TRAVEL DEMAND MANAGEMENT OPTIONS IN BEIJING

ASIAN DEVELOPMENT BANK

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ASIAN DEVELOPMENT BANK

6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel +63 2 632 4444; Fax +63 2 636 2444
www.adb.org

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Foreword

Beijing, the capital of the People's Republic of China (PRC), is one of the most economically advanced cities in the PRC, with a population of 21 million. Beijing symbolizes the country's rapid economic growth and serves as a model of urban development. Its transport policy influences other large cities in the PRC. The magnitude of its transport-related problems—and the implications for other large cities and for global climate change—is also attracting considerable international attention.

Rapid urbanization and motorization, combined with high population density, have led to serious congestion and air quality problems in Beijing. While Beijing accounts for less than 2% of the PRC's population, it has more than 10% of its vehicles. The number of registered vehicles grew by an average annual rate of 13.8% from 1997–2009, and the number of vehicles almost doubled in 2015 compared to 2009.

This study supports the Beijing Municipal Government (BMG) in finding suitable and sustainable solutions to its urban transport problems. The Asian Development Bank's (ADB) technical assistance project—Beijing Urban Sustainable Transport—was designed to cooperate with the multiyear research project jointly administered by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Beijing Transportation Research Center (BTRC). Three policy challenges identified were (i) travel demand continues to grow, (ii) continued improvements to public transport alone are insufficient in addressing Beijing's transport challenges, and (iii) effective management of the direction, pace, and density of urban developments is critical.

The current study identifies several directions for improving Beijing's approach to travel demand management (TDM): (i) a multipronged suite of measures continues to be necessary, (ii) congestion charging offers the opportunity to manage demand, and associated congestion and emissions, and (iii) retention of the vehicle ownership quota and progressive reforms of parking and other TDM measures is essential.

This study is part of ADB's initiative to support greener and more sustainable transport that aims to provide society with a transport system that will bring comfort and convenience, and lessen carbon dioxide emissions.

Ayumi Konishi
Director General
East Asia Department
ADB

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Abbreviations

ADB	Asian Development Bank
ASI	avoid–shift–improve
BMG	Beijing Municipal Government
BRT	bus rapid transit
BTRC	Beijing Transportation Research Center
CBD	central business district
CNY	yuan
DMC	developing member country
GDP	gross domestic product
GHG	greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German International Cooperation Agency)
HOV	high occupancy vehicle
ITS	intelligent transportation system
km	kilometer
kph	kilometer per hour
LEZ	low emission zone
MOC	Ministry of Construction
MOT	Ministry of Transport
MRT	mass rapid transit (rail)
NMT	nonmotorized transport
PBS	public bicycle sharing
$PM_{2.5}$	particulate matter (<2.5 microns)
PM_{10}	particulate matter (<10 microns)
PRC	People's Republic of China
TDM	travel demand management
TPI	traffic performance index
µ	unit of mass equal to one millionth (1×10^{-6}) of a gram

Executive Summary

The Beijing Municipal Government (BMG) implemented "28 Measures to Relieve Traffic Jams" in December 2010 which provided traffic support for the comprehensive promotion of a "culture-enriched Beijing." This publication evaluates the current TDM measures, and suggests suitable and sustainable solutions to Beijing's urban transport problems.

Longer term measures examined included studying the potential for congestion charging, optimizing the usage of existing infrastructure, and providing good quality public transport to accommodate passengers diverted from private vehicle use.

Three key policy challenges can be determined from Beijing's extensive experience with the expansion of multimodal transport infrastructure, introduction of TDM, and changes in the organizational arrangements for urban transport:

(i) **Travel demand and motorization continue to grow rapidly.** Current TDM measures appear to be fairly effective as they tackle both the ownership and use of vehicles but much more remains to be done.

(ii) **Continued improvements to public transport alone are insufficient in addressing Beijing's transport challenges.** The quadrupling of subway length and bus services since 2003 has been extremely beneficial in providing an alternative to private vehicle use and acts as a "relief valve" to congestion. Nevertheless, while combined subway and bus usage has increased by more than 50%, a large component of this growth was apparently diverted from bicycle usage. With the introduction of the vehicle quota and the one-day-a-week driving restriction and other measures, car use seems to have peaked and declined slightly, as the proportion of daily trip making is growing.

(iii) **Effective management of the direction, pace, and density of urban development is critical.** While population and household income growth have been key drivers of travel demand, the demand for affordable housing and modern commercial offices has driven much new development to the edge of the expanding urban area. The building of new large roads on the fringes of the urban area too far in advance of urban development may contribute to urban sprawl. The current institutional responsibilities for urban development, transport infrastructure provision, TDM, and provision of public transport have improved in recent years at city level, but there is room for further coordination improvements.

The current study identifies several directions for improving Beijing's approach to TDM:

(i) **A multipronged suite of measures continues to be necessary.** Beijing has already demonstrated that a comprehensive approach to addressing congestion, accessibility, road safety, and emissions is essential to merely keep pace with growing demand. This has involved provision of public transport infrastructure and services, enhancement of conditions for walking and cycling, restrictions on car ownership and use, and pricing measures for parking and public transport. Greater research and careful planning of measures is needed to ensure the most beneficial are implemented. In the past, not all TDM measures were subject to detailed study prior to being proposed.

(ii) **A comprehensive approach to congestion charging is essential.** Various forms of congestion charging appear to offer significant traffic congestion relief and reduction in emissions, and do so in an equitable and transparent manner. In contrast to other types of transport improvement, charging of road use tends to minimize the potential to create new demand, as a result of reduced traffic congestion. The objectives for congestion charging vary considerably and the choice of objective(s) will influence the form of the congestion scheme adopted. A dual focus on environment and revenue raising may lead to a different form of congestion scheme and associated measures with targeted use of revenues for public transport and other urban realm improvements. For travelers on all modes to perceive the beneficial impact, a comprehensive congestion charging policy is required that covers the majority of roads in Beijing. While a limited form of congestion charging could be implemented in a small part of Beijing initially, this needs to be seen as a transition to a larger scheme that ultimately could be a distance-based charge, where the distance-based charge could vary to reflect congestion at different periods of the day.

(iii) **Retention of the vehicle ownership quota and progressive reforms of parking and other TDM measures is essential even if a form of congestion charging is pursued.** Experience shows that the demand for car ownership and use of cars is extremely high. Congestion charging alone cannot reasonably curb this demand. Significant "quick wins" are available to enhance the management of travel demand apart from planned rail mass rapid transit (MRT):
- Develop new extensive bus lanes and bus rapid transit (BRT) corridors;
- Strategically extend an improved public bike sharing scheme primarily within the Fifth Ring Road, and enhance opportunities for use of individually owned bicycles to access rapid transit stations (bus and rail) and bus stops;
- Improve the efficiency of traffic management, including the design of urban expressways based on how these actually operate;
- Enhance sidewalks and pedestrian facilities throughout the city, in particular connecting to rapid transit stations and bus stops or linking activity areas to residential areas; and
- Continue to rationalize the pricing and management of parking cars throughout the city.

Other matters to consider should congestion charging be pursued are:

(i) **Revisions to current road use charges.** The current system of road use charges does little to moderate use of vehicles during congested times and in congested locations; registration charges are a fixed charge that does not vary with distance (or time of travel) and encourages extensive vehicle use once these charges are paid. Fuel excise charges do not vary by time of travel. A suitable congestion charging scheme could allow some existing charges to be reduced (e.g., motor vehicle registration and driver license fees) so that these charges then might simply recover their ongoing administration costs. Such an approach may be useful to convince car and fleet owners of the merits of congestion charging.

(ii) **Sophisticated travel demand forecasting tools.** Development of an explicit congestion charging scheme requires careful preparation, sound feasibility assessments, and a robust transport modeling capability sensitive to the critical policy issues. The Government of the PRC, with the support of GIZ and ADB, is already using a very advanced sophisticated transport model, but further refinements are possible, for example, to include time period modeling. London's congestion charging scheme has shown a charge's impact can have far-reaching short and medium to long-term effects. The short-term effects include changes in travel patterns manifested in traffic diversion (time, location, and route), modal switching, and more. In the medium to long term, the effects of changes in land use, including impacts on the property market and business, could all be significant. The impact of charges can have very different effects on cars, trucks, and other vehicle users (and revenue expectations).

(iii) **Monitoring impacts of a road use charging scheme.** If it is decided to proceed with an explicit road use charging scheme, a suitable monitoring program will be needed to respond to all stakeholders' concerns, to measure actual outcomes, and to identify needed management interventions. Even with the most sophisticated forecasting and planning tools, it is important to monitor the actual impacts on traffic, public transport, business, and other stakeholders. Many of these impacts will be quite subtle and may only be discernible in the medium to long term. Monitoring of the effects of any major transport change requires the establishment of a suitable baseline, and a monitoring program and defined survey methods that can be implemented at an appropriate time. Adequate budgets are also needed.

(iv) **Impact of congestion charging on the BMG and related organizational arrangements.** If it is decided to proceed with an explicit congestion charging scheme, an important consideration will be to define what the scheme entails, including the various functional requirements of planning, design, operations, monitoring, and enforcement. The impact of these functions on the BMG and other relevant agencies should be defined in staffing, skills, budget, and necessary practical enforcement powers. Moreover, all relevant legislation needs to be reviewed to ensure the BMG has the power to set and apply charges, enforce the scheme, and carry out any other relevant actions to support the scheme's implementation and operation.

(v) **Optimal level of congestion charge.** A technical review would be desirable to establish the optimal charge and structure of charges. An optimal charge implies maximizing benefits to the community. Setting higher charges, even if practically possible, would reduce community benefits compared to the optimum, and may lead to perverse effects which may not be immediately apparent.

(vi) **Review of implementation and recurrent costs and continued review of advances in technology.** Detailed estimates of implementation costs need to be made based on promising and feasible options. Recurrent operations and maintenance costs estimates, and demand and associated revenue forecasts are needed. Technological advances should be continuously monitored, but it is clear from this study that a range of technology providers could implement even the most advanced charging scheme using proven technology and components.

CHAPTER I

Introduction

A. Background

Beijing, the capital of the People's Republic of China (PRC), had a population of 21.1 million in 2013, having grown by 47% from 2002. One of the most economically advanced cities in the PRC, Beijing symbolizes the country's rapid economic growth and serves as a model of urban development. Its transport policy influences other large cities in the PRC. The magnitude of its transport-related problems—and the implications for other large cities and for global climate change—is also attracting considerable international attention.

Rapid urbanization and motorization, combined with high population density, have led to serious congestion and air quality problems in Beijing. A recent study by IBM found that Beijing, Shenzen, and Mexico City were the worst of 20 global cities for traffic jams, with scores of 95, 95, and 108, respectively, out of a theoretical maximum of 100 for IBM's "commuter pain index."[1] While Beijing accounts for less than 2% of the PRC's population, it has more than 10% of its vehicles.[2] Per capita motor vehicle registration has surpassed the level of many leading cities in the world (1.8 times the level in Paris, 2.3 times of that in New York). The number of registered vehicles grew from 1 million in 1997 to 4.5 million in 2010, and the number of vehicles was expected to double by 2015.

The adverse effects of congestion have been estimated to cause significant economic losses. Congestion and air pollution costs contribute the most, although climate change and road injury costs are also substantial. Research has shown that more than three-quarters of the air pollution in Beijing come from vehicular carbon monoxide, particulate matter, and hydrocarbon emissions.

In December 2010, the Beijing Municipal Government (BMG) announced 28 new travel demand management (TDM) measures to reduce traffic congestion and vehicle emissions. These focused on (i) introducing quantitative restrictions on vehicle ownership and peak-hour usage, (ii) providing more parking spaces and park-and-ride facilities, and (iii) prioritizing public transport and road construction to address bottlenecks. Most of these are aimed at producing temporary relief from congestion. More comprehensive and long-term approaches are also urgently needed. This study evaluates the current TDM measures, and suggests suitable and sustainable solutions to Beijing's urban transport problems.

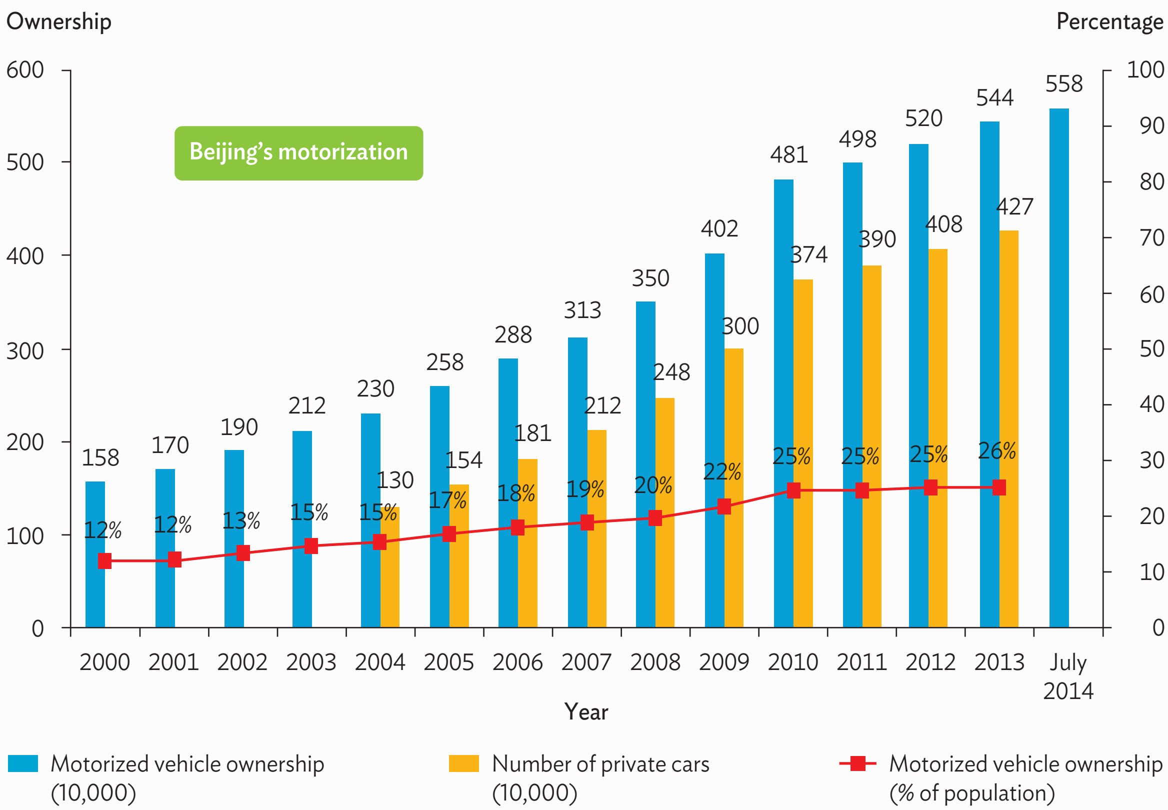
B. Current Urban Transport Issues

Population and motor vehicles growth. With its population of 21.1 million at the end of 2013, Beijing is the PRC's most populated city. It also has the largest fleet of cars with 4.27 million cars registered at the end of 2013, of which individuals owned 72%, and the rest owned by public enterprises and private firms.

1 IBM. 2011. Commuter Pain Index. http://www-03.ibm.com/press/us/en/photo/35360.wss (accessed 15 April 2015).

2 Footnote 1.

Figure 1: Motorization and Car Availability, 2000–2014



Note: Growing motorization in Beijing is putting pressure on road capacity and contributing to air pollution.

Source: Based on data from Beijing Traffic Management Bureau. 2014. Traffic Management Data from 2000. http://www.bjjtgl.gov.cn/publish/portal0/tab803/

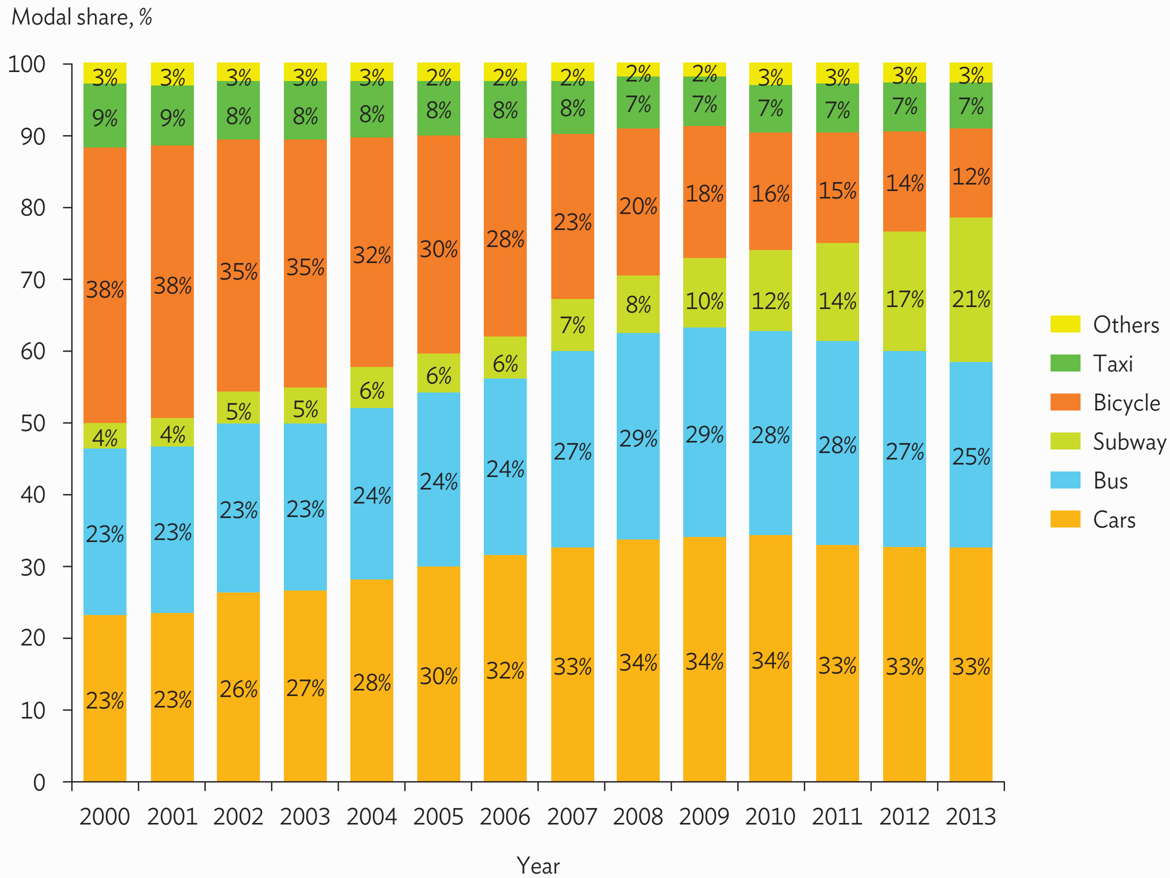
Private car ownership grew at a compound annual growth rate of 9.8% per annum between 2000 and mid-2014 with the fleet increasing by 250% over the period. Population growth was a more modest 3.4% per annum over the same period, but due to nominal gross domestic product (GDP) growing by 15% per annum, nominal per capita income rose at 11.2% per annum (Figure 1).

Growth in travel 2005–2010. Within the Sixth Ring Road, total daily person trips increased from 29.2 million in 2005 to 41.3 million in 2010 with the trips per capita growing from 2.64 trips per capita in 2005 to 2.82 in 2010. Of the total daily person trips, only 0.8% of all trips were reported as "business" in the recent household travel survey so may likely be underestimated. In Beijing, trucks are banned from entering the Fifth Ring Road during peak hours. Therefore, trips to carry goods to the city center are shifted to other time periods or substituted by ordinary car trips. In the peak periods, it is estimated that 10.7% of traffic on Beijing's roads in the morning peak period, and 36.5% of traffic in the evening peak period are business-related trips.[3] Increased energy use and greenhouse gas emissions (GHGs) accompany this growth in motorized travel with impacts on climate change.

[3] PTV Group. 2014. *Updating and Enhancement of the Beijing VISUM Transport Model—Model Calibration and Model Validation Report.* January.

The estimated modal shares excluding walking[4] from 2000 to 2013 as observed by household travel surveys conducted by the Beijing Transportation Research Center (BTRC) are shown in Figure 2. In 2003, private car travel represented 27% of daily trips (excluding walking). Public transport trips (bus and subway) represented 28% of trips at the time. With an increase from 4 to 18 subway lines, and a quadrupling of its length over 2003 to 2013, plus extensive TDM measures introduced since 2008, including "28 Measures" in 2010 the share of daily passenger trips by car peaked at 34% of daily trips in 2008, 2009, and 2010, after which it declined to 33% of daily trips. At the same time, public transport's share grew from 28% of daily trips in 2003 to 40% of daily trips by 2010, and has since grown again to 46% by 2013. Much of this growth appears to be at the expense of cycling which was 35% of daily trips in 2003, 16% in 2010, and 12% in 2013. Cycling declined slightly and so did cars' share of daily trips (down from 34% in 2010 to 33% in 2013).

Figure 2: Changes in Modal[a] Shares, 2000–2013



[a] excludes walking trips.

Source: Beijing Transportation Development and Research Center. 2014. *Beijing Traffic Development Annual Report.* Beijing.

[4] Walking was estimated to represent 1,270 trips per day in 2010. This report relies on typical reporting by BTