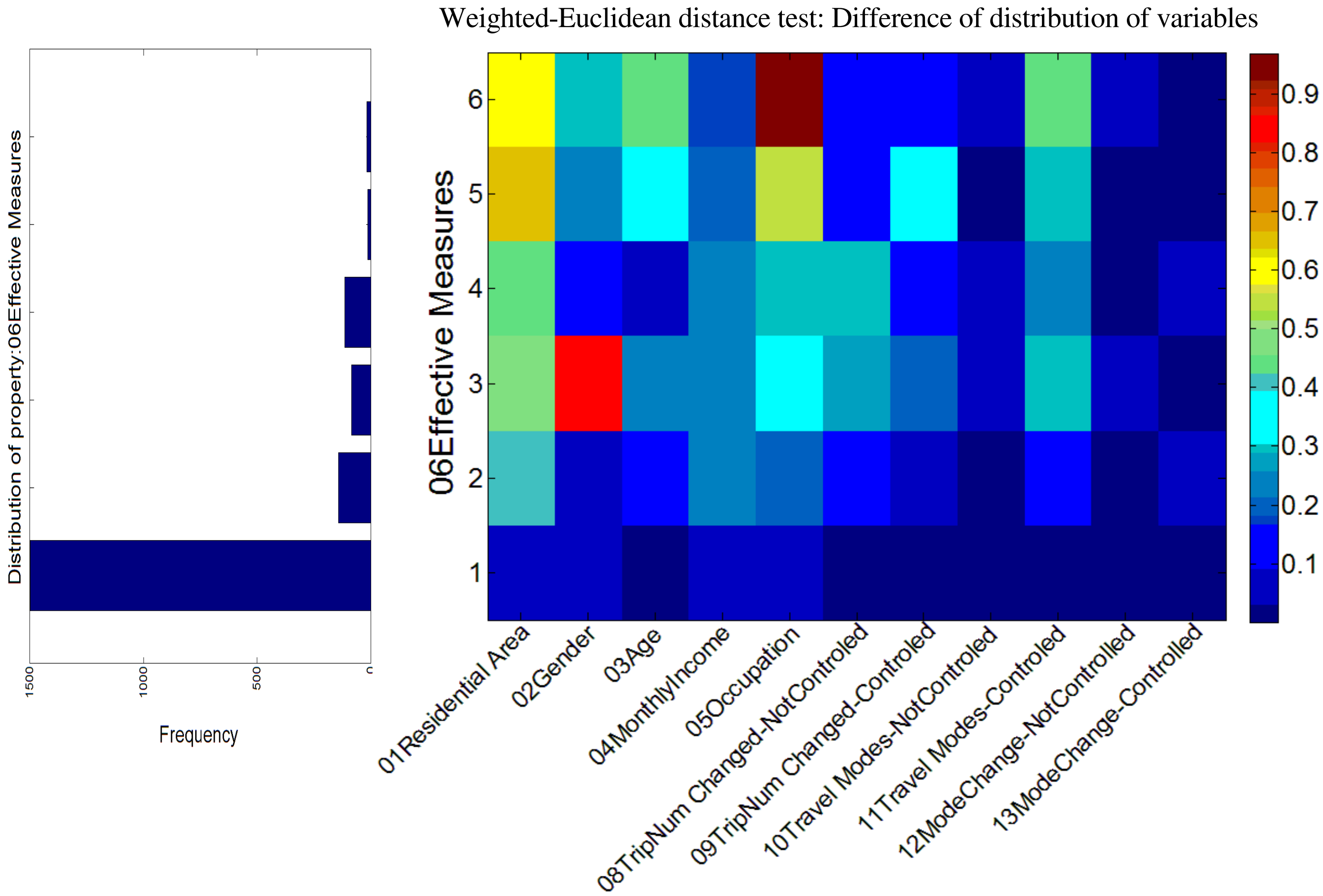
Games time primary travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus;
6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger); 12. Non-private car (drive)

As discussed earlier, the changes in trip number were compared for public transport users by their attitudes towards Travel Demand Management (TDM) measures in Figure 8-11. Public transport users who thought the Odd-even alternate day-off scheme was the most effective measure to their Games time daily travel might increase their travel demands compared to others. However, those travellers who were positive to the government's appeal and public calls were very likely to reduce their daily travel frequencies as shown in Figure 8-11.

8.4. Car users' attitudes on TDM measures

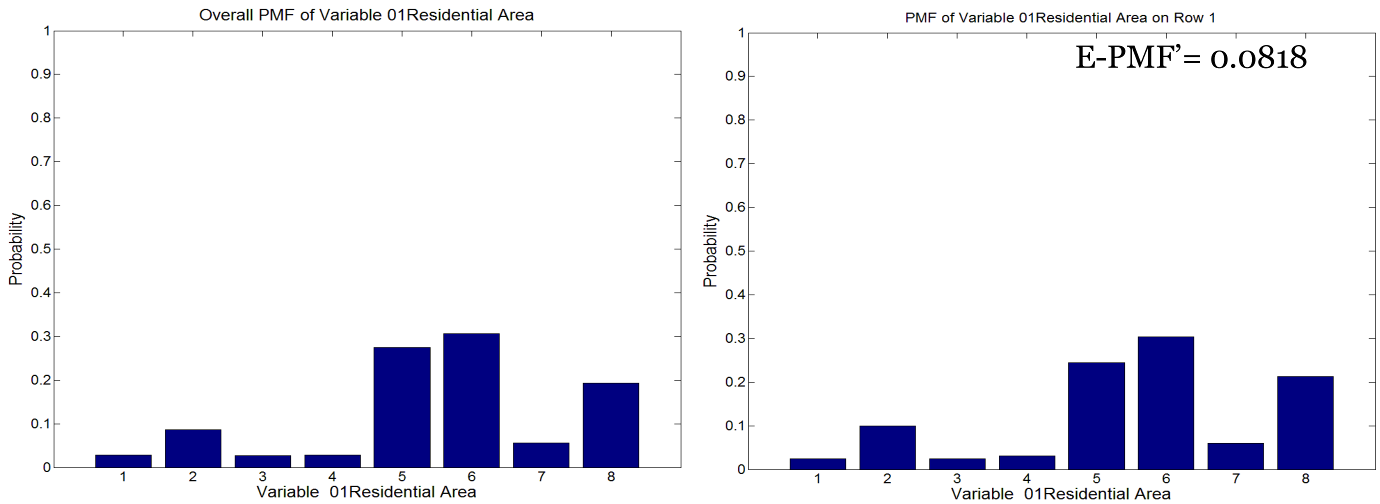
For the car users, the 1st measure (Odd-even alternate day-off scheme) was the most effective, receiving a share of 80.3%. Car users with nearly all different backgrounds agreed to this assertion. The Weighted-Euclidean distance PMF test results in Figure 8-13 show that there was no significant highlighted characteristic of the car users on Row 1. In other words, most car users, no matter what demographic profile, thought the Odd-even alternate day-off scheme was the most impactful measure on their daily travel.

Figure 8-13 Weighted-Euclidean distance PMF test for Attitudes on the effectiveness of TDM measures of car users



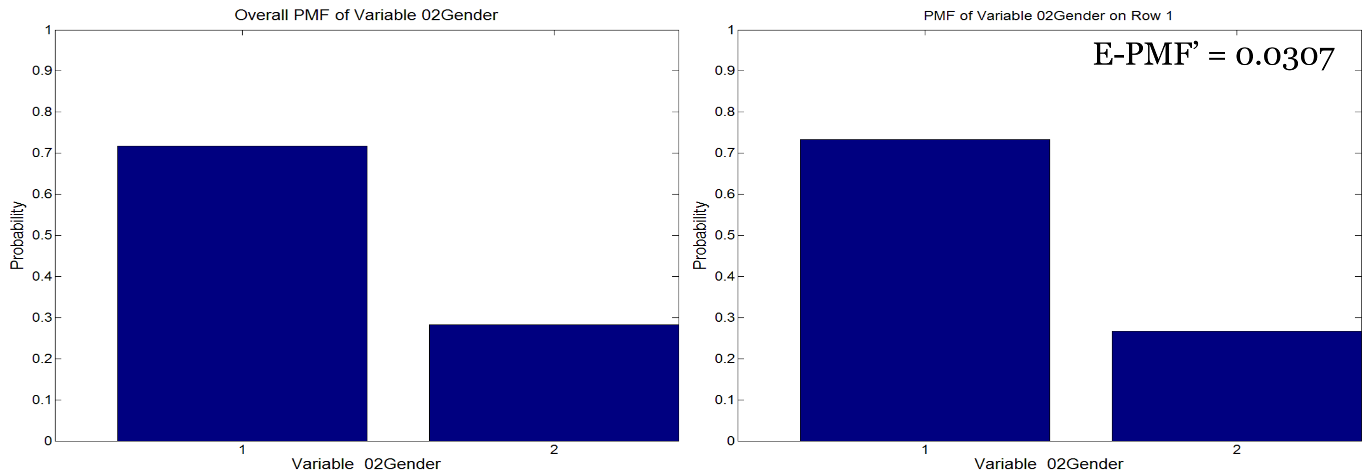
Effective measures (Y-axis):
1. Odd-even alternate day-off 2. Alter work hours 3. Changes on business hours of shops
4. Temporary road closure 5. Vacation encouragement 6. Government appeal and public call

Figure 8-14 Comparison of $PMF_{specific\ group=1}$ and $PMF_{overall}$ of Variable **Residential area** for car users



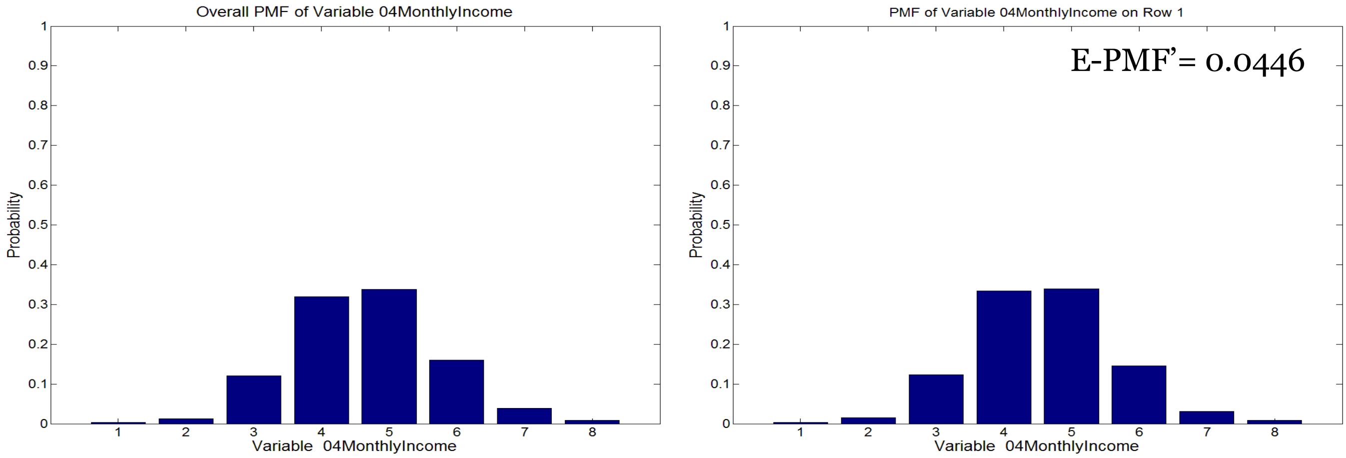
Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

Figure 8-15 Comparison of $PMF_{specific\ group=1}$ and $PMF_{overall}$ of Variable **Gender** for car users



Gender:
1. Male; 2. Female

Figure 8-16 Comparison of $PMF_{specific\ group=1}$ and $PMF_{overall}$ of Variable **Monthly income** for car users



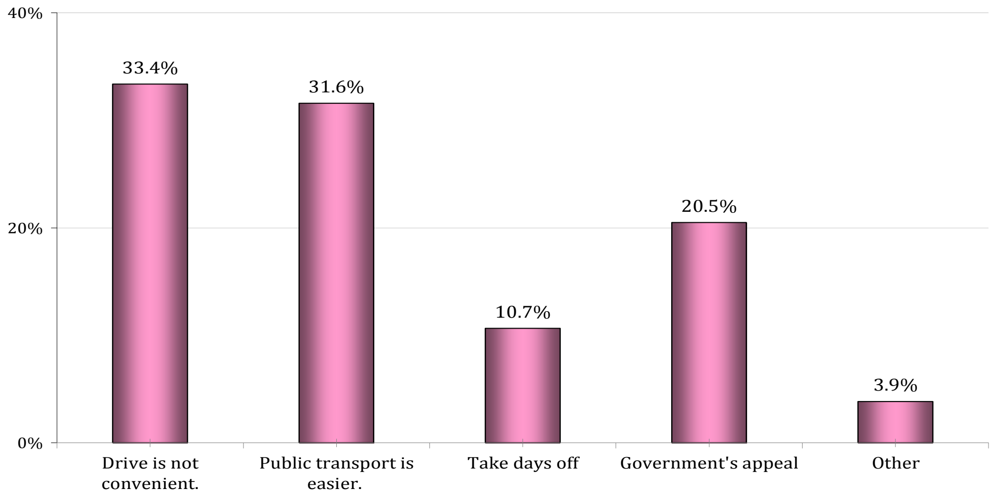
Monthly income (RMB):
1. <1500; 2. 1501-2500; 3. 2501-3500; 4. 3501-5500; 5. 5501-10000;
6. 10001-20000; 7. 20001-30000; 8. >30001

Figures 8-14~16 show the comparisons for those highlighted points on Row 1 respectively, which are Residential area, Gender, and Monthly income. From the comparisons, we see that the differences in PMF distribution are very small.

8.5. Reasons for not using cars

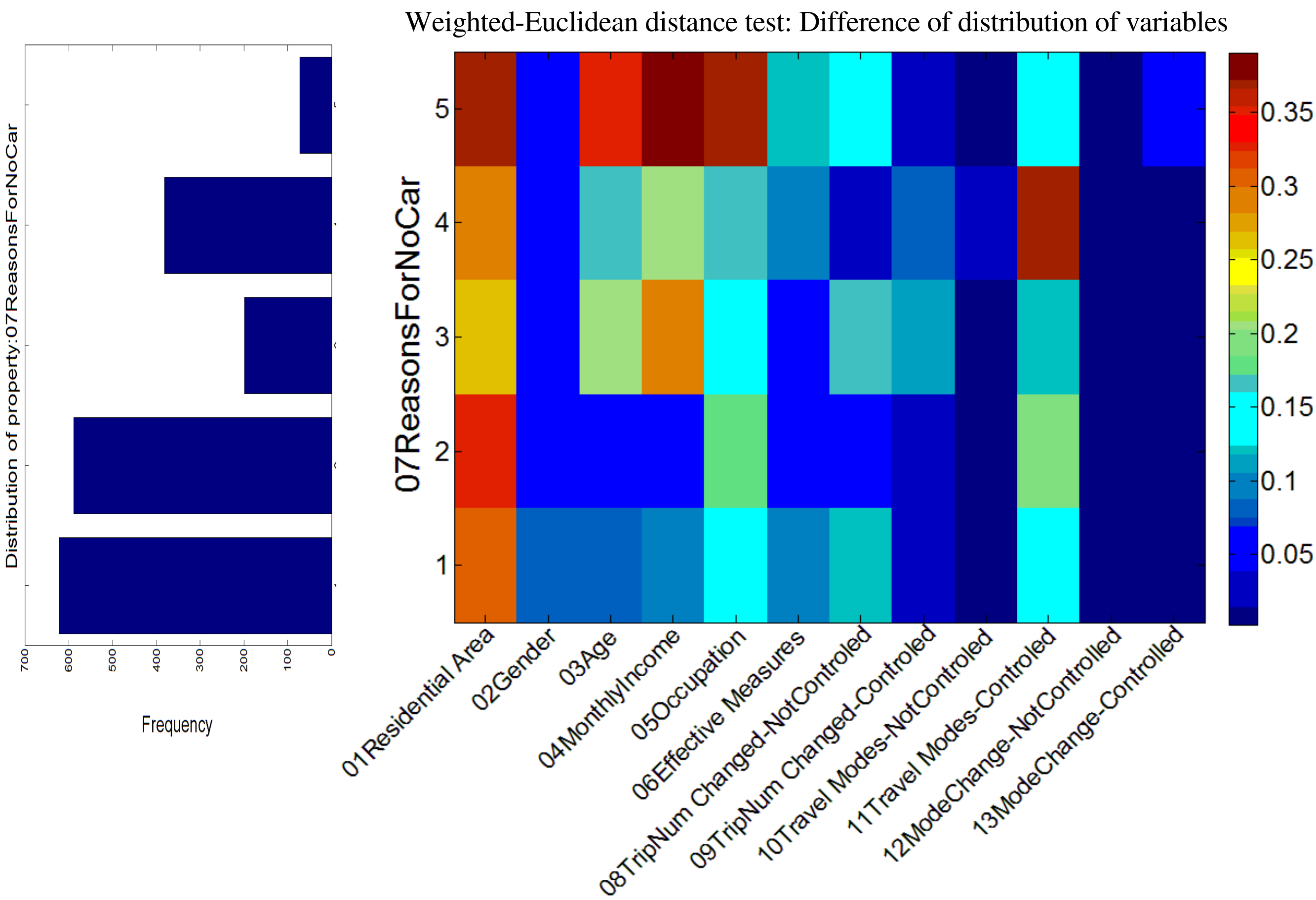
The supplementary survey also investigated for what reason the car users might give up using cars when their vehicles were allowed on the roads during Games time. 'Driving is inconvenient' and 'public transport is easier' were the main factors, while 20.5% of car users stated that it might be because of the 'government's appeal', as shown in Figure 8-17.

Figure 8-17　Reasons for not using cars



Source: Database owned by Beijing Transportation Research Center

Figure 8-18　Weighted-Euclidean distance PMF test for Reasons for not using cars

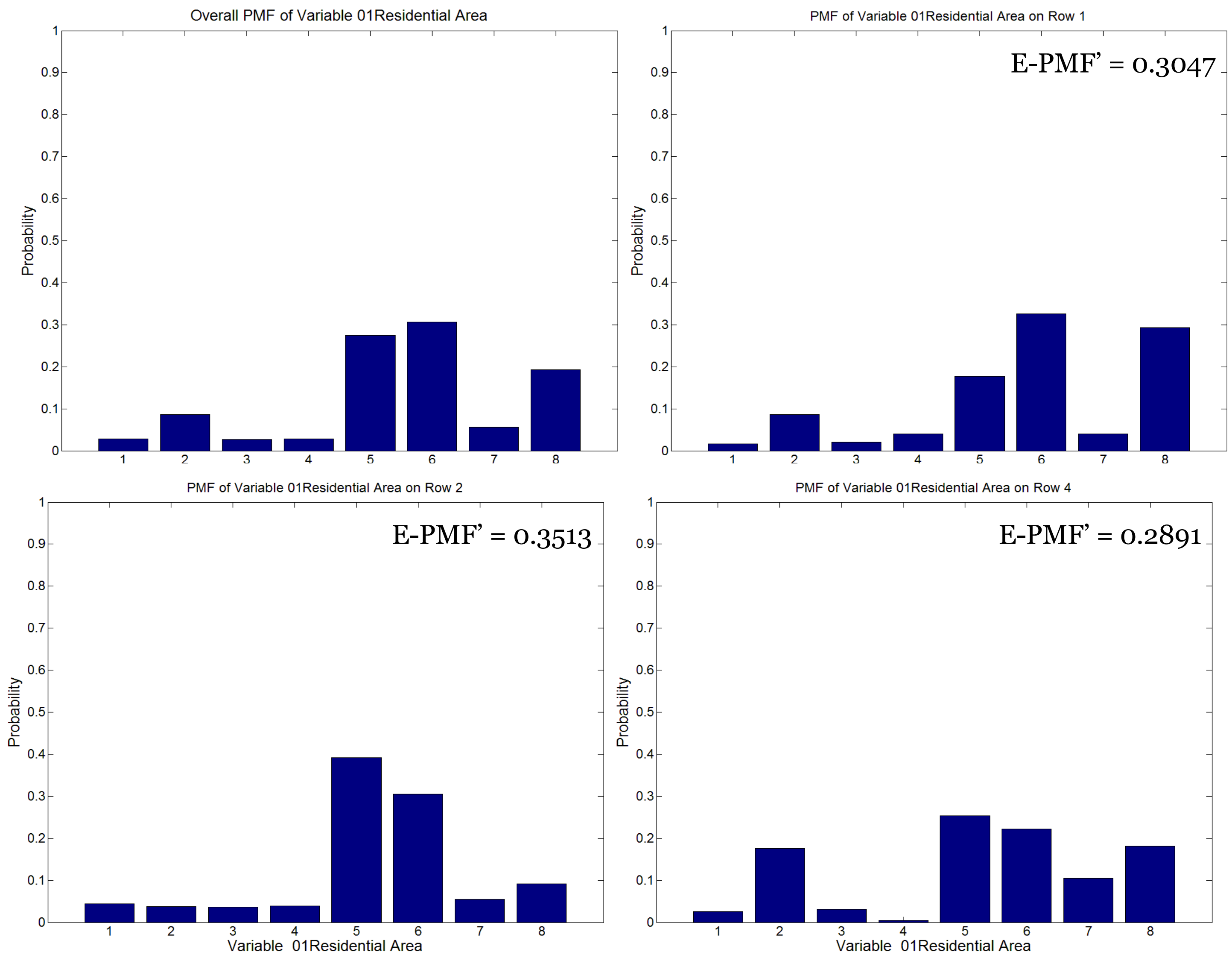


Reasons for not using car (Y-axis):
1. Drive is not convenient　2. Public transport is easier　3. Take days off
4. Government's appeal　5. Other

From the result of the Weighted-Euclidean distance PMF test in Figure 8-18. We see that these characteristics show significance: 'Residential area', 'Monthly income', 'Effective measures', 'Trip rate changes on Non-controlled days for car users' and 'Travel modes on the controlled days for car users', with the E-PMF' values greater than 15%. By comparison, we can find that:

1) Most people who felt driving was inconvenient usually thought the 'Odd-even alternate day-off scheme' was the most impactful measure for their daily travels, as shown in Figure 8-21. After their cars were banned on the nominated days, they might continue to go without due to the inconvenience of using cars during Games time. They appeared to prefer taxi over other means as compared in Figure 8-23.
2) People who felt public transport was easier than using cars usually lived in areas with good public transport network and preferred to use public buses as the alternative.
3) People who reduced car use due to taking holiday earned higher monthly income than the average, as shown in Figure 8-20. They also reduced their trip rates as seen from Figure 8-22.
4) People who gave up cars because of the governments' appeal tend to live in central areas and earned a higher monthly income, which was different from those of public transport users. As discussed in Section 8.2 and Figure 8-9, the public transport users who supported the governments' appeals earned slightly lower income than others. It can be seen from Figure 8-18 that people who would like to give up using cars as a response to the government's appeal appeared to be significantly different in travel mode on the controlled days. Figure 8-21 shows that they were more likely to use subway than others.

Figure 8-19 Comparison of $PMF_{specific\ group=1,\ 2,\ 4}$ and $PMF_{overall}$ of Variable **Residential area** for car users



Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

Figure 8-20 Comparison of $PMF_{specific\ group=3,\ 4}$ and $PMF_{overall}$ of Variable **Monthly income** for car users

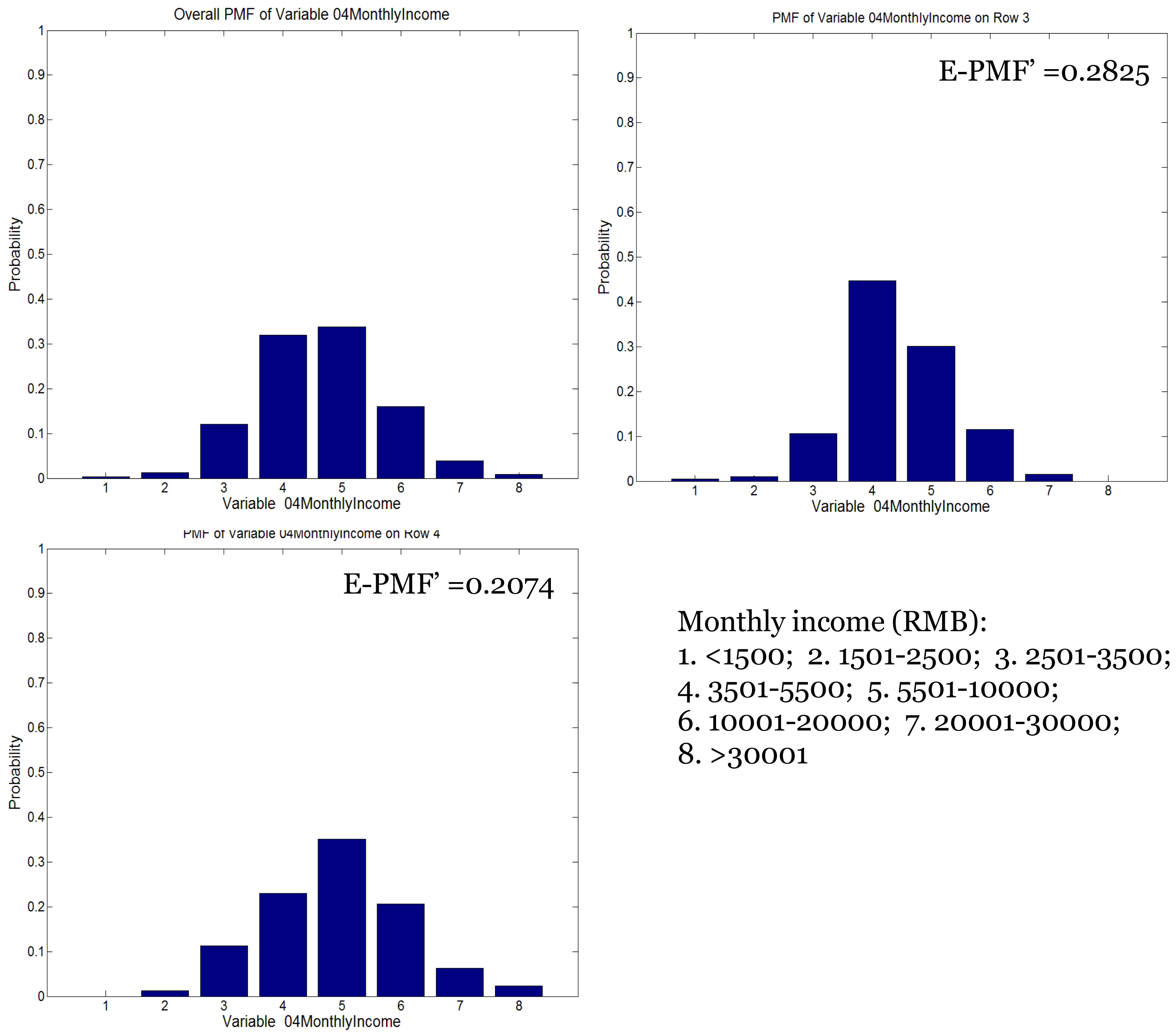


Figure 8-21 Comparison of $PMF_{specific\ group=1,2,3,4}$ and $PMF_{overall}$ of Variable **Effective measures** for car users

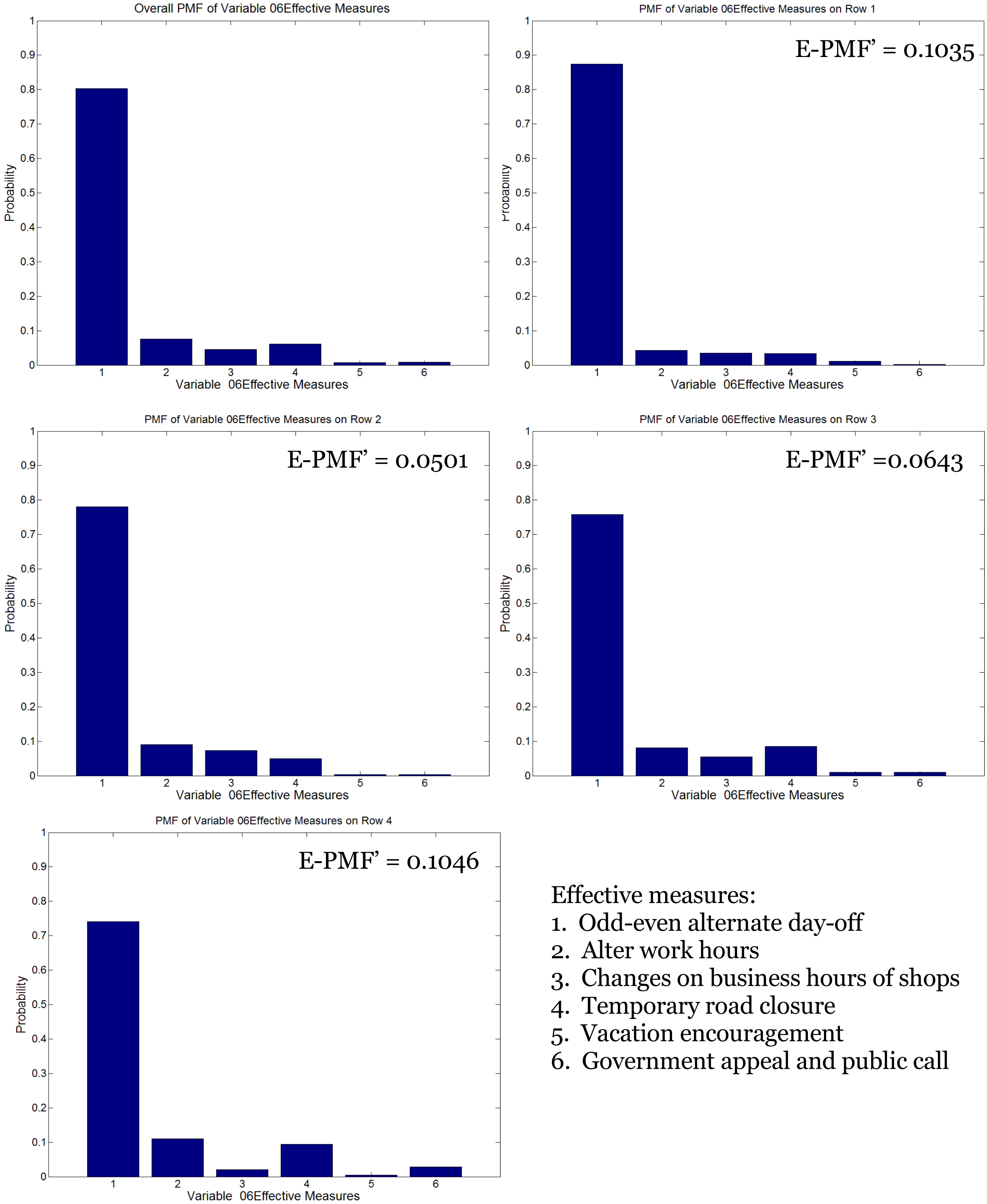
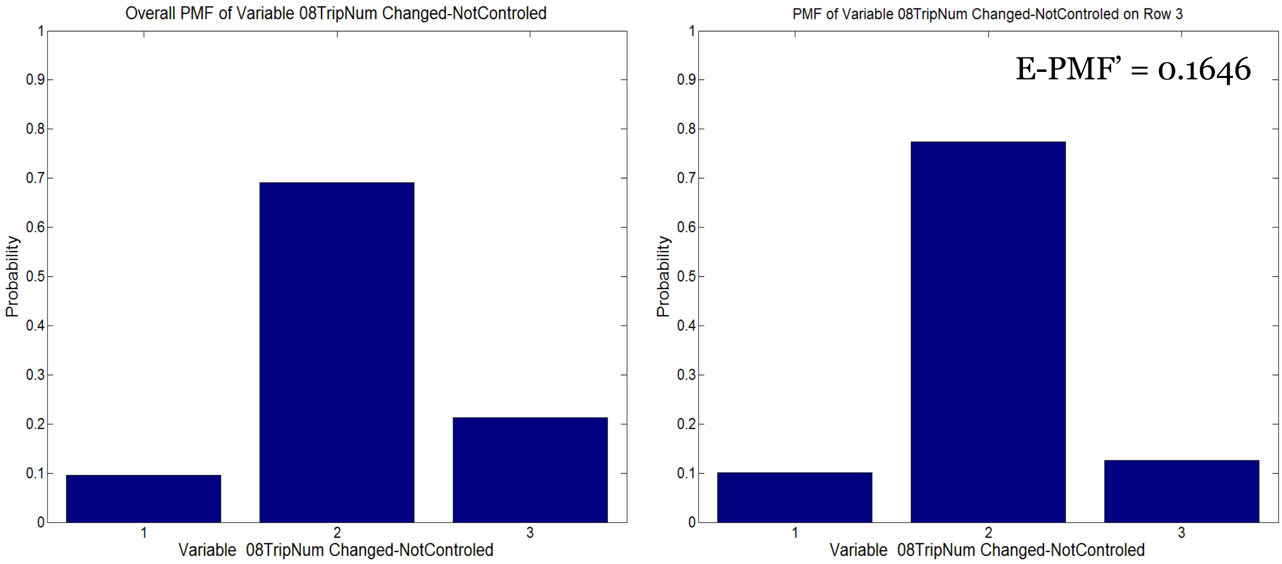
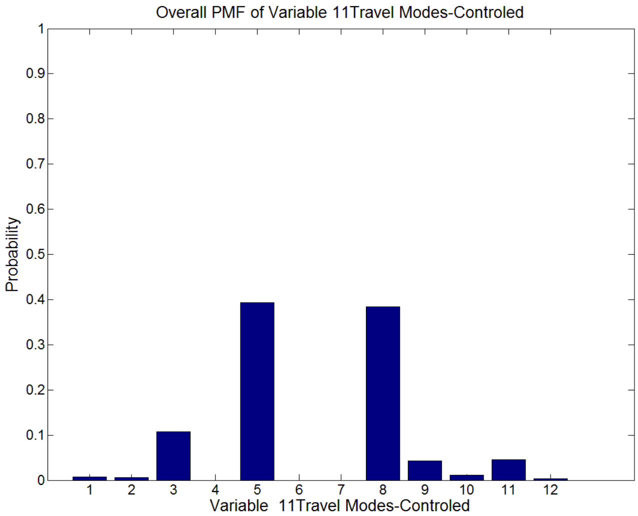


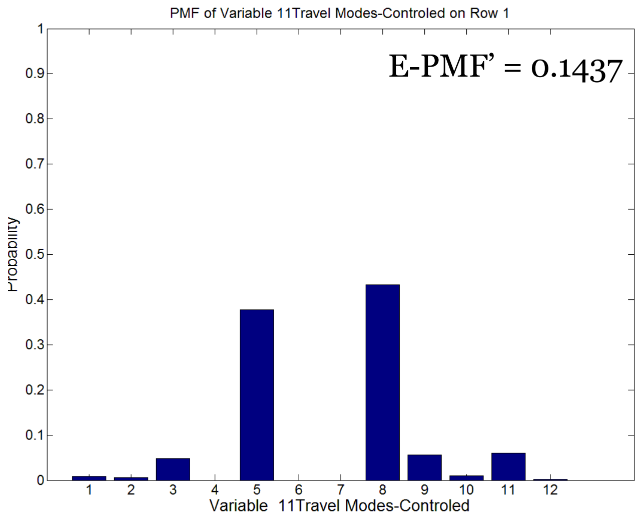
Figure 8-22 Comparison of $PMF_{specific\ group=3}$ and $PMF_{overall}$ of Variable **Trip rate changes on Non-controlled days** for car users

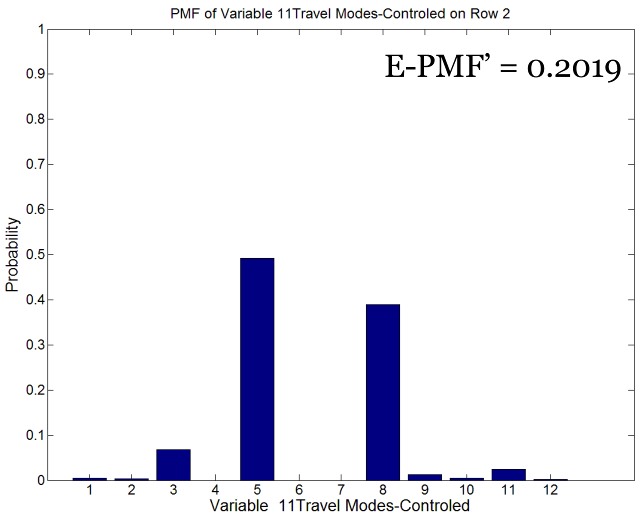


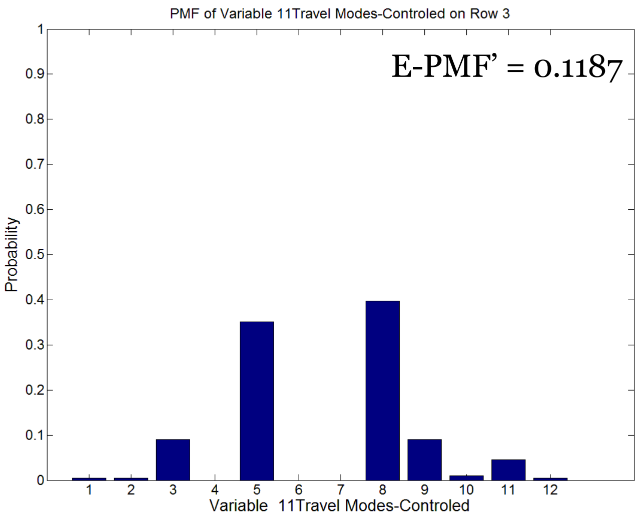
Change of Trip rates on Non-controlled days during Games time:
1. Decreased; 2. No change; 3. Increased

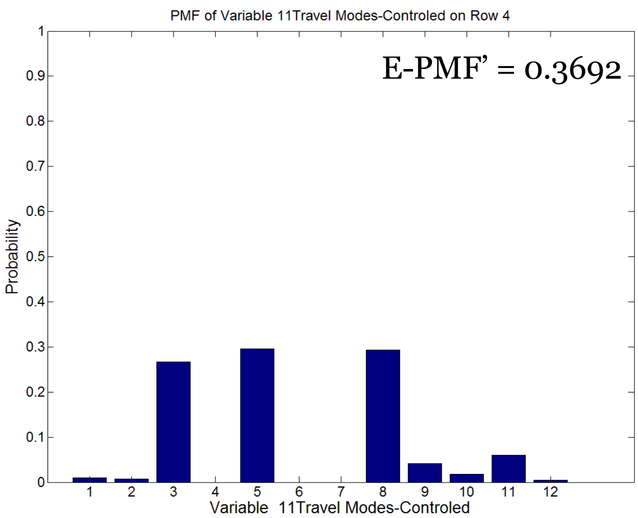
Figure 8-23 Comparison of $PMF_{specific\ group=1,2,3,4}$ and $PMF_{overall}$ of Variable **Travel modes on the controlled days** for car users











Travel modes on the controlled days for car users:

1. Walk only; 2. Cycle; 3. Subway;
4. Mix use of public transport; 5. Bus;
6. Car+Public transport 7. Private+Company Cars;
8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Non-private car (drive);
13. Non-private car (passenger)

8.6. Discussion

This chapter focused on the impacts of Olympic Travel Demand Management (TDM) measures on public transport passengers and car users during Games time. The comparisons showed that the Olympic related Travel Demand Management (TDM) measures affected these two groups of travellers differently, which can be summarized as below:

1. The Odd-even alternate day-off scheme was much more effective on the car users' daily travel than on public transport passengers. This was not only indicated in the survey on respondents' opinions on the measures, but also found in their actual behaviour changes.

   Public transport passengers reduced their travel demands to a certain extent, but their changes were significantly smaller than car users during Games time.

   For car users, on the days when their cars were banned, most of them were observed to resort to other travel means in addition to reducing travel frequencies. On the days when car use was allowed, car users were found to stay with the same travel patterns as before with the same travel frequencies and same travel methods.
2. From the comparisons, public transport passengers with different characteristics in 'Residential area', 'Monthly income', 'Gender' and 'Changes of trip rates' appeared significant in opinions towards the Travel Demand Management (TDM) measures during Games time.
3. Meanwhile, most car users indicated that they were significantly impacted by the 'Odd-even alternate day-off scheme', regardless of demographic profile.
4. Convenience was the main point for the car users to decide whether to drive during Games time, even if they had the access to the car use. The governments' appeal also appeared effective on people's choices on travel means. Furthermore, people with different thoughts on the Travel demand management (TDM) measures made different choices for the alternative travel modes.

Chapter 9

DATA ANALYSIS: FORECASTING THE BEHAVIOUR CHANGES

As discussed in Chapter 3, forecasting the short-term and long-term pressures and behaviour changes in transport have been a critical issue for previous Games. Quite a few people were observed to use a different travel means rather than what they indicated before the Games. This chapter compares the travel patterns indicated before the Games and residents' actual behaviour changes during the Games or after, to understand the differences between the forecast and actual behaviours changes.

9.1 Forecast the changes for Games time travel patterns

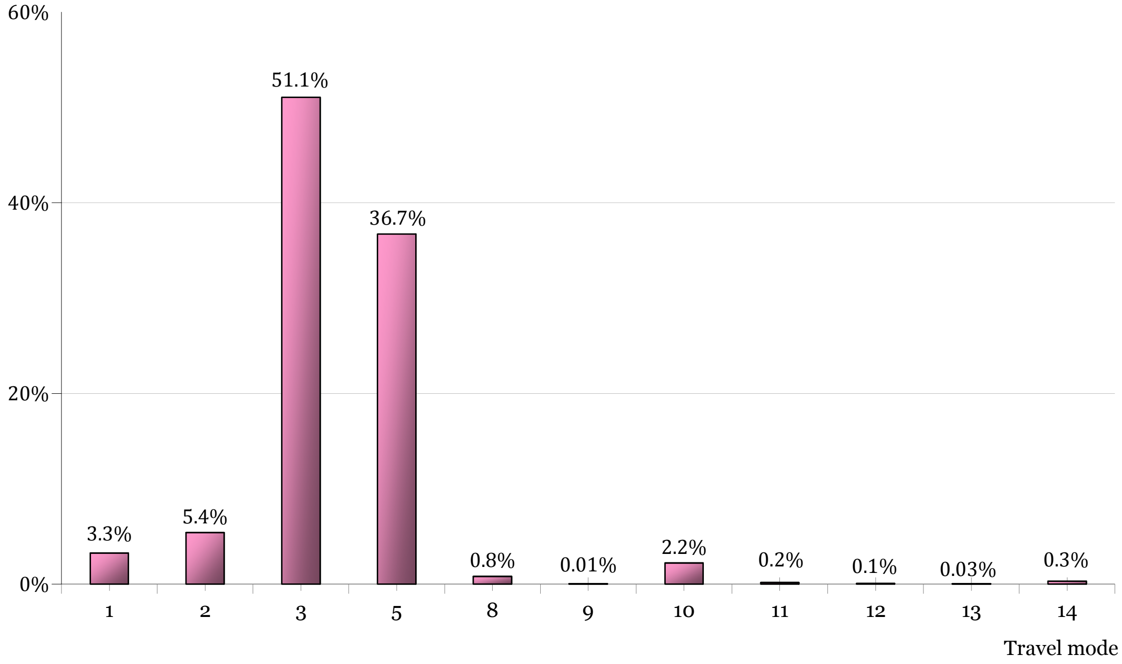
The analysis in this section uses the whole data set for analysis as introduced in Table 7-1. In the first wave of household surveys which was undertaken prior to the Games, three questions were asked to learn the residents' attitudes towards Games time TDM measures as below:

1) How would you like to go to the venues for watching the competitions?
2) Will you go on holiday or take some days off during the Games?
3) What are your alternative travel methods when your cars were under control? (only for those households with car)

9.1.1. Indications before the Games

Figures 9-1~3 summarize the indications of Beijing residents towards the TDM measures during the Olympic Games. As stated in Figure 9-1, public transport was the major choice for the venues, which claimed 88.6% in the mode share. This reflected the government's efforts on encouraging public transport and various restrictions on car use. Of all the public transport methods, subway was the most popular, followed by public buses. This might be a result of the good coverage and access of subway network around the Olympic venues.

Figure 9-1 Preferred travel methods to venues of Beijing residents

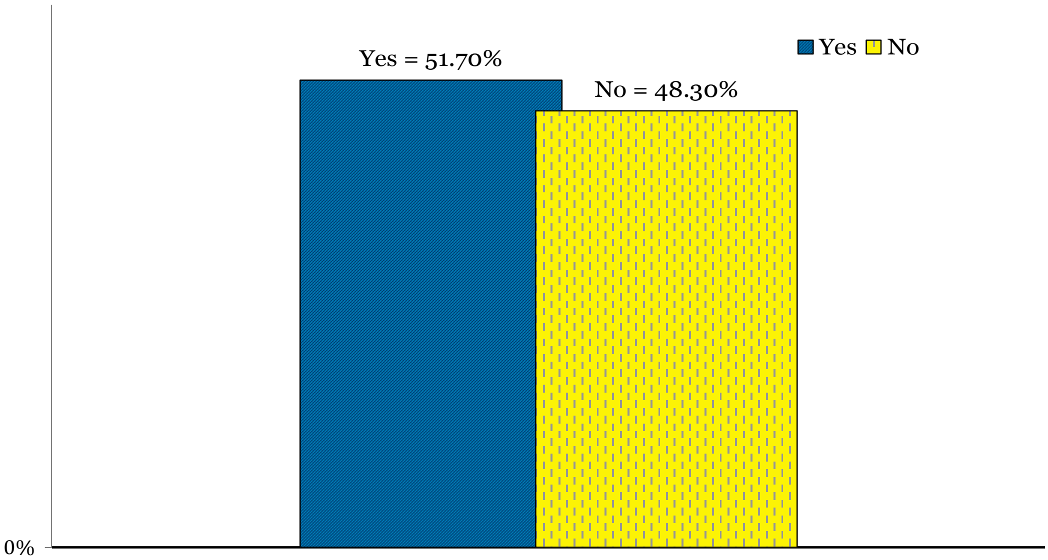


Travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus;
6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Non-private car (drive); 13. Non-private car (passenger); 14. Other

Source: database owned by Beijing Transportation Research Center.

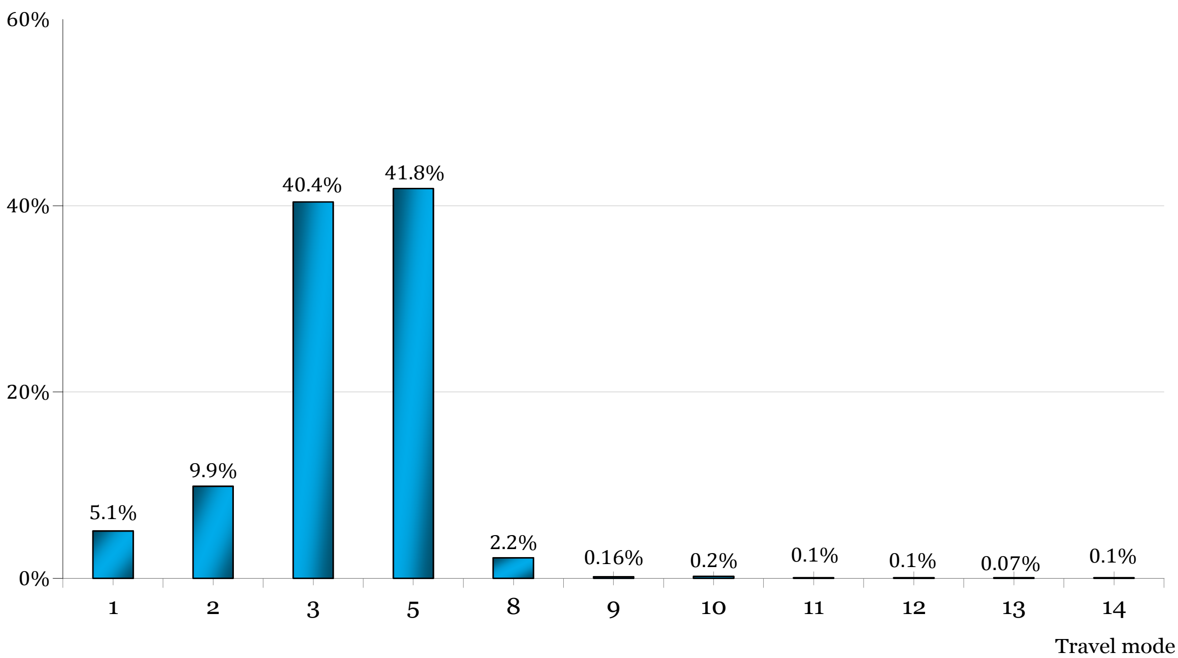
As seen in Figure 9-2, 51.7% of people planned to take days off during Games time, while 48.3% said no in the survey prior to the Games. However, the later survey taken during the Games showed 59.9% people actually took days off, indicating a positive attitude and acceptance by both companies and residents towards the relevant measure.

Figure 9-2 Intention for holiday during the Games



Source: database owned by Beijing Transportation Research Center.

Figure 9-3 The share of preferred alternative travel methods during the Games



Travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus; 6. Car+Public transport
7. Private+Company Cars; 8. Taxi; 9. Company coach; 10. Private car (drive); 11. Private car (passenger);
12. Non-private car (drive); 13. Non-private car (passenger); 14. Other

Source: database owned by Beijing Transportation Research Center.

For households with cars, their choices for alternative to car use also focused on public transport. Intentions as indicated by survey prior to the Games show that buses are slightly preferred over subway for daily travel, which is different from preferences to travel to venues. Meanwhile, bicycle and taxi were more popular in daily travels than for travelling to the venues. Considering the general situation around the city, it might be because 1) the coverage of public buses network was far bigger than that of subway; 2) the destinations of daily life, such as work places and schools, had good access for bicycle use, while some venues as well as their surrounding areas were not friendly to cyclists.

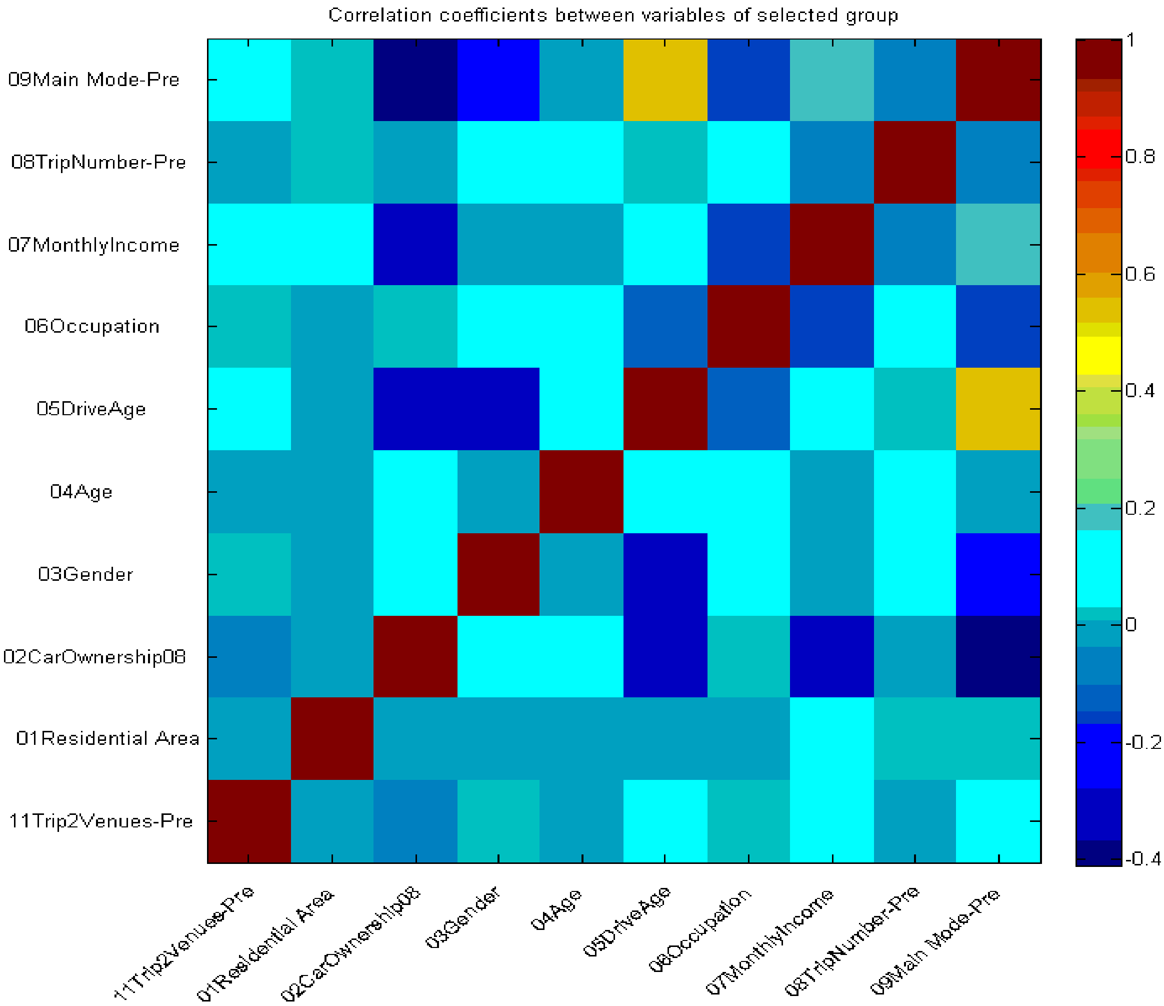
In summary, the measures to encourage public transport and holidays were widely accepted by Beijing residents since early 2008. Residents had very positive attitudes towards relevant measures and intended to alter their daily travel to more sustainable styles. Given this backdrop, we set out to understand who in fact wanted to change and how they changed during the Games. The rest of this chapter is devoted to answering these questions.

9.1.2. Who wanted to change

This section investigates the difference between groups of people in their attitudes towards Games time TDM measures. The main purpose here is to identify the groups who were significantly different from others in certain aspect or choice of intentions.

9.1.2.1. Travel methods to venues

Figure 9-4 Correlation coefficients between **Travel methods to venues** and other variables (whole sample set)

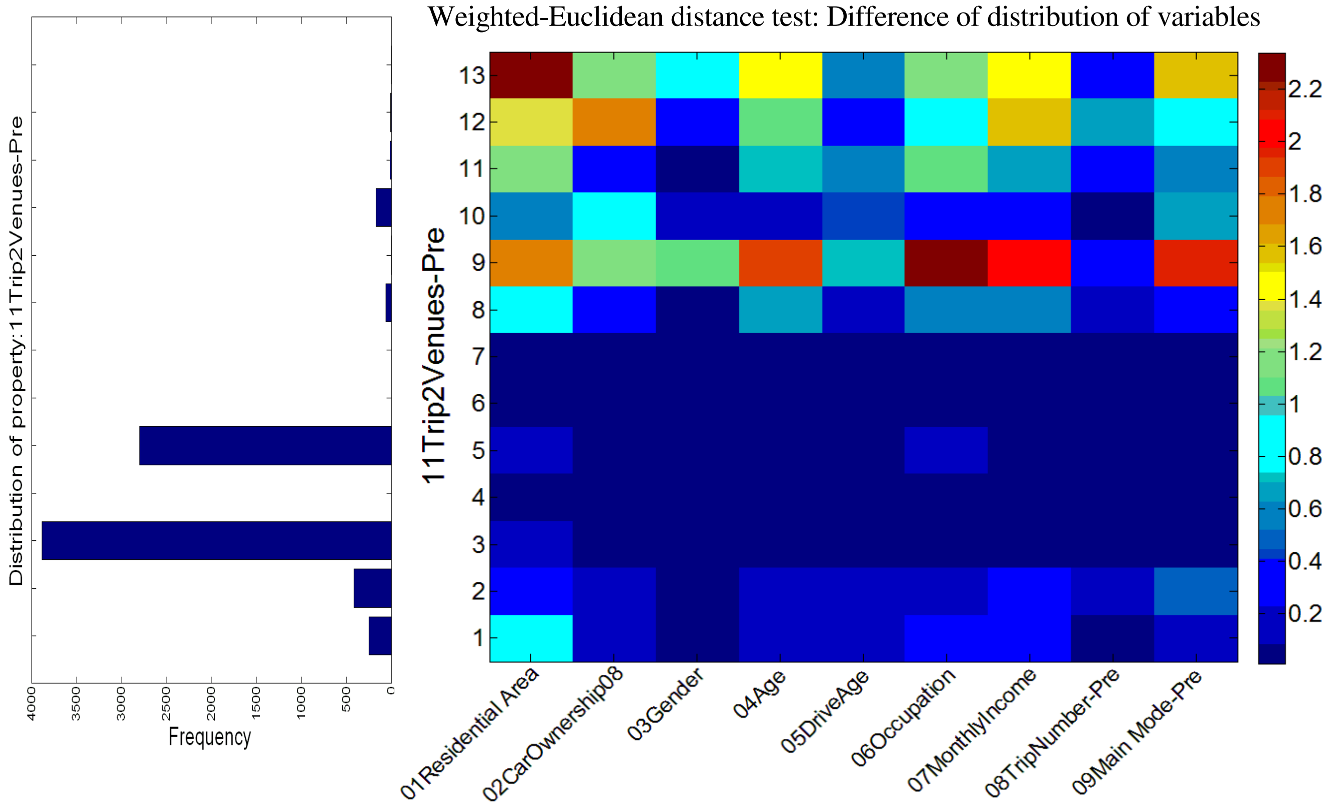


In Figure 9-4, the correlation coefficients between the intentions of **Travel methods to venues** and other variables of the sample set were calculated. We see that the characteristics of Car ownership and Primary travel mode before the Games correlated to the intentions of travel mode for venues more closely than other variables.

In Figure 9-5, each possible choice of travel methods to venues was examined by the Weighted-Euclidean distance PMF test on nine characteristics of travellers. As discussed in Section 2.3.2, there might be significant bias on those comparisons for groups of very small size. Thus we only discuss rows with more than 3% of the whole sample set, which are Rows 1, 2, 3, and 5. Among these four rows, the most significant point is the comparison between $PMF_{specific\ group=1}$ and $PMF_{overall}$ of Variable **Residential area**, which shows that the distribution of residential areas of people who intend to walk to venues was significant to the others in the whole sample set. Figure 9-6 shows that people choosing to travel on foot were more concentrated in Zones 1 and 7. Meanwhile, the comparison on household monthly income was highlighted for people who intended to walk to venues in Figure 9-5 as well. From Figure 9-7 we see that people with higher monthly income might prefer to walk than others. By comparing household monthly income of the people who wanted to walk to venues by residential areas further in Figure 9-8, we see that people living in Zones 1 and 7 didn't have higher household monthly income than those in other areas. Thus, the significance in residential areas was not because of the significance in household monthly income.

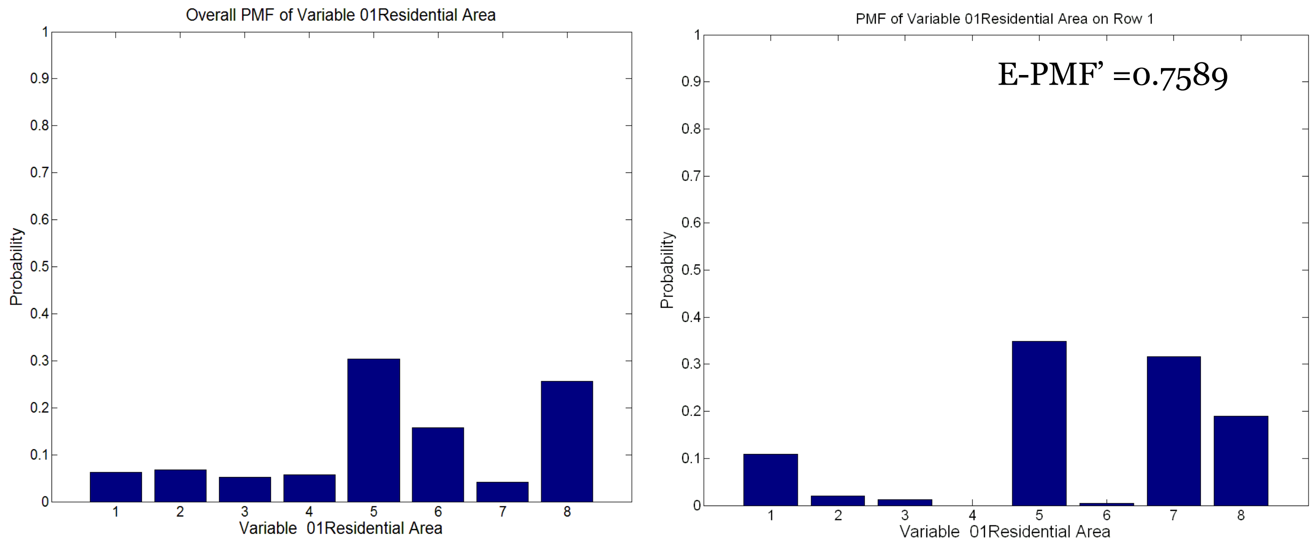
Looking into the comparisons, we find that 1) people living in some compact districts, such as Zones 1 and 7, might prefer to walk to the venues than the others, as the distance of venues was not great. 2) People with higher income might prefer to travel to the venues on foot, in addition to using public transport.

Figure 9-5 Weighted-Euclidean distance PMF test for the Travel methods to venues



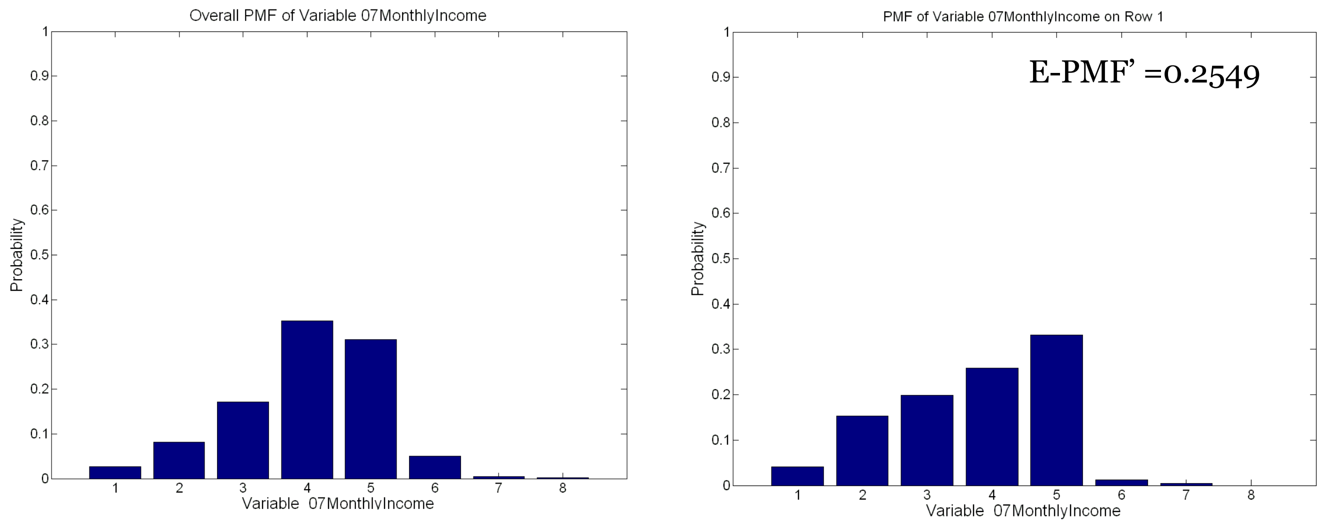
Travel mode to venues (pre-Games intention) (Y-axis):
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport ; 5. Bus;
6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Company car (drive); 13. Company car (passenger);

Figure 9-6 Comparison of $PMF_{specific\ group=1}$ and $PMF_{overall}$ of Variable **Residential area**



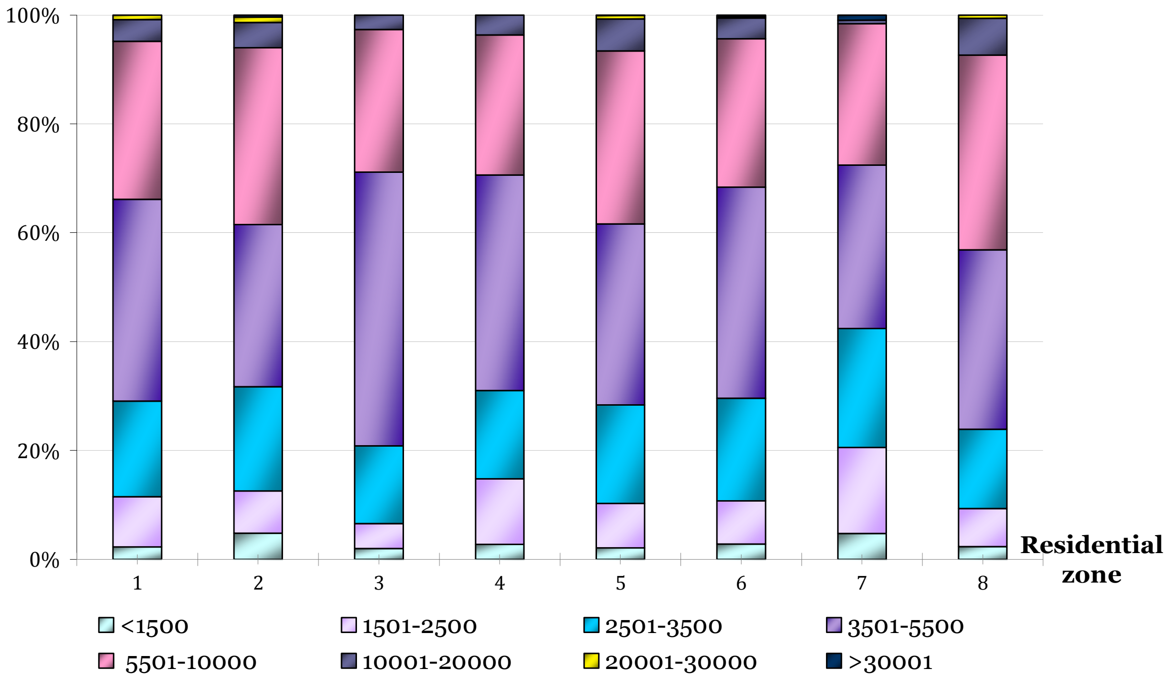
Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

Figure 9-7 Comparison of $PMF_{specific\ group=1,}$ and $PMF_{overall}$ of Variable **Monthly income**



Monthly income (RMB):
1. <1500; 2. 1501-2500; 3. 2501-3500; 4. 3501-5500; 5. 5501-10000;
6. 10001-20000; 7. 20001-30000; 8. >30001

Figure 9-8 Comparison of Household income by residential zone

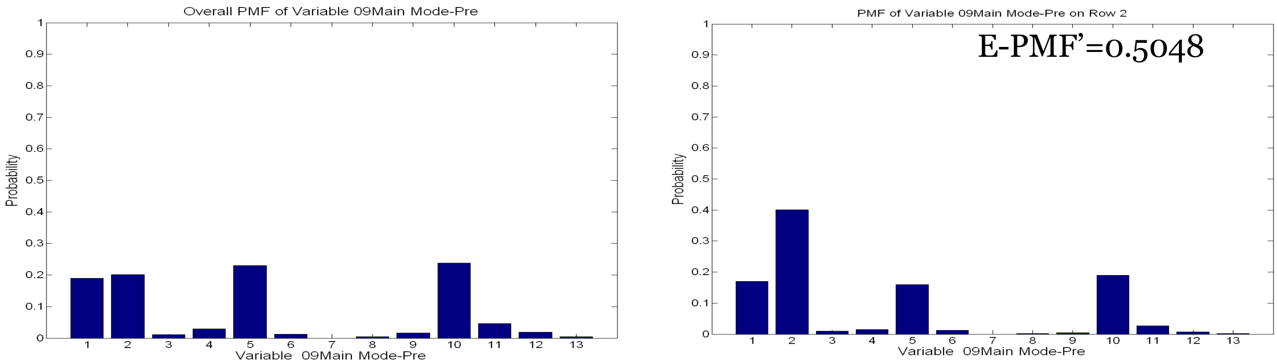


Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

Source: database owned by Beijing Transportation Research Center.

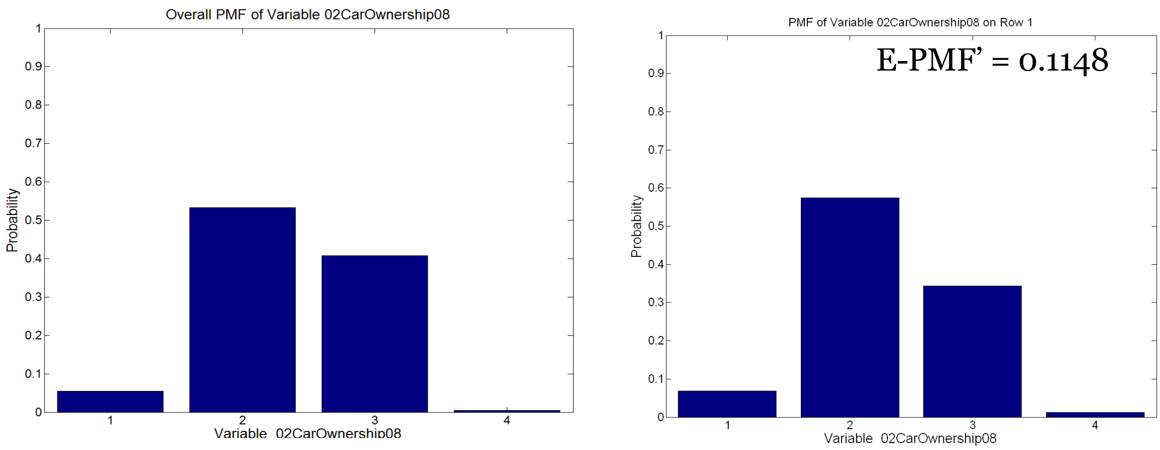
Looking at the people who wanted to bike to venues, their Primary travel mode before the Games and Car ownership appeared different from others. Figures 9-9 and 9-10 show that the original travel mode of those people who intended to go to venues by bike was mainly bike, rather than buses or cars, while people with other original travel modes including cars and public transport preferred to take subway and buses to the venues. This result echoes the findings in Section 7.4. On car ownership, the comparison in Figure 9-10 shows that people without car access (Car access=3) were more likely than those with car access to choose bicycle for venues.

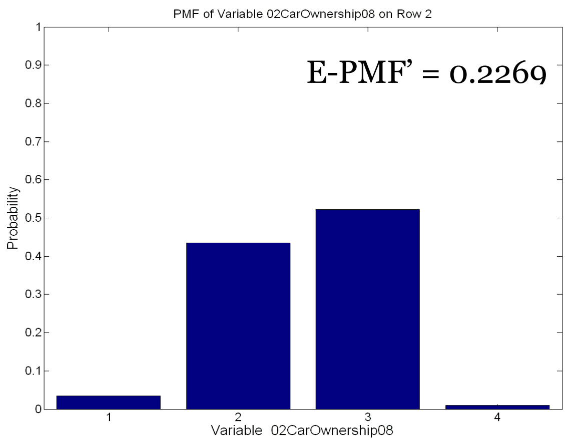
Figure 9-9 Comparison of $PMF_{specific\ group=2}$, and $PMF_{overall}$ of Variable **Pre-Games primary travel mode**



Pre-Games primary travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus;
6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Non-private car (drive); 13. Non-private car (passenger); 14. Other

Figure 9-10 Comparison of $PMF_{specific\ group=1,\ 2}$ and $PMF_{overall}$ of Variable **Car ownership**

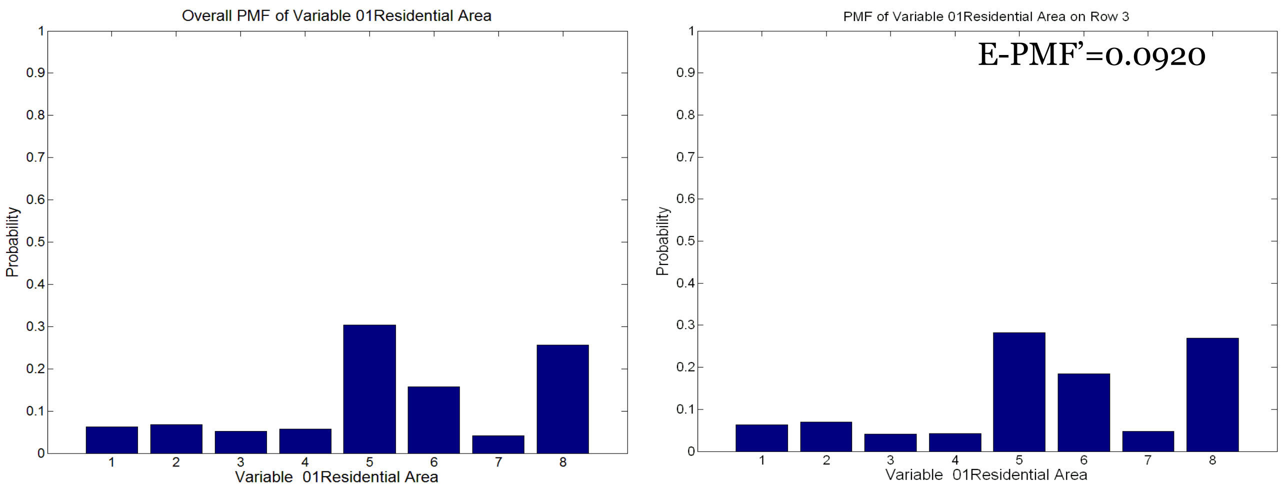




Car ownership
1. Non-private car (government/company car) only;
2. Private car only;
3. No access to car;
4. have access to both non-private car and private cars

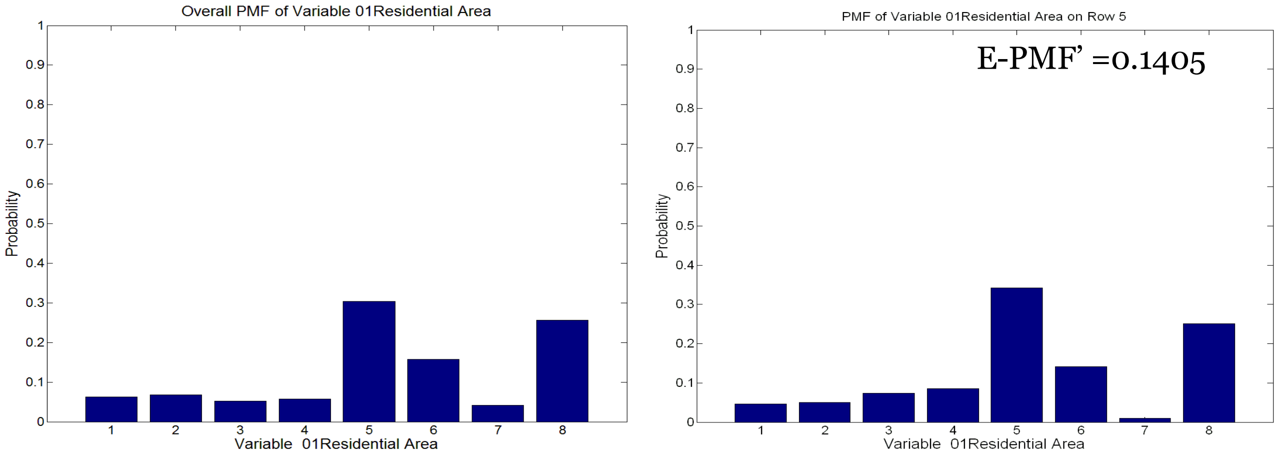
As seen in Figure 9-5, the distribution seems not very significant from others for the 3rd and 5th groups. All the Weighted-Euclidean distance PMF values (PMF') on these two rows were less than 0.150. Particularly, for the 3rd group (go to venues by subway), the distribution on different characteristics appeared to correspond to each other very well as shown in Figure 9-5. The Weighted-Euclidean distance PMF values (PMF') for this group were no more than 0.092 for all characteristics. However, the Weighted-Euclidean distance PMF values (PMF') for the brightest spot observed for the 5th specific group was only 0.1405. As reflected in Figure 9-12, the difference between this group of people and the whole sample appeared not to be significant.

Figure 9-11 Comparison of $PMF_{specific\ group=3}$ and $PMF_{overall}$ of Variable **Residential area**



Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

Figure 9-12 Comparison of $PMF_{specific\ group=5}$ and $PMF_{overall}$ of Variable **Residential area**



Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

9.1.2.2. Leaving for holidays

Looking at the correlation coefficients between 'Intention to go to holiday' and the characteristics of residents of the whole sample set in Figure 9-13, we find that Residential area and Occupation were more linked to the intentions on taking holidays, while Gender and Drive age appeared less related to this studied variable.

Investigating the comparison map in Figure 9-14, we see that no group stood out from the rest for the Weighted-Euclidean distance PMF values (PMF') were mostly lower than 0.15. It means that residents choosing to go on holiday or not had similar background characteristics. However, we would like to investigate Occupation (E-PMF'= 0.1293 for group0, 0.1383 for group1) and Residential areas (E-PMF'= 0.0930 for group_0, 0.0995 for group_1), which appeared more significant than other variables in Figure 9-14 in their correlation with holidays.

Figure 9-13 Correlation coefficients between Intention to go to holiday and other variables of the whole sample set

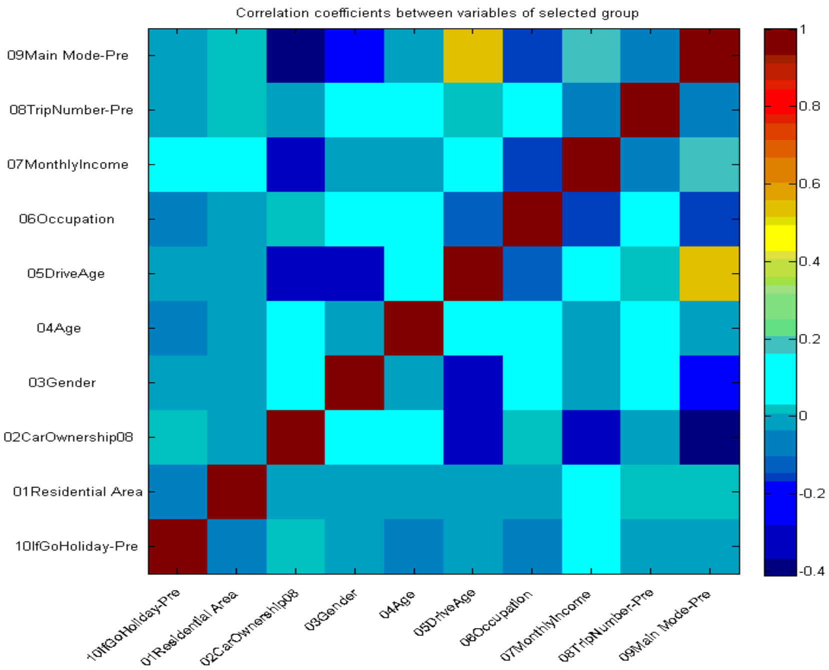
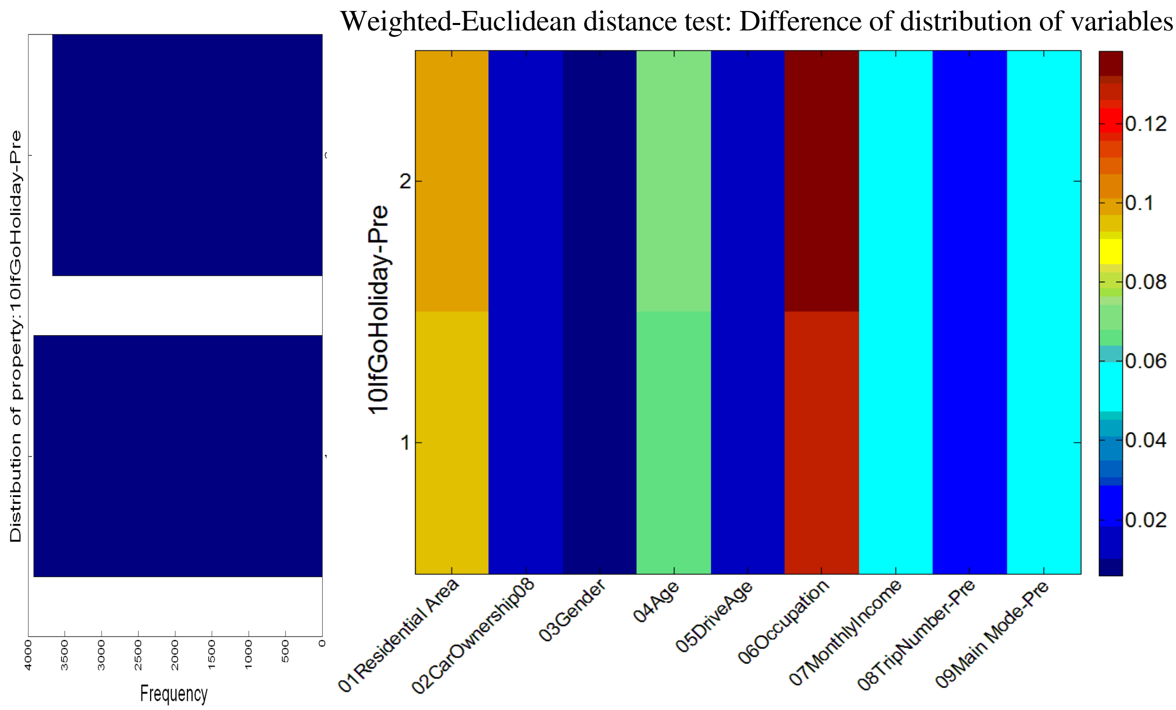


Figure 9-14 Weighted-Euclidean distance PMF test for Intention to go to holiday (Whole sample set)



Whether take holiday during the Games time (pre-Games intention) (Y-axis): 1. Yes; 2. No

Occupation

As seen in Figure 9-15, it was more likely for office-based staff (Occupation=3) and waiters/waitresses (Occupation=8) to opt against going for holiday than others. It might be because office based staff always had fixed calendar for work, which was not easy to change, while the employers at hotels/restaurants expected to be too busy to get days off during the Games.

As seen in Figure 9-16, the difference between groups was too small to notice. That means people didn't have significant differences in such characters connecting to their intention for holiday.

As their E-PMF' values for all other characteristics were even lower than the two discussed above, we conclude that residents with different intentions for holidays were not significantly different from each other on investigated characteristics.

Figure 9-15 Comparison of $PMF_{specific\ group=1,2}$ and $PMF_{overall}$ of Variable **Occupation**

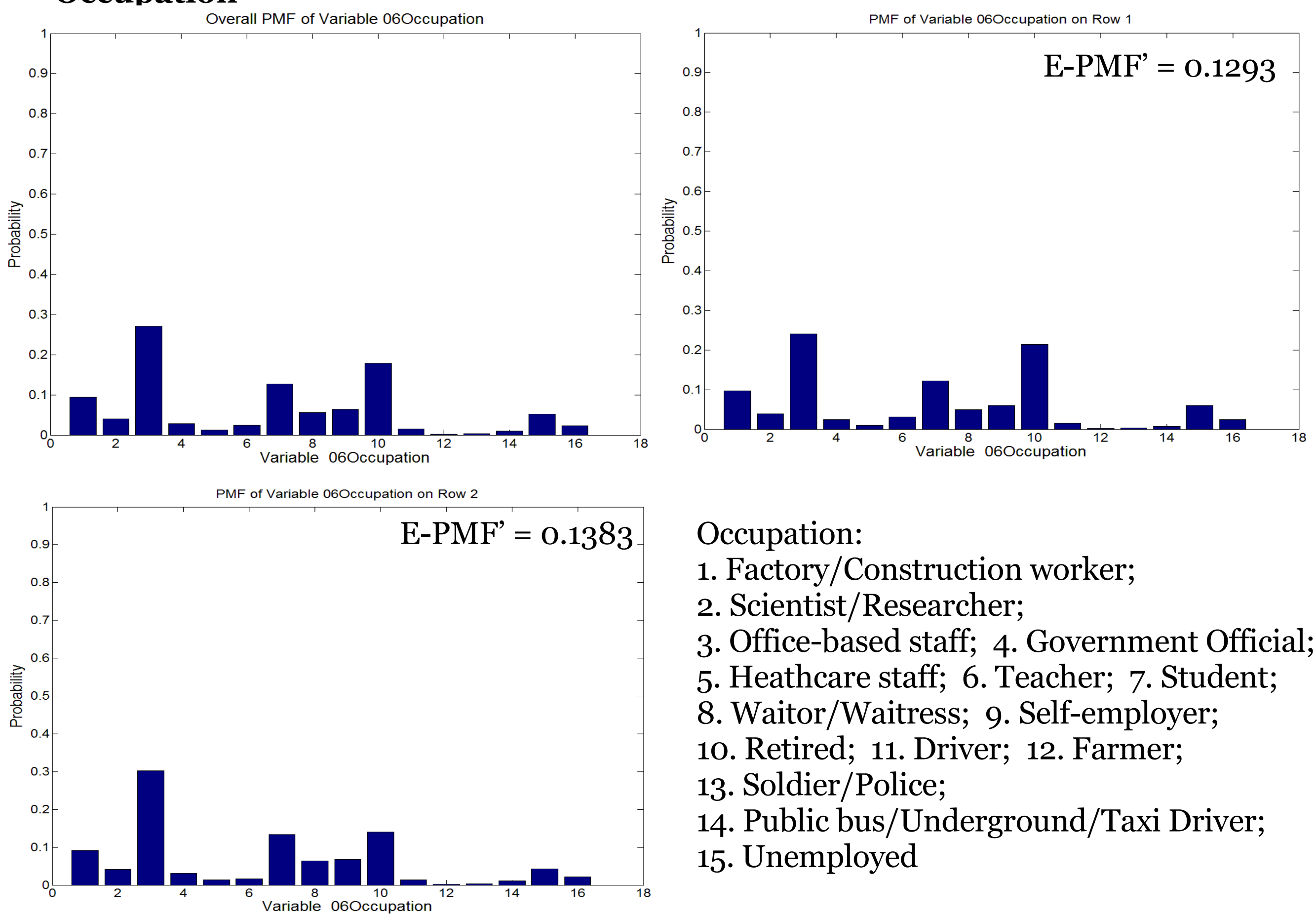
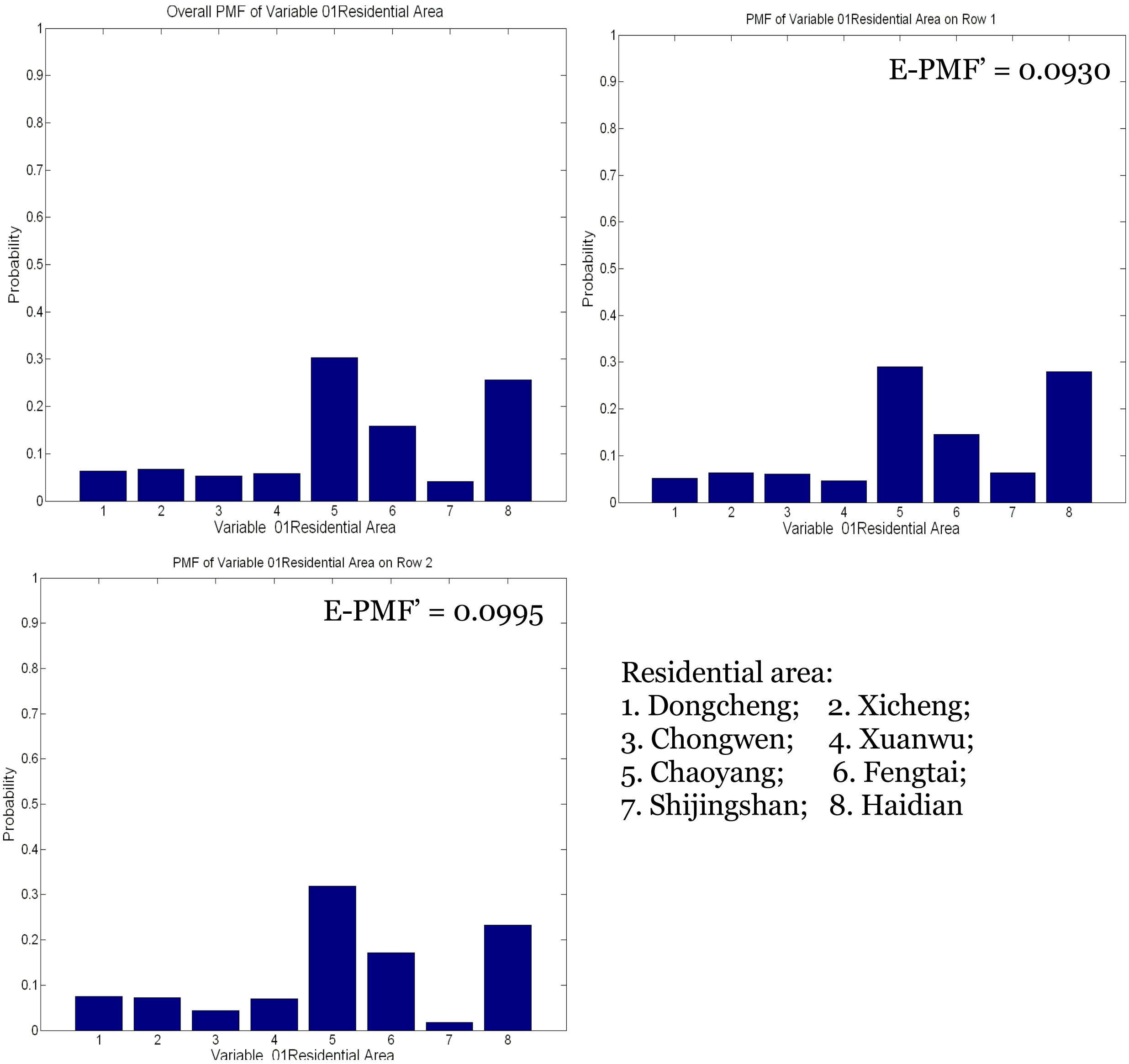


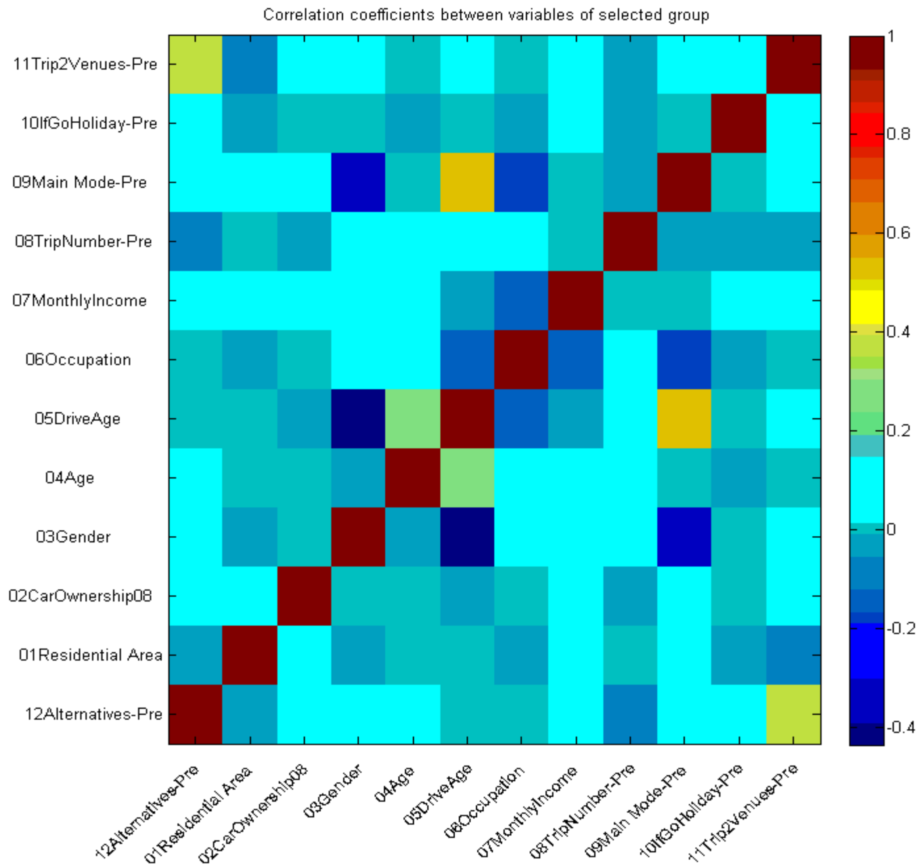
Figure 9-16 Comparison of $PMF_{specific\ group=1,\ 2}$ and $PMF_{overall}$ of Variable **Residential area**



9.1.2.3. Alternative travel modes to car travels

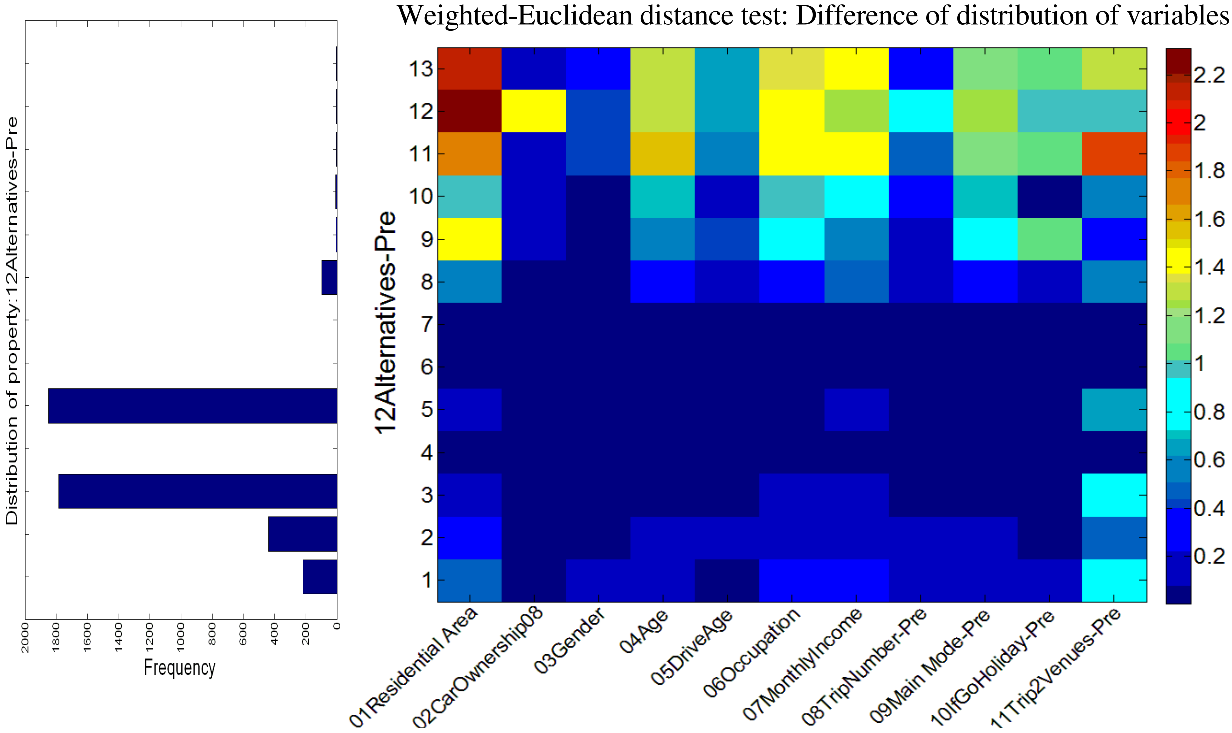
Looking at the correlation coefficients between 'Alternatives to car travel' and other characteristics of residents in Figure 9-17, residents' choices on travel means to venues are closely correlated to their supposed alternative travel means to car. Besides, 'Monthly income' and 'Trip number Pre-Games' were lightly correlated to the choice of 'Alternatives to car travel' as well.

Figure 9-17 Correlation coefficients between **Alternatives to car travel** and other variables for the residents with car access



As shown in the distribution chart on the left of Figure 9-18, most car users chose public transport as their alternative travel means during Games time, while about 14.9% preferred walking or cycling instead. In order to interpret the difference between groups of residents, we applied the Weighted-Euclidean distance PMF test between the studied variable and characteristics of travellers in Figure 9-18, and selected the groups with more than 3% population to further analyze. We find that the distributions of residents for Rows 1, 2, 3, and 5 were significant from the whole sample set on the variable of 'Travel methods to venues'. From further comparison in Figure 9-19, people made similar choices on their alternatives for daily travel and trips to venues in general. Particularly, about 85% of the people who chose subway as the alternative went to venues by subway as well. However, 30% of the people who took buses for daily travel said that they preferred to go to venues by subway. This might be because the venues were well linked by subway network, but not completed in some other areas.

Figure 9-18 Weighted-Euclidean distance PMF test Alternatives to car travel (Residents with car access)



Alternative travel mode in Games time (pre-Games intention) (Y-axis):
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport ; 5. Bus;
6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach;
10. Private car (drive); 11. Private car (passenger);
12. Non-private car (drive); 13. Non-private car (passenger);

Figure 9-19 Comparison of $PMF_{specific\ group=1,2,3,5}$ and $PMF_{overall}$ of Variable **Travel method to venue** (pre-Games indications)

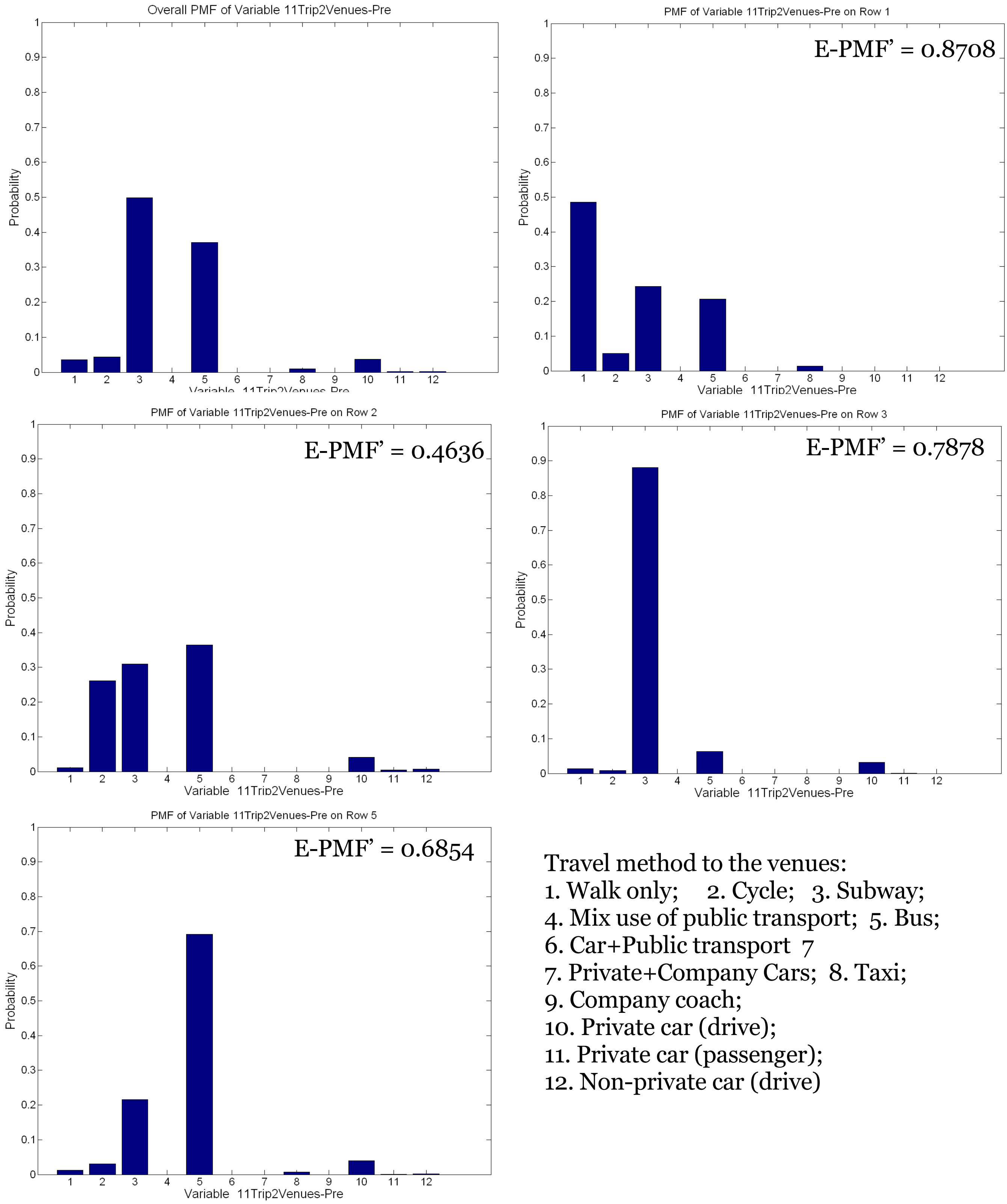
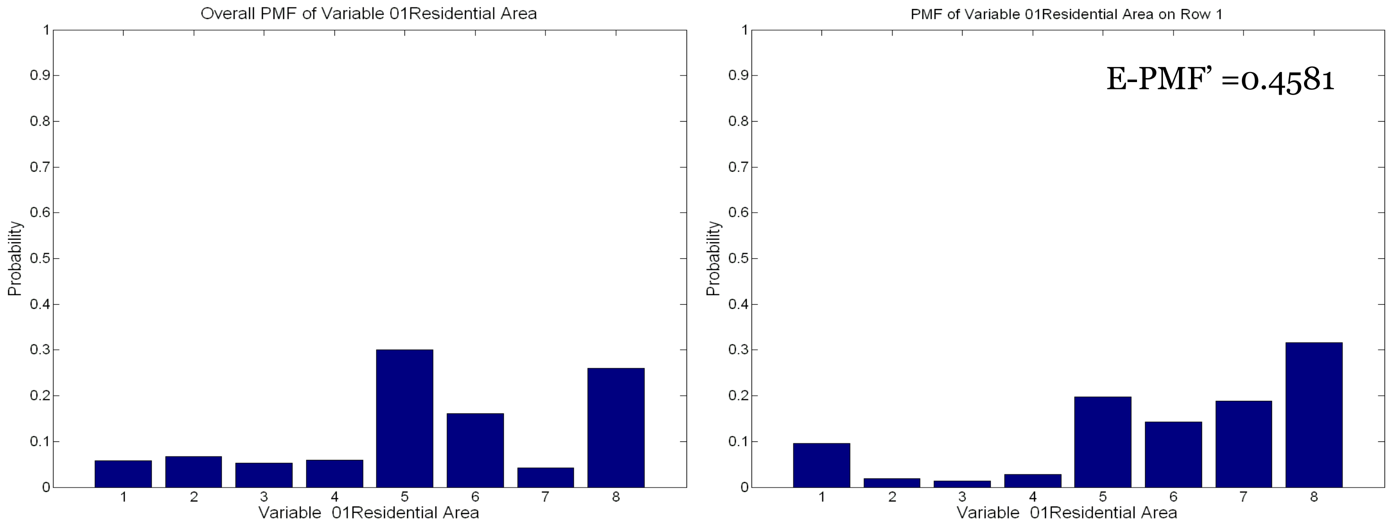
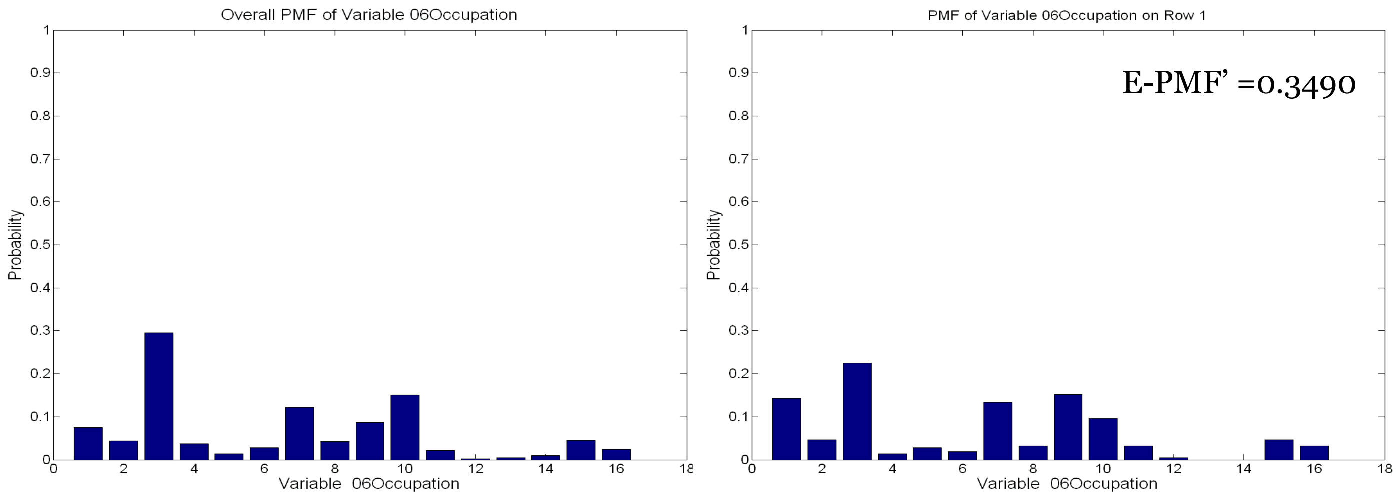


Figure 9-20 Comparison of $PMF_{specific\ group=1}$ and $PMF_{overall}$ of Variable **Residential area**



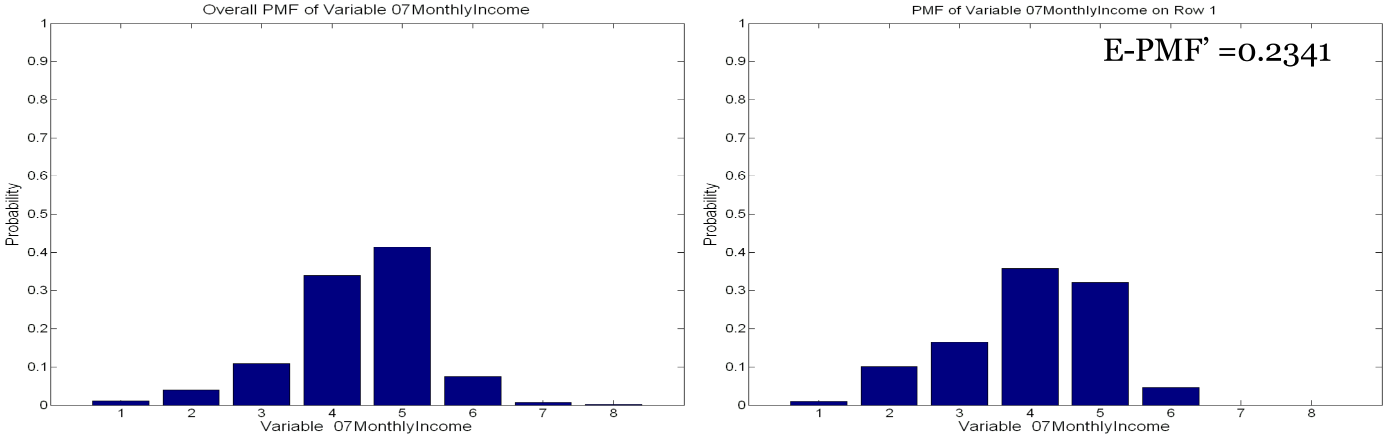
Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

Figure 9-21 Comparison of $PMF_{specific\ group=1}$ and $PMF_{overall}$ of Variable **Occupation**



Occupation:
1. Factory/Construction worker; 2. Scientist/Researcher; 3. Office-based staff;
4. Government Official; 5. Heathcare staff; 6. Teacher; 7. Student; 8. Waitor/Waitress;
9. Self-employer; 10. Retired; 11. Driver; 12. Farmer; 13. Soldier/Police;
14. Public bus/Underground/Taxi Driver; 15. Unemployed

Figure 9-22 Comparison of $PMF_{specific\ group=1}$ and $PMF_{overall}$ of Variable **Monthly income**



Monthly income (RMB):
1. <1500; 2. 1501-2500; 3. 2501-3500; 4. 3501-5500; 5. 5501-10000;
6. 10001-20000; 7. 20001-30000; 8. >30001

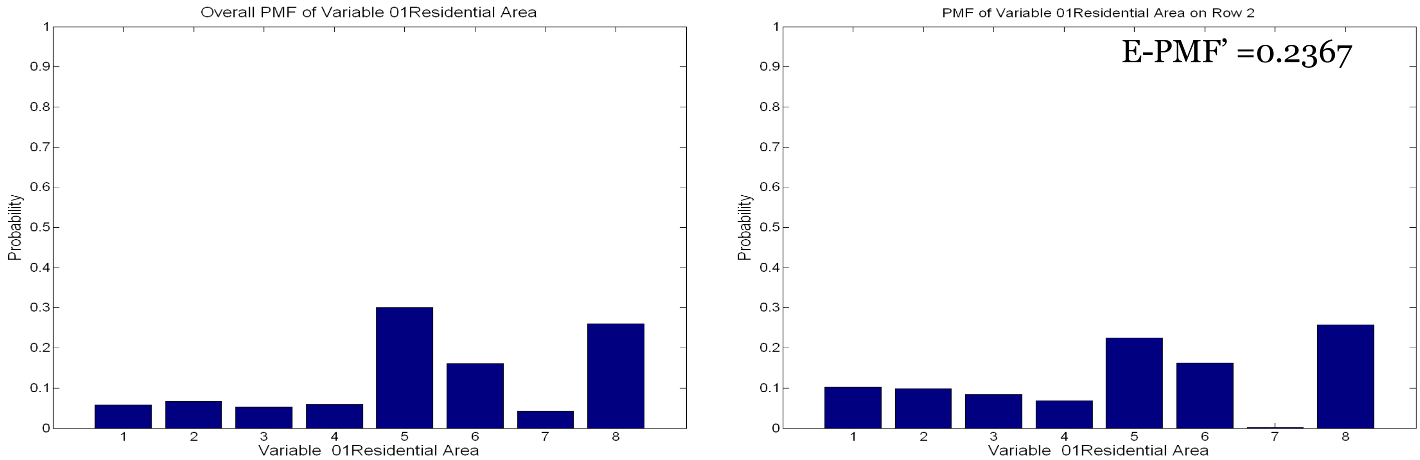
Focusing on car users who chose walking as the alternative, their residential areas appeared more concentrated in Zones 1 and 7, rather than in Zone 5, when compared with the overall households with car access in the whole data sample set as in Figure 9-20. This result is similar to that of Figure 9-6 for the intention of travel for venues.

Comparing occupations in Figure 9-21, factory workers, government officials, and self-employers were more likely to choose walking instead of cars than others. This is likely because their work places were closer than other people.

On household monthly income, the group choosing walking as alternative was compared in Figure 9-22. Car users who intended to walk during the Games earned less income than other car users. Particularly, people who earned 3500-5500 RMB each month were more likely to use walk for daily travel than those who earned 5501-10000 RMB. This result was different from that found in Figure 9-7, which showed people with higher household monthly income preferred to walking to the venues.

As shown in Figure 9-23, people in the central region (Zones 1-4) were more likely to use bicycles when TDM measures applied. It might be because the central region was the old city of Beijing with many traditional citizens and a lot of small roads. They own and are used to bicycles.

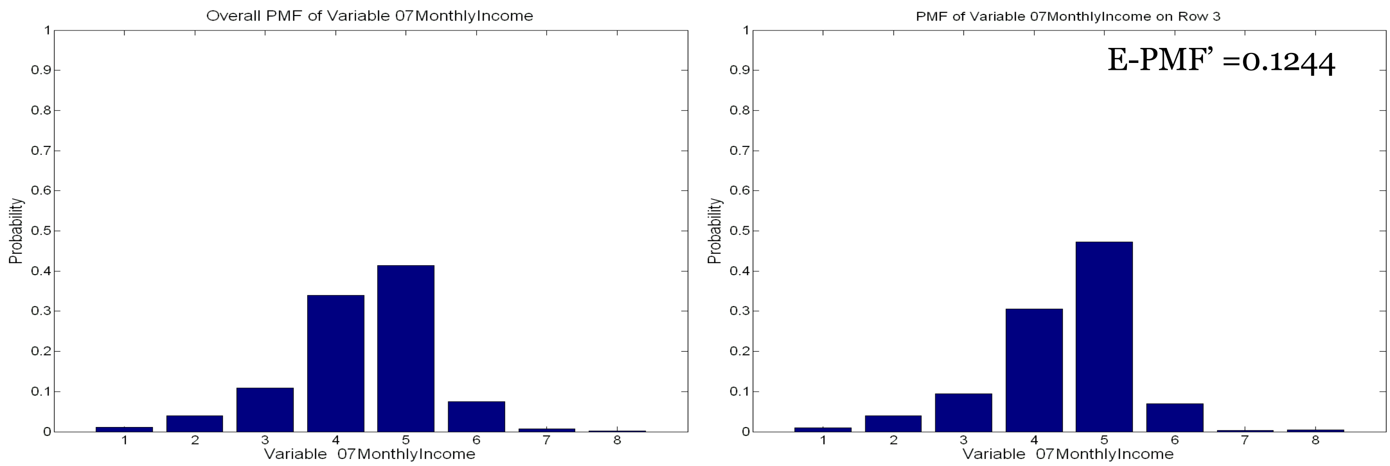
Figure 9-23 Comparison of $PMF_{specific\ group=2}$ and $PMF_{overall}$ of Variable **Residential area**



Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

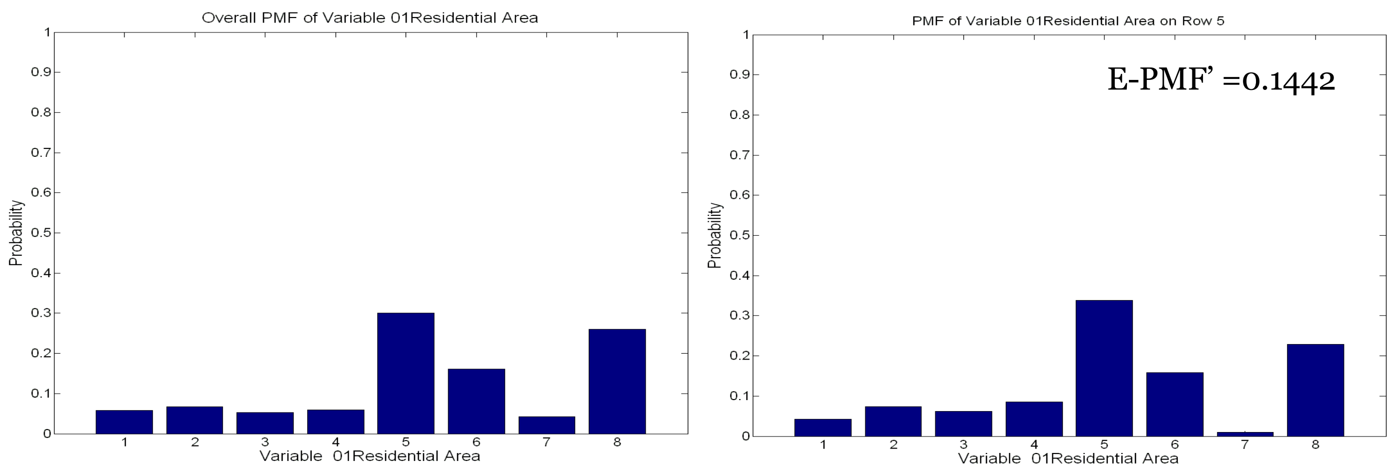
We see from Figure 9-18 that most people chose public transport as alternative during Games time, and there was no highlighted significance shown on the investigated aspects. Though they appeared slightly different in monthly income and residential areas as shown in Figures 9-24 and 25, all the Weighted-Euclidean distance PMF values (E-PMF') for groups 3 (subway) and 5 (buses) were smaller than 15%. It means that people with different demographic characteristics had similar choice of public transport as the alternatives for their daily travel.

Figure 9-24 Comparison of $PMF_{specific\ group=3}$ and $PMF_{overall}$ of Variable **Monthly income**



Monthly income (RMB):
1. <1500; 2. 1501-2500; 3. 2501-3500; 4. 3501-5500; 5. 5501-10000;
6. 10001-20000; 7. 20001-30000; 8. >30001

Figure 9-25 Comparison of $PMF_{specific\ group=5}$ and $PMF_{overall}$ of Variable **Residential area**



Residential area:
1. Dongcheng; 2. Xicheng; 3. Chongwen; 4. Xuanwu;
5. Chaoyang; 6. Fengtai; 7. Shijingshan; 8. Haidian

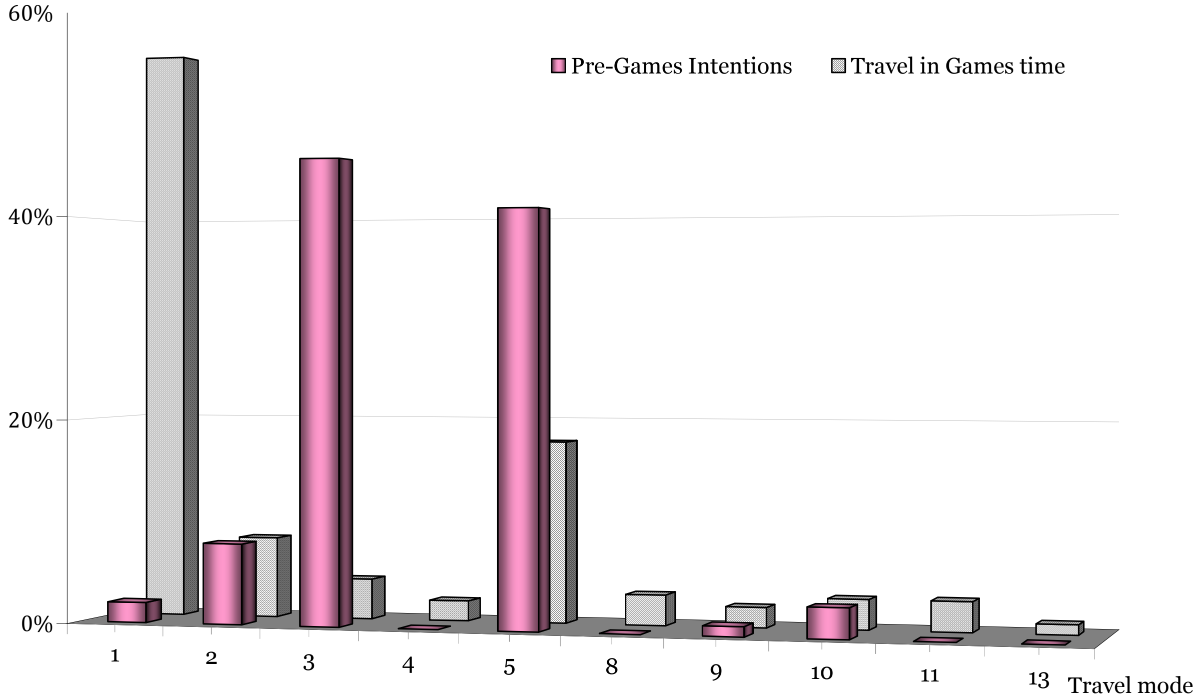
We see from above that most people preferred to use public transport as their alternative for daily travel during the Games, similar with their choices for going to the venues. However, 20% of those who selected buses for daily purposes chose subway for venues, which might be due to the good subway coverage for the venues. Upon looking into their demographic background, only 'residential areas' and 'occupation' showed some differences between groups with various intentions for the alternatives, while other characteristics seemed not significant between groups.

9.2 Forecasting behaviours and Actual behaviours

According to the theory of travel behaviour change discussed in Chapter 2, the behavioural achievement depends jointly on intentions and abilities (Ajzen, 1991). This section investigates the relationship and differences between forecasted intentions based on Travel demands management (TDM) measures prior to the Games and actual behaviours during the Games on the basis of main surveys.

In the main surveys, 101 people responding to both surveys prior to and during the Games went to watch the Games. By comparing their supposed travel modes to venues from the survey prior to the Games and their actual travel modes to venues during the Games in Figure 9-26 and Table 9-1, we see that people's forecasted travel modes to the venues were significantly different from what they actually used. Prior to the Games, most people said they would use public transport to the venues, especially with the subway, while most of them chose to walk instead during Games time. From Figure 9-26, we also learn that taxi and sharing of private cars were used for the venues much more than expected.

Figure 9-26 Preferred travel methods & Actual travel method to venues (whole sample)



Pre-Games primary travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus; 8. Taxi; 9. Company coach; 10. Private car (drive); 11. Private car (passenger); 13. Non-private car (passenger)

Source: Database owned by Beijing Transportation Research Center

Table 9-1 Chi-squared test for travel modes to venues

Compared periods	Chi²	Sig (2-sided)
Forecasted travel modes & Actual travel modes to venues	104.851[a]	<0.0001

a. 12 cells (60.0%) have expected count less than 5. The minimum expected count is .50.
Source: Database owned by Beijing Transportation Research Center

We use the selected sample set described in Table 5-3 to compare and analyze the differences between the intentions on travelling before the Games and actual travelling during Games time.

As tested in Table 9-2, the primary travel modes of pre-Games and Games time were significant for the 2,450 residents in the selected sample sets. As compared in Figure 9-27, we find that the share of public transport in pre-Games survey was significantly higher than that of Games time actual records, meaning a lot of people who said they would like to use public transport as the alternatives actually travelled by walk or bicycle during Games time.

Table 9-2 Chi-squared tests for travel modes (selected sample)

Compared periods	Chi^2	Sig (2-sided)
Primary travel modes of Pre-Games & Games time	447.480[a]	<0.0001
Travel modes for work of Pre-Games & Games time	306.760[b]	<0.0001

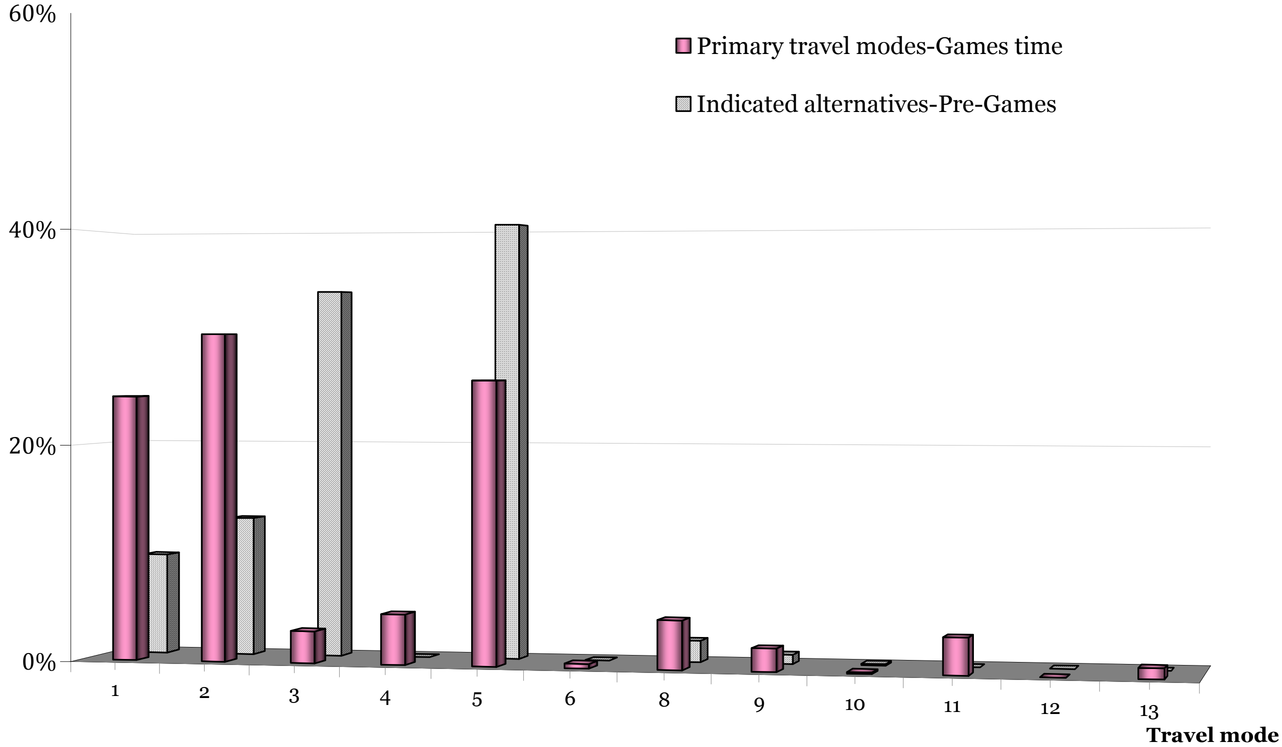
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.00.
b. 6 cells (23.1%) have expected count less than 5. The minimum expected count is .50.
Source: Database owned by Beijing Transportation Research Center

For better understanding of the travel behaviour changes, we compared the work trips before and during Games time to the indications of alternatives in Figure 9-28. The comparison also showed that people's behaviour during the Games was significant different from what they planned before the Games. Particularly for those who intended to travel by public transport, they appeared more likely to use non-motorized travel modes such as walking and cycling for work. The result of the Weighted-Euclidean distance PMF test in Figure 9-29 shows that no group with specific choices on travel alternatives before the Games appeared more likely to change their travel modes for work during Games time. We did a further Weighted-Euclidean distance PMF test for the choices of alternatives before the Games to the characteristics of travellers in Figures 9-35 and 9-36, finding that:

1. People selecting walking as their alternative were more likely to use cycling and public buses for work during Games time.
2. People choosing cycling as their alternative were likely to use bicycles indeed. They appeared not very interested in using public transport, including buses and taxi.

3. People indicating subway as their alternative during Games time were found to be more interested in travelling on foot during their daily travel.
4. People planning to use bus for alternative appeared not significant from the overall choices on work trip during Games time. The E-PMF' value was only 0.1284.

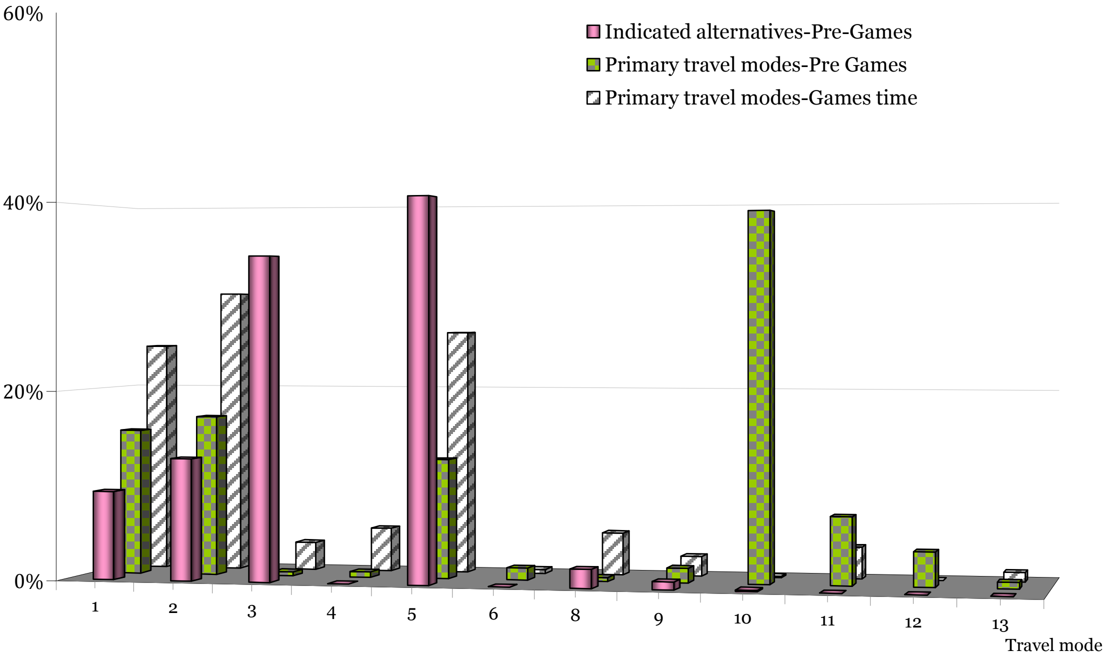
Figure 9-27 Comparison of indicated alternatives and Actual travel patterns in Games time



Travel mode (X-axis):
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus; 6. Car+Public transport; 8. Taxi; 9. Company coach; 10. Private car (drive); 11. Private car (passenger); 12. Company car (drive); 13. Company car (passenger);

Source: Database owned by Beijing Transportation Research Center

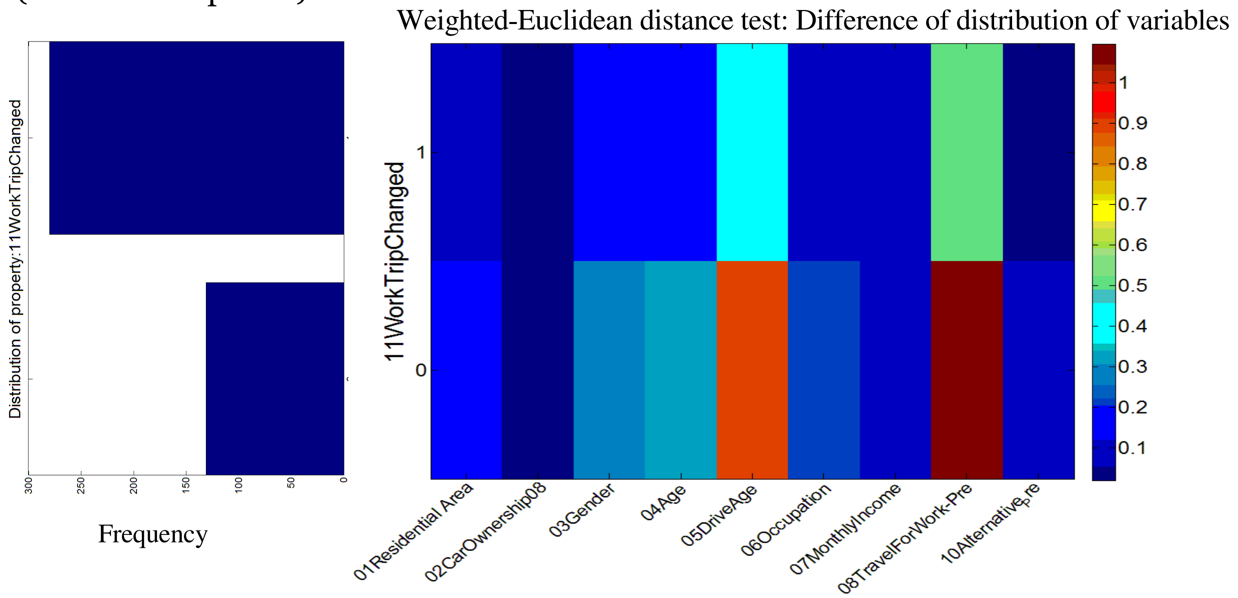
Figure 9-28 Comparison of commuting travel patterns



Travel mode:
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport; 5. Bus; 6. Car+Public transport; 8. Taxi; 9. Company coach; 10. Private car (drive); 11. Private car (passenger); 12. Company car (drive); 13. Company car (passenger);

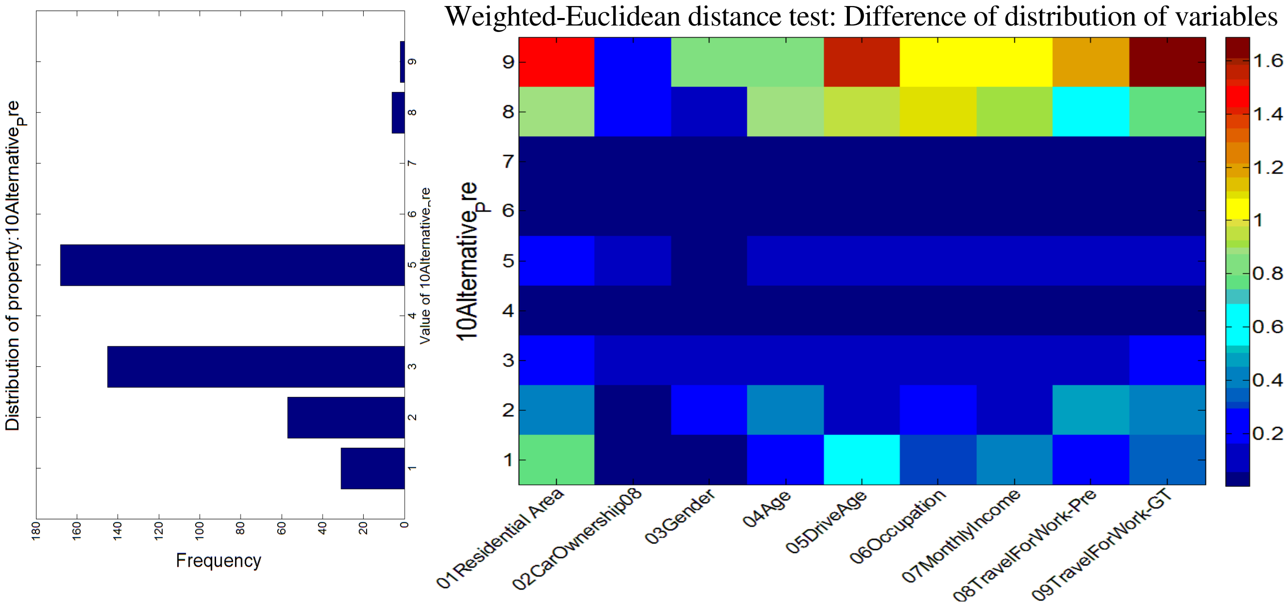
Source: Database owned by Beijing Transportation Research Center

Figure 9-29 Weighted-Euclidean distance PMF test for the Work trip changes (Selected sample set)



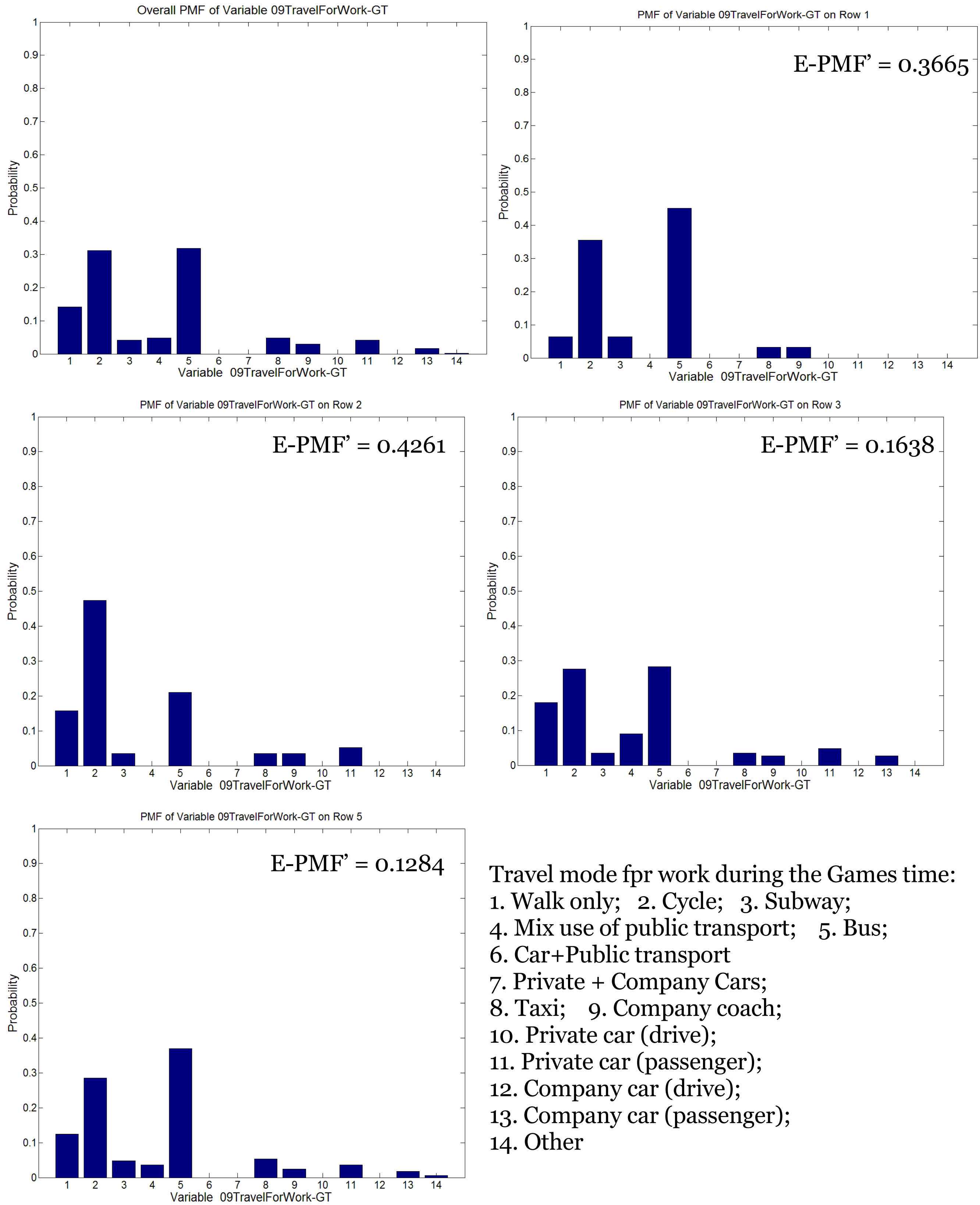
Change of travel mode for work between pre-Games and Games time (Y-axis):
0. Unchanged; 1. Changed

Figure 9-30 Weighted-Euclidean distance PMF test for the Choice for alternatives (Selected sample set)



Pre-Games indication on alternative travel mode for work during the Games time (Y-axis):
1. Walk only; 2. Cycle; 3. Subway; 4. Mix use of public transport ; 5. Bus;
6. Car+Public transport 7. Private+Company Cars; 8. Taxi; 9. Company coach;

Figure 9-31 Comparison of $PMF_{specific\ groups=1,2,3}$ and $PMF_{Overall}$ of Games time travel modes for work (Selected sample set)

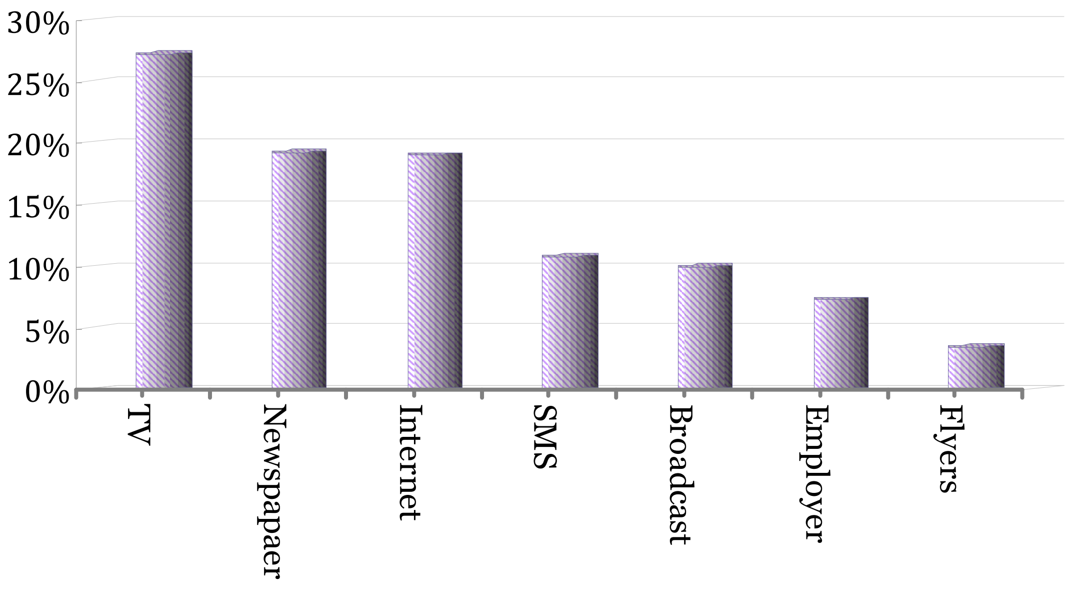


In summary, travellers' actual alternative choices were significantly different from what they planned before the Games, especially on walking and subway. Many people planned to go by subway or bus, though they actually walked or cycled during the games. Understanding the differences and internal correlations between the intentions and actual behaviours might have interesting implications on the research of Games time demands forecasting, as well as communication strategies.

9.3 Communication, Education and Influence

Referring to the communicating ways and channels, Figure 9-32 provided the information on the percentage of interviewees received traffic information through each channel. As indicated, the most effective channels in Beijing were Television broadcasting, followed by newspaper and internet, while printed flyers with little influence on residents' perception and attitudes towards to Games time transport.

Figure 9-32 Communication channels comparison



Source: Beijing Transportation Research Center

Together with the planning concept for the Olympic transportation that the impacts of the games should be minimized for the background daily travel, the local government looked forward to take the games' opportunity to educate the local for not only smooth operation during Games time, but also more sustainable transportation for the future. As indicated in 6.2, a lot of people took voluntary changes during Games time, as a result from the pre-Games education and Games time measures. Also, the choices on the travel patterns during the Games were result in the education and government's appeals as shown in early discussion in this Chapter.

9.4 Discussion

This chapter focused on the comparisons of residents' pre-Games indications and Games-time behaviour changes in daily travel patterns. The results showed that people might behave very differently from what they indicated before the Games.

In pre-Games survey, public transport was indicated to be the most preferred travel means during the Games. Over 50% of respondents stated that they would like to use subway to go to the venues, while more than 80% chose public transport (subway: 40.4% and bus: 41.8%) as their primary travel mode during Games time. This reflected the effect of Travel Demand Management (TDM) measures to a certain extent, which encouraged public transport for Games time travelling.

The Weighted-Euclidean distance PMF test reveals that the residents' intention on their travel means to venues are correlated closely to their supposed alternative travel means to car. People who chose subway for alternative travel means to car normally preferred using subway for the venues as well. Due to the good coverage of subway for competition venues, 30% 'supposed' bus passengers also selected subway as their travel means to the venues when they took the survey before the Games. People living in the compact districts preferred to go to venues on foot or choose walking as the alternative to driving cars. However, people who chose to go to the venues by walking earned a higher household monthly income, whereas people who chose walking as the alternative daily travel means earned a lower household monthly income.

With the Games-time survey, we find that people's actual travel choices were significantly different from what they indicated before the Games, especially on the travel means of walking and subway. Comparing the travel means for venues, the primary travel mode as well as commuting travel mode, we learn that certain residents who intended to use public transport before the Games altered to other means during Games time. They chose walking, taxi, or shared cars to go to venues, or used walking and cycling as the alternative travel means during Games time, though they said they would like to use public transport. Particularly, people who said they would use subway as their daily alternative travel means were observed to prefer walking during Olympic Games time.

Chapter 10

CONCLUSIONS AND RECOMMENDATIONS

10.1 Introduction

Hosting mega events such as the Olympic Games not only brings global focus to the host cities, it also provides an intense period of investment and construction of transport facilities and system improvements. The impacts of the Olympic Games upon the transport systems of the host cities have proved significant (Bovy, 2007a). They have brought huge pressures and risks to the smooth operation of the events themselves as well as the whole city during Games time. Past experience demonstrates that accurately forecasting the travel demands during the Olympic Games is very difficult, as people might behave very differently from their normal habits. We not only need an essential knowledge of the demands of the 'new comers' such as the Games family, the spectators, and other visitors during Games time, but also a good understanding of the potential behaviour changes of the local residents. On the other hand, the host cities and event organizers emphasize a more ambitious objective time and time again, which was to leave a positive legacy to the city and the Olympic movements (Amodei et al., 1997, Official Report of the Games of the XXVI Olympiad, 1996, Official Report of the Games of the XXVII Olympiad, 2000, Official Report of the Games of the XXVIIII Olympiad, 2008). On transportation, building the legacy was normally considered in two aspects, namely the transport infrastructure/facilities and a sustainable travel pattern. For the former, meeting a balance between Games' requirements and local demands is crucial; while for the latter, an appropriate 'change' path designed for encouraging the sustainable travel patterns needs to fit the local residents is a must. Thus, there is a need for more information to understand the behaviour changes in local daily travel as a result of Games-related measures, to assess the impacts of the Games on local transport, to forecast the demands for future events or changes for similar transport measures, and to create confidence for decision making.

The travel behaviour changes were gauged on five aspects of daily travel: trip rates (number of trips per person per day), mode shares, journey purpose, journey distance and time, and travel to work. The research found that the changes in these aspects during Games time were significant, while only few of them lasted past the Games.

This research identified the transport impacts of past Olympic Games on the host cities by a comprehensive review of previous Olympic Games in Chapter 3. The comparisons were given in five aspects: Games' operational demands, Games' short-term impacts on transport, Travel demand management (TDM) measures used in previous Olympic Games and their performance during the Games, the behaviour changes in daily travel in previous host cities, and the transport legacies found in the Olympic histories. In Chapter 4, the details of recent transport development as well as the urban travel pattern of Beijing were brought up for comparison with previous games. The analysis and comparison showed that the Olympic Games brought increasing impacts and opportunities to the transportation of the host cities, which might affect not only the visitors, but also the residents' travel behaviour. Understanding and balancing the demands between the Games and local residents are essential in both event and legacy planning. The all-around background knowledge in this chapter is also very important for the research and discussions for the travel behaviour changes in the given circumstance.

In this research, a series of continuous surveys of Beijing transport were studied to track and identify the travel behaviour changes of Beijing residents during the pre-Games, Games Time and post-Games periods. Different statistical analysis techniques including the Weighted-Euclidean distance PMF test and Cluster analysis were applied on a sample of travel records of thousands of residents in Beijing to identify the categories of travel behaviour changes and the significance between different groups of residents in making changes in their daily travels. The methodologies were explained in Chapter 2, while the details of the comparisons were provided in Chapters 6 to 9. Particularly, the changes in travel patterns and responses to the Games-related Travel Demand Management (TDM) measures of public transport passengers and car users were compared in Chapter 8, as it was learnt from earlier comparisons that car ownership was an important factor for the residents to choose their travel changes during the Games. To assist in a better understanding of travel behaviour changes of residents during the Olympic Games, an extended comparison of expected and actual changes in travel behaviour was given in Chapter 9, where some residents were found to behave similarly as they indicated before the Games but others might behave differently.

10.2 Conclusions

- This research set out to create a comprehensive review on the transport impacts of past Olympic Games on the host cities during and subsequent to the Olympics. With the approach developed and deployed here, the capability of cities to host mega events such as the Olympic Games could be assessed and evaluated, by considering: (1) the characteristics of the basic transport system of the cities and of mega events; (2) the implementation of Travel Demand Management measures and the transport performance; (3) the legacies and lasting influences on the host cities and local residents. The study showed that the balance between the transport development of host cities including the background demographic characteristics, basic travel demands and developing stages of public transport, and the Games' requirement is crucial for gauging the impacts of the Games upon city transportation, planning the transport system for the Games, forecasting the transport performance during Games time, as well as building the legacy for the host cities. The study also indicates that understanding the impacts of the Olympic Games on the residents' behaviour changes in daily travel, which was lacking in previous research, is very important for predicting the measures' performance and building legacies for the host cities.
- A comparative analysis has been done to investigate the behaviour changes of Beijing residents prior to, during and after the Olympic Games, on the basis of

the information of a three-wave survey of travel patterns in Beijing. The main finding from the analysis is that local residents' daily travel was interrupted by the Travel Demand Management (TDM) measures and significantly changed during the Olympic Games, and returned to their pre-Games norm in most aspects after the Games. The impact of the Olympic Games was only observed to have a lasting effect on local travel patterns in slowing down the rebound of travel volume and encouraging the use of public transport. While in many aspects of local daily travel, especially for non-motorized travellers and the car users, the lasting effect didn't appear significant.

On trip rate (trips per person per day), the residents were observed to reduce their daily travel from 2.35 trips per person per day before the Games to 2.22 during the Games, which was believed to be result in the launch of Travel Demand Management measures, including car-use restriction and holiday encouragement programs. While the average trip rate rebounded to 2.28 in 2009, it was still 2.94% less than that in early 2008. Considering the economic development and increasing social/entertainment activities in Beijing during the same period as well as the annual growth in travel demands as shown in Section 6.1, the trip rate was originally expected to be 2.60 in 2009. This would suggest trip suppression of 12% due to the interruption of Olympic Games. The reduction in travel demands reflected the lasting effect of the Travel Demand Management measures of Olympics on the local residents.

On mode share, the overall car usage decreased significantly and car sharing increased during the Olympic Games due to the control schemes and traffic interruption, while public transportation and non-motorized travel means including walking and cycling became more popular when the Olympic Games were held. The changes were believed to be a result of the Travel Demand Management measures, which restricted car usage and enhanced public transport services. One year after the Olympic Games in 2009, non-motorized travel means were not enough to support residents' daily travel demands. This resulted in a decrease of their share in modal split as shown in Figure 6-4. Particularly, cycling trips decreased to a lower level in mode share compared with that of the normal days in early 2008. Meanwhile, car usage rebounded in mode share in 2009, but was still 2.69% less than that of early 2008. Different from other travel means, the public transport kept the same changing trend in mode share from pre-Games to post-Games period, showing a continuing increase. The changes in travel modes found in the surveys coincide with the changes reported by the annual reports and are seen in Figure 6-3. We can learn from Figure 6-3 that car use rebounded significantly after the Games finished, but its mode share was still 0.6% less than expected if the normal annual growth is taken into consideration. One possible reason was the continuing input and improvement in services, such as the improvements on the access/egress and transfer conditions of public transport during and after the Olympic Games as seen in the comparison in 6.1.2.

On journey purposes, because of the summer vacation, trips for education were observed to decrease significantly, while those for leisure got more share during Games time as compared in Section 6.1.3. For longer term, the share of journey purposes reverted back to a certain extent. Commuting and education related travels reduced by 1.23% and 2.19% respectively, while the share of trips for shopping/leisure remained much higher than before. Viewing the journey purposes for public transport travel and car travel individually in Section 6.1.4, commuting by public transport increased significantly during Games time, but decreased after.

On travel speed, it was found in Section 6.1.4 that local daily travel became faster during Games time as the average travel distance increased but the average journey time became shorter. It was because of the traffic and car-usage control, as well as the upgrade of public transport services. After the Games, the travel speed was observed to drop back. The Games didn't bring much lasting impact in this aspect of local travel.

On commuting transport, the modal alteration appeared more significant during the Olympic Games as compared in Section 6.1.6. Using car for work decreased more sharply than that for other purposes, while public transport and cycling were much more popular in commuting travel when compared to trips with other purposes. Meanwhile, the residents were more likely to share cars for work during the Olympics, especially for private car users. After the

Games, many people restarted driving to work, but the mode share of cars for work was still 2.85% less than that of pre-Games period. As a main legacy observed across the compared periods, public transport got an increase of 3.4% in mode share for commuting between the pre-Games and post-Games periods. On the car sharing for work, there was no lasting impact observed after the Games, as driving alone for work kept increasing in Beijing in the post-Games period.

- A major contribution of this research is to find out how individuals responded to the Games impacts on transport. In Chapter 7, we found that residents changed their daily trip rates (number of trips per person per day), primary travel mode, as well as commuting travel mode significantly during the Olympic Games. It was observed from the comparisons that the people who changed in trip rates might continue their changes for longer term after the Games, while those who changed their travel modes might not. People with different demographic characteristics made different changes in trip rates and travel modes when the Olympic came. For trip rate, the characteristics of 'Age', 'Residential area', 'Occupation' and 'Pre-games primary travel mode' were found effective in the related changes, while for travel modes, the characteristics of 'Car ownership', 'Pre-games and Games time primary travel modes' were found effective in the related changes. People who owned a car or normally used a car for travelling were disturbed significantly during Games time, due to the vehicle restriction and traffic control. They were observed to be more likely to change, voluntarily or not, to an alternative mode instead of car. However, car users were more likely to return to their original travel mode after the Games. Residents demonstrated more resistance in their travelling for work during Games time. Over the long term, the analysis also showed that people with private cars were unlikely to change their travel means after the Games.

- Comparing the public transport passengers and car users, it was found that the Games-related Travel Demand Management measures were much more effective on car users' daily travel than on public transport passengers. This was not only indicated in the survey on their opinions on the measures, but also found in their actual behaviour changes. On the days when car use was under control, most drivers were observed to use other travel means instead, and are further observed to have reduced travel frequencies. On the days when car use was allowed, the drivers were found to stay with the same travel patterns as before, as well as the same travel frequencies and travel methods. Car users with different thoughts on the Travel Demand Management measures had different intentions for the alternative travel modes. The convenience was the main consideration for car users to decide whether to drive during Games time, even if they were not bound by the TDM measures. The governments' appeal also appeared effective on people's choices on travel means.

- The comparative study in chapter 9 showed that people might behave very differently from what they indicated before the Games. Particularly, people showed a preference in indicating public transport as their Games time travel means, especially the subway, but they appeared to actually travel by walking or using other travel means such as taxi or car sharing during Games time.

10.3 Recommendations

This research compared and identified the travel behaviour changes in the context of the Olympic Games, revealed that the impacts of Olympic Games were significant to the cities with different travel demands and transport development stages. Meanwhile, the travel behaviour changes of difference residents were found to be significantly different from each other under the circumstance of Olympic Games. Therefore, understanding the transport impacts of the Olympic Games and those behaviour changes of residents is necessary for evaluating the ability of a city to host the Games, forecasting the travel demands and transport impacts during the Games, as well as the building of long-term legacies for both the Games and the host cities. As a whole, it is expected that if the following recommendations are considered, they could result in a better choice of host cities for such mega events, as well as an improved planning process for the sustainable urban transport and mega events' transport.

- The current developing stage and long-term perspective of travel pattern of host cities, especially the daily travel demands and mode share, need to be comparable with the Games' demands. The reviews on the past games showed that if only there was a balance between the local travel demands and Games' demand in transport, the smooth operation during the Games and a sustainable transport development might be achieved.
- The residents are likely to reduce their daily travel demands during the Games. The people who are aged between 35 and 44, or live near the venues or travel by car normally were found to be more likely to reduce or change their daily travel demand during the Games. These segments should be emphasized in the consideration of demand analysis.
- Residents' change in travel mode was significant during the Games. People who owned private cars and used car for travelling normally appeared more likely to change their ways of travelling during the Games. For the alternative travel means, the subway was not as popular as supposed. Buses and walking turned out to be the popular alternatives to the car during the Games for the residents.
- People were unlikely to make many changes in their travel patterns for work during the Games. However, if the changes were encouraged by employers, the objectives were easier to achieve.
- For the long-term, the evidence showed that the changes in trip rates (number of trips per person per day) were more likely to show a lasting effect than those in travel modes. Car users were unlikely to keep their changes during the Games for long after the Games finished.
- The evidence also showed that the difference between presumed and actual travel patterns during the Games was significant. It is difficult and risky to get an accurate forecast in travel demands by doing surveys with the residents.
- For communication programs, TV is more effective than other media. Print publications or flyers were not as helpful as hoped in encouraging or introducing smart travel means to travellers during the Games.

- The Weighted-Euclidean distance PMF test is a good technique in comparing the significance between groups in travel behaviour change.

10.4 Suggestion for forthcoming events and future research

As indicated at the very beginning of this thesis, the results of this research should provide implications for future events, especially the London 2012 and Rio de Janeiro 2016 Olympic Games. Particularly, three points deserve emphasis:

1) Residents might change their travel mode during the Games. Instead of over-investing on the public transport, non-motorized travel modes such as walking and cycling need to be designed and looked after carefully. The analysis in this study shows that while people intended to take the subway during Games time, a lot of them actually travelled by walking or cycling when the Games took place.
2) People were less likely to change their travel patterns for commuting during Games time. By working together with employers, organizers might be able to achieve more efficient behaviour.
3) The Games' impacts on travel behaviours were unlikely to last for the long-term. To build up a long-term legacy in sustainable transportation for the local area, the organizers must invest continuous efforts into both policies and communications. The information broadcasted and the channels used must be tailored to the characteristics of local travellers carefully.

Accordingly, there are several considerable scopes for further research in travel behaviour change in the context of mega events such as the Olympic Games. One aspect that was mentioned earlier in Chapter 3 is that the continuous information on the travel patterns of host cities was lacking for tracking the changes and comparing the impacts across different periods. Some questions also changed between the surveys, which made the information hard to trace across the periods. A continuous series of surveys with consistent questions were required for this research. Furthermore, the stated preference questions and certain self-report of some travel patterns such as the frequency of car use, etc. are suggested to include in the future questionnaire design, which may enhance the ability of surveys for capturing longer term behaviour change with less bias.

It was acknowledged that communication was an essential approach for the behaviour changes and marketing objectives (ODA, 2007). Missing information that would have encouraged people to change their daily travel towards a sustainable pattern might be taken into consideration of future surveys and research. This could be associated with the analysis of the categories of changes for strategic consideration. For example, for the groups with different intentions of making changes in their travel behaviour during or after the Games, what information or communication programs could encourage or persuade them to move to sustainable travel patterns? Especially for the forthcoming Olympic Games of London 2012, the work of travel demand management and its relevant marketing face even more challenges than Beijing. On one hand, we learnt from the reports and discussions on various media that Londoners' opinions towards Olympic Games are very different from those of the residents of Beijing or other cities (Guardian, March 2010; Telegraph, March 2010; BBC, July 2009; Guardian, February 2009). The difference might be due to the culture factors as well as the Games' approaching process. It was learnt from behaviour change process that the importance of social norms and the role of media who sends 'influencing message' should be emphasized. Well-designed information and efficient distribution methods are required to target different client groups with varying potential in changing travel patterns. On the other hand, different government systems and background situations such as the organizing committee's effectiveness of operation make the preparation process very different. For London 2012 Games, communication and encouragement will be more important for the TDM measures' application. Thus, further research on this point should be taken into consideration, for holding a successful event and building positive legacies for both the Games and the local people.

Appendix I. 2008 Beijing resident daily travel survey form

Form Reference No.: BJ-TPT-Q-1
Produced by: Beijing Municipal Committee of Communications
Authorited by: Beijing Municipal Bureau of Statistics
Authorited No.: [2008]103
Valid Date: till 30th September, 2008

This is voluntary survey
Family ID :

Dear citizen:

We are taking 2008 Daily Travel Survey for Beijing residents, investigating on the travel diaries of your family's during one day. Your kindly supports and co-operation will be highly appreciated.

Car ownership (number of used cars on survey day): 1 (Questionnaire type : B)			
1st Survey Date: __(MM)__(DD), __(TUE, WED, THU) 2nd Survey Date: __(MM)___(DD), __(TUE, WED, THU)	Sample Type	take both surveys	1
		take 1st survey only	2
		take 2nd survey only	3
		addtional samples (random)	4
		addtional samples (supplementary)	5

District Codes			
Core Districts of Capital Function		**Urban Function Extended Districts**	
Dongcheng	1	Chaoyang	5
Xicheng	2	Fengtai	6
Chongwen	3	Shijingshan	7
Xuanwu	4	Haidian	8
New Districts of Urban Development		**Ecological Preservation Dev. Districts**	
Fangshan	9	Mentougou	12
Daxing	10	Pinggu	15
Tongzhou	11	Yanqing	16
Changping	13	Huairou	17
Shunyi	14	Miyun	18

Basic Information
Name:_______________
Household type: 1.family___ 2.other
Location:_______________
Investigator Name:_______________
1st investigate date: ___(MM)___(DD), __ (TUE, WED, THU)
2nd investigate date: ___(MM)___(DD), __ (TUE, WED, THU)
Instructor:
Supervisor:

Date: __(MM)__(DD) _____(TUE, WED, THU)

Beijing Resident Travel Survey
Form I: Household Information

Form Ref. No.: BJ-TPT-Q-1
Produced by: Beijing Municipal Committee of Communications
Authorited by: Beijing Municipal Bureau of Statistics
Authorited No.: [2008]103

Please fill in information of all your household members, including persons living at your home temporarily on the survey day as well as baby sitter and babies, etc.

Member Code –in Household	Gender	Relationship to HOUSEHOLDER	Age	Residence Type	Permanent Resident	Occup-ation	Drive Age	Address code of your Work place/School, etc.	Do you have public transport IC card? （Card number）
1 (HOUSEHOLDER)	1 M 2 F	[ ]	[ ]	1 Local, 2 Non-local 3 Short-term, 4 Temporary	1 Y 2 N	[ ]	[ ]	[ ]	[ ]
2	1 M 2 F	[ ]	[ ]	1 Local, 2 Non-local 3 Short-term, 4 Temporary	1 Y 2 N	[ ]	[ ]	[ ]	[ ]
3	1 M 2 F	[ ]	[ ]	1 Local, 2 Non-local 3 Short-term, 4 Temporary	1 Y 2 N	[ ]	[ ]	[ ]	[ ]
4	1 M 2 F	[ ]	[ ]	1 Local, 2 Non-local 3 Short-term, 4 Temporary	1 Y 2 N	[ ]	[ ]	[ ]	[ ]
5	1 M 2 F	[ ]	[ ]	1 Local, 2 Non-local 3 Short-term, 4 Temporary	1 Y 2 N	[ ]	[ ]	[ ]	[ ]
6	1 M 2 F	[ ]	[ ]	1 Local, 2 Non-local 3 Short-term, 4 Temporary	1 Y 2 N	[ ]	[ ]	[ ]	[ ]

1.Householder 2.Spouse
3.Child (Inc. adopted) 4.Parent
5.Grand-child 6.Grand-parent
7.Brother/Sister
8.other relative (please specify)
9.non-relative

1.Local: registed Beijing resident at this address,

2.Non-local: registed Beijing resident but not at this address,

3.Short-term: non registed Beijing resident but stay for longer than 3 months,

4.Temporary: non registed Beijing resident

1. Factory/Construction worker,
2.Scientist/Researcher,
3. Office-based staff, 4. Government Official,
5. Heathcare staff, 6.Teacher, 7.Student,
8. Waiter/Waitress, 9. Self-employer,
10.Retired, 11.Driver, 12.Farmer, 13. Soldier/Police,
14.Public bus/Underground/Taxi Driver
15. Unemployed, 16. Others (Please specify)

Please fill the exact card number of your in your public transport IC card, such as: 10007510023740723

Please fill in all travel details of yours from 00:00 to 24:00
on ___(MM)___(DD).

Beijing Resident Travel Survey
Form II: Traveller Information (Page 1 of 2)

Form Ref. No.: BJ-TPT-Q-1
Produced by: Beijing Municipal of Communications
Authorized by: Beijing Municipal Bureau of Statistics
Authorized No.: [2008]103
Valid Date: till 30th September, 2008

Your Member Code (-in Household) in Form I: [ ] If you don't travel at all on the survey day, please specify the reason here, [ ].
Otherwise, please fill in your first origin on the day: 1 Home, 2 Work place/School, 3 Other [ ] (please use the **Facility Code**)

Travel Mode Codes
1. walk, 2. bicycle,
3. underground,
4. electrical bicycle,
5. public buses, 6. mini bus,
7. motorbike, 8. taxi,
9. company bus,
10. drive private car,
11. share private car(seated)
12. drive company car,
13. share company car(seated)
14. unlicenced taxi,
15. other, please specify_____

Trip Purpose Codes
1. for work, 2. for school,
3. back home, 4. to station
5. transfer,
6. return from somewhere, but not go back home,
7. for shopping,
8. for gym or relax,
9. for dinner, 10. to the hospital,
11. visit family / friends,
12. for entertainment,
13. for business,
14. give somebody a lift,
15. fetch car, 16. parking,
17. other, please specify______
18. Olympic related activities, please specify__________

Note: please use reverse side or additional paper if you make more than 10 trips on the day.

Trip No.	Departure Time (24-hour)	Travel Mode(s) (codes)	Destination		Arrival Time (24-hour)	Travel Distance (metre)	Bus line No.	Travel Cost		Trip Purpose (code)
			District (code)	Facility (code)				Cash	IC card	
1	_(HH):_(MM)				__(HH):_(MM)					
2	_(HH):_(MM)				__(HH):_(MM)					
3	_(HH):_(MM)				__(HH):_(MM)					
4	_(HH):_(MM)				__(HH):_(MM)					
5	_(HH):_(MM)				__(HH):_(MM)					
6	_(HH):_(MM)				__(HH):_(MM)					
7	_(HH):_(MM)				__(HH):_(MM)					
8	_(HH):_(MM)				__(HH):_(MM)					
9	_(HH):_(MM)				__(HH):_(MM)					
10	_(HH):_(MM)				__(HH):_(MM)					

Facility Codes:
1.hotel, 2.office, 3.business/service centre, 4.market, 5.hospital, 6.stadium/sport facilities, 7.museum/library, 8.cinima/theatre, 9.school, 10.residence/apartment, 11.exhibition, 12.tourism place, 13.restaurant/entertainment, 14.airport/station/whalf, 15.factory, 16. other(please specify)__________

Please fill in all travel details of yours from 00:00 to 24:00 on ___(MM)___(DD).

Beijing Resident Travel Survey
Form II: Traveller Information (Page 2 of 2)

Form Ref. No.: BJ-TPT-Q-1
Produced by: Beijing Municipal of Communications
Authorized by: Beijing Municipal Bureau of Statistics
Authorized No.: [2008]103
Valid Date: till 30th September, 2008

Travel Mode Codes

1. walk, 2. bicycle,
3. underground,
4. electrical bicycle,
5. public buses, 6. mini bus,
7. motorbike, 8. taxi,
9. company bus,
10. drive private car,
11. share private car(seated)
12. drive company car,
13. share company car(seated)
14. unlicenced taxi,
15. other, please specify_____

Trip Purpose Codes

1. to work, 2. to school,
3. go home, 4. to station
5. transfer,
6. return from somewhere, but not go back home,
7. shopping,
8. for gym or relax,
9. for dinner, 10. to the hospital,
11. visit family / friends,
12. entertainment,
13. on business,
14. give somebody a lift,
15. fetch car, 16. parking,
17. other, please specify______
18. Olympic related activities, please specify_________

Trip No.	Departure Time (24-hour)	Travel Mode(s) (codes)	Destination		Arrival Time (24-hour)	Travel Distance (metre)	Bus line No.	Travel Cost		Trip Purpose (code)
			District (code)	Facility (code)				Cash	IC card	
1	_(HH):_(MM)				__(HH):_(MM)					
2	_(HH):_(MM)				__(HH):_(MM)					
3	_(HH):_(MM)				__(HH):_(MM)					
4	_(HH):_(MM)				__(HH):_(MM)					
5	_(HH):_(MM)				__(HH):_(MM)					
6	_(HH):_(MM)				__(HH):_(MM)					
7	_(HH):_(MM)				__(HH):_(MM)					
8	_(HH):_(MM)				__(HH):_(MM)					
9	_(HH):_(MM)				__(HH):_(MM)					
10	_(HH):_(MM)				__(HH):_(MM)					

Facility Codes:
1.hotel, 2.office, 3.business/service centre, 4.market, 5.hospital, 6.stadium/sport facilities, 7.museum/library, 8.cinima/theatre, 9.school, 10.residence/apartment, 11.exhibition, 12.tourism place, 13.restaurant/entertainment, 14.airport/station/whalf, 15.factory, 16. other(please specify)__________

Member Code. (-in Household) in Form I: [ ]

Beijing Resident Travel Survey
Form III: Daily Vehicle Parking (Page 1 of 1)

Form Ref. No.: BJ-TPT-Q-1
Produced by: Beijing Municipal of Communications
Authorized by: Beijing Municipal Bureau of Statistics
Authorized No.: [2008]103
Valid Date: till 30th September, 2008

Facility Codes:
1.hotel,
2.office,
3.business/service centre,
4.market,
5.hospital,
6.stadium/sport facilities,
7.museum/library,
8.cinima/theatre,
9.school,
10.residence/apartment,
11.exhibition,
12.tourism place,
13.dinner/entertainment,
14.airport/station/whalf,
15.factory,
16.other (please specify)
____

Parking Codes
1.temporary parking (roadside),
2.on-street parking (with parking lot),
3.on-street parking (without parking lot),
4.under-flyover parking,
5.parking lot attached to public facilities,
6.off-street parking lot,
7.residential area parking,
8.parking lot belongs to company/organization,
9. other, please specify

Trip No. (Refer to Form II)	Time of entering parkings (24-hour)	No. of passengers (exc. driver)	Walking time from parking to final destination (minutes)	Walking distance from parking to final destination (metre)	Time of leaving parkings (24-hour)	Parking fee -- Once (RMB)	Parking fee -- Monthly (RMB)	Parking Code	Facility Code for parking	Address of Parking
	__(HH):_(MM)				__(HH):_(MM)					
	__(HH):_(MM)				__(HH):_(MM)					
	__(HH):_(MM)				__(HH):_(MM)					
	__(HH):_(MM)				__(HH):_(MM)					
	__(HH):_(MM)				__(HH):_(MM)					
	__(HH):_(MM)				__(HH):_(MM)					
	__(HH):_(MM)				__(HH):_(MM)					
	__(HH):_(MM)				__(HH):_(MM)					

Night parking (Normal)	Time of entering parkings (24-hour)	No. of passengers (exc. driver)	Walking time from parking to home (minutes)	Walking distance from parking to home (metre)	Time of leaving parkings (24-hour)	Parking fee -- Once (RMB)	Parking fee -- Monthly (RMB)	Parking Code	Facility Code for parking	Address of Parking
	__(HH):_(MM)				__(HH):_(MM)					

Note: 1) everv user of all kinds of vehicle except motorbike and taxi are required to fill in this Fomr III. Please refer to Form II when vou fill this.
2) please use the record of more often user for 'night parking'form, in case there are two or even more users of the car during the day.

Member Code (-in Household) in Form I: [ ]

Beijing Resident Travel Survey
Form IV: Drive routes (Page 1 of 1)

Form Ref. No.: BJ-TPT-Q-1
Produced by: Beijing Municipal of Communications
Authorized by: Beijing Municipal Bureau of Statistics
Authorized No.: [2008]103
Valid Date: till 30th September, 2008

Trip No. (Refer to Form II)	Main roads or junction travelled -- I	Main roads or junction travelled -- II	Main roads or junction travelled -- III	Main roads or junction travelled -- IV	Main roads or junction travelled -- V
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Note: 1) please only include trips made by non-public transport, including private car and company car, etc.
2) Main road: roads with two and more lanes in each direction, such as Chang'an Str. and Liangguang Rd.
Main junction: flyover as well as those biggest junctions, e.g.: Xinxing Flyover, Xisi junction, etc.

Note: If your household type is not 'family', please skip the section below and go to the questiones on the last page. Otherwise, please complete this section: 'Background information about your family'.

Background information about your family

Do you mind giving some information for the questions below, which are about your family background and only for research purpose? We will keep it confidential strictly.

A. Accommodation type of your family: _____, with ______ rooms in total. Covered area is ____Sq².

B. Is there any **private car** belonging to your family or **company car** allocated to you, which you could keep overnight?

1. Use company car(s), please fill the form below.
2. Own private car(s), please fill the form below.
3. Neither, please go to Question C directly.

Veh. No.	Vehicle Ownership	Vehicle Type (code)	Main user(s) (please us Member Code-in Household filled in Form I)	Vehicle registed place	If under control policies	
					1st survey day	2nd survey day
1	1) Company car, 2) Private car					
2	1) Company car, 2) Private car					
3	1) Company car, 2) Private car					
4	1) Company car, 2) Private car					
5	1) Company car, 2) Private car					

Vehicle Type

1. Motorbike,
2. Mini van,
3. Car,
4. Small truck,
5. Lorry
6. Other, please specify ______

Accommodation type

1. Bungalow,
2. Economic accommodation
3. Ordinary dwelling,
4. Commercial residential building,
5. Apartment,
6. Villa,
7. Other, please specify _____

If under control policies on the survey day:
1. Yes, 2. No

C. Number of household owned bicycles =____, electronic bicycles =____.

Could you please provide some information for the last questions, which will be used for research purpose only.

D. Have you bought ticket(s) for this Olympics? （1. Yes, 2. No） What sport(s)? ____________________ (please specify).

E. How early are you going to arrive at the venue for this competition?
1) not earlier than 30 minutes in advance, 2) 30 minutes – 1 hour in advance, 3) 1-1.5 hours in advance, 4) 1.5-2 hours in advance, 5) earlier than 2 hours before it starts

F. If you won't go to watch competitions, do you have any plan to have sightseeing around the Olympic venues?
1) Yes, 2) No

G. Will any relatives / friends come to stay in your accommodation during Games time?
1) Yes, 2) No

H. Are you going to have day(s) off during Games time? 1) Yes, 2) No

What is your plan for that then? (Multiple choices possible) 1) rest at home, 2) travel to somewhere outside Beijing, 3) relax in Beijing, 4) watch competition at venue. 5) Other, please specify ____________

I. Travelled by public buses and underground on the competition day will be free of charge for ticketed spectator. How will you go to the venue? (Multiple choices possible, please select **Travel Mode Codes** from Form II) _________________.

J. （***for household with car only***） To ensure the environment quality during Olympic Games time, your car will be under controlled. How will you go to work? (Multiple choices possible, please select **Travel Mode Codes** from Form II and rank the most important one firstly) _________________.

K. Which category below best describes

Your household monthly income: _____

(one answer only)

1500 Yuan or less	1	5501-10000 Yuan	5
1501-2500 Yuan	2	10001-20000 Yuan	6
2501-3500 Yuan	3	20001-30000 Yuan	7
3501-5500 Yuan	4	30001 Yuan or above	8

End of survey, thank you for all your supports again!

Appendix II. Concepts on the Transport Policies for Olympic Games

Basic information

Ref. No.:____Investigator:_______________________________________

Location:___________________________________Date: ___(MM)___(DD)

District:

Do you have access to a car? Yes _, including __Company Car(s) / _Private Car(s).

Number:

Background Information :

- Gender : **Male** □ **Female** □
- Age : **19 or under** □ | **20~29** □ | **30~39** □ | **40~49** □ | **50~59** □ | **60 or older** □
- Monthly income: ___________ (please select one answer below)

a. 1500 Yuan or less	b. 1501-2500 Yuan	c. 2501-3500 Yuan	d. 3501-5500 Yuan
e. 5501-10000 Yuan	f. 10001-20000 Yuan	g. 20001-30000 Yuan	h. 30001 Yuan or above

- Occupation ___________

a. Senior member of government or state-owned (collective) enterprise.
b. Government official.
c. Professional (academic, teacher, doctor, editor, journalist, etc.)
d. Private enterprise owner.
e. Lawyer, tax advisor, accountant, consultant.
f. Self-employed
g. Soldier, policeman
h. Student
i. State-owned (collective) enterprise staff.
j. Private company staff.
k. Retired.
l. Unemployed.

About the measures and your travel

Measures		
A. Odd-even alternate day-off	B. Altering working hours	C. Temporary traffic controls
D. Freight trucks/lorries control	E. Stop all high-emission vehicles	

1. What measures above have you heard about? ______ (Please rank the most familiar firstly).
   How did you know about these? __________ (Please select from below)
   a. Television, b. Newspaper, c. Broadcast, d. Flyers,
   e. Internet, f. Employers, g. SMS, h. other

2. In your opinion, which measures are most helpful for the transport operation during Olympic Games time?
   (Please select three measures and rank the most helpful one firstly)
   Other (please specify) ________________.

3. For Games time, what is your opinion towards to the measures above?
   (Please rank the strongest agreed or disagreed ones at first and less ones behind）
   You agree with: ; disagree with:

4. For the period after the games, what is your opinion towards to the measures above?
   (Please rank the strongest agreed or disagreed ones at first and less ones behind）
   You agree with: ; disagree with:

5. Your company offered ___ days' holiday during the games, while you actually took ___ days off.

6. At normal time before the Games, the office working time started at: ___ (hh) ___ (mm).
   During Games time, this time is changed (a. earlier; b. later) by: ___ (hh) ___ (mm).
   During Games time, your actual departure time for commuting is (a. earlier; b. later)
   By: ___ (hh) ___ (mm).
   If no changes during the games, it is because:
   a. school timetable doesn't change b. Travel habit c. for life d. for work
   e. no relative policies applied f. other

7. If certain tax discount provided, would you like to join the campaigns of using car less? __ Yes/No
   If yes, how many days off do you prefer?
   a. odd-even alternate day-off; b. one day off per week;
   c. two days off per week; d. other (please state________)

8. Would you like to take car-pool or share car with others, supported by relative policies? __ Yes/No

9. Do you have any suggestion for future transport policies in Beijing?

Appendix III. Questionnaire for Beijing CAR USERS (2008)

Dear citizen,
Beijing government takes several traffic measures during games time for ensuring smooth Olympic operation. In order to evaluate the performance of these measures, we launch this survey. Thanks for your time and cooperation of giving your valuable information.

■ Identification

1. If your car with Beijing license plate? **Yes□No□**
2. Are you a car-dependent in week days? **Yes□No□**

If only your answers to both questions above are yes, please continue following questions.

■ Your trips

During the Beijing Olympic & Paralympic Games time, your vehicle will be applied with the Odd-even alternate day-off control, please give you answers for the days when your vehicle is allowed or not respectively:

A. On the days your vehicle is under the traffic controlled and not allowed:

1. Your travel **less □ similar □ more □** compared with normal.
2. Main travel mode _______

(multiple choices possible, please rank according the Importance, put most Important one firstly)

a. Private car	b. Company car	c. Taxi	d. Car sharing	e. Company bus	f. Rent car
g. Public buses	h. Underground	i. Bicycle	j. Walk	k. Other	

**If you have chosen a or b, please continue question 3, otherwise go to Section B directly.*

3. You choose to drive because you _________
   a. own different vehicles with odd and even license plates.
   b. borrow from others
   c. have the vehicle pass
   d. other, please specify: _________________

B. On the days your vehicle is allowed:

1. Your travel times are **less □ similar □ more □** compared with normal.
2. Main travel mode _______

(multiple choices possible, please rank according the Importance, put most Important one firstly)

a. Private car	b. Company car	c. Taxi	d. Car sharing	e. Company bus	f. Rent car
g. Public buses	h. Underground	i. Bicycle	j. Walk	k. Other	

3. Your drive route will keep the **same □ / change to avoid games areas □.**
4. Is there anybody sharing your car as a result of the traffic control? **Yes □ No □**

■ Your opinion on the traffic policies

1. Your daily schedule might be changed during Games time, because: _______

(multiple choices possible, please rank according the Importance, put most Important one firstly)

a. go to watch competition at Olympic venue
b. go to some public venue for watching the games (e.g.: road events)
c. watch competition on TV
d. attend Olympic-related event (not competitions)
e. provide service/work for the Olympics
f. no change

2. Which policies effect on your choice of travel mode most? _______

(multiple choices possible, please rank according the Importance, put most Important one firstly)

a. Odd-even alternate day-off control
b. alter working hours
c. changes on operate hours of shops
d. other temporary traffic control
e. vacation encouragement
f. government appeal and public call

3. Do you think transport is getting smoother in Beijing now? Yes □ No □

** if yes, please continue, otherwise go to question 5.*

4. Which policies below you think are best contribute to the improve on Beijing transport?

    ____

(multiple choices possible, please rank according the Importance, put most Important one firstly)

a. Odd-even alternate day-off control
b. alter working hours
c. changes on operate hours of shops
d. other temporary traffic control
e. vacation encouragement
f. government appeal and public call
g. other, please specify _________
h. not relevant

5. You don't drive when your car is allowed, because ___

(multiple choices possible, please rank according the Importance, put most Important one firstly)

a. drive is not convenient.
b. public transport is easier.
c. take a break.
d. the government calls for driving less.
e. other

■ Your personal information

1. Gender：**Male □ Female □**

2. Age：**19 or under □ | 20~29 □ | 30~39 □ | 40~49 □ | 50~59 □ | 60 or older □**

3. Your monthly income is about ________RMB.（please select from below）

a. under 1500	b. 1500-2500	c. 2500-3500	d. 3500-5500
e. 5500-10000	f. 10000-20000	g. 20000-30000	h. above 30000

4. Occupation: _____(one answer only)

a. Senior member of government or state-owned (collective) enterprise.
b. Government official.
c. Professional (academic, teacher, doctor, editor, journalist, etc.)
d. Private enterprise owner.
e. Lawyer, tax advisor, accountant, consultant.
f. Self-employed
g. Soldier, policeman
h. Student
i. State-owned (collective) enterprise staff.
j. Private company staff.
k. Retired.
l. Unemployed.

End of survey, thank you for your kindly support again!

No:
Surveyor:
Date: __MM __DD,
District of survey:___ Location of survey:
Reviewed by: ______

Form Reference No.: 5-1
Produced by：Beijing Municipal Committee of Communications
Authorited by：Beijing Municipal Bureau of Statistics
Authorited No.：[2008]103
Valid Date：Auguest, 2008

Appendix IV. Questionnaire for Beijing Public transport passengers (2008)

Dear citizen,
Beijing government takes several traffic measures during games time for ensuring smooth Olympic operation. In order to evaluate the performance of these measures, we launch this survey. Thanks for your time and cooperation of giving your valuable information.

■ Identification

3. Are you a car-dependent in week days? **Yes□No□**

If only your answers to both questions above are yes, please continue following questions.

■ Your opinion on the traffic policies

5. Which policies effect on your choice of travel mode most? _______

(multiple choices possible, please rank according the Importance, put most Important one firstly)

a. Odd-even alternate day-off control
b. alter working hours
c. changes on operate hours of shops
d. other temporary traffic control
e. vacation encouragement
f. government appeal and public call

6. Your daily schedule might be changed during Games time, because: _______

(multiple choices possible, please rank according the Importance, put most Important one firstly)

a. go to watch competition at Olympic venue
b. go to some public venue for watching the games (e.g.: road events)
c. watch competition on TV
d. attend Olympic-related event (not competitions)
e. provide service/work for the Olympics
f. no change

7. Your travel **less □ similar □ more □** compared with normal.

8. Main travel mode at normal time _______

Main travel mode during Games time _______(multiple choices possible, please rank according the Importance, put most Important one firstly)

a. Private car	b. Company car	c. Taxi	d. Car sharing	e. Company bus	f. Rent car
g. Public buses	h. Underground	i. Bicycle	j. Walk	k. Other	

9. How do you feel about the public transport service in Beijing now, comparing last year?

Speed: **much faster □ a little bit faster □ similar □ slower □**

In-vehicle: **more crowd □ similar □ less crowd □**

Waiting time: **longer □ similar □ shorter □**

■ Your personal information

4. Gender : **Male □ Female □**

5. Age : **19 or under □ | 20~29 □ | 30~39 □ | 40~49 □ | 50~59 □ | 60 or older □**

6. Your monthly income is about _________RMB. (please select from below)

a. under 1500	b. 1500-2500	c. 2500-3500	d. 3500-5500
e. 5500-10000	f. 10000-20000	g. 20000-30000	h. above 30000

4. Occupation: _____(one answer only)

a. Senior member of government or state-owned (collective) enterprise.
b. Government official.
c. Professional (academic, teacher, doctor, editor, journalist, etc.)
d. Private enterprise owner.
e. Lawyer, tax advisor, accountant, consultant.
f. Self-employed
g. Soldier, policeman
h. Student
i. State-owned (collective) enterprise staff.
j. Private company staff.
k. Retired.
l. Unemployed.

End of survey, thank you for your kindly support again!

No:
Surveyor:
Date: __MM __DD,
District of survey:___ Location of survey:
Reviewed by: ______

Form Reference No.: 5-1
Produced by: Beijing Municipal Committee of Communications
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Valid Date: Augeust, 2008

Appendix V. Explanation of standardization variables

Standard Code	Variables						
	Gender	Age	Area	Access to car	Drive experience	Travel mode	Journey Purpose
0				No car	Not drive		
1	Male	0-14	Dongcheng	With car	<5	Walk only	Commuting
2	Female	15-24	Xicheng		>=5, <10	Cycle	Education
3		25-34	Chongwen		>=10, <20	Subway	Shopping
4		35-44	Xuanwu		>=20, <30	Mix use of public transport	Leisure
5		45-54	Chaoyang		>=30	Bus	Hospital
6		55-64	Fengtai			Car+Public transport	Business
7		65-74	Shijingshan			Private+Company Cars	Serve passenger
8		75+	Haidian			Taxi	Other
9						Company coach	
10						Private car (drive)	
11						Private car (passenger)	
12						Company car (drive)	
13						Company car (passenger)	
14						Other	

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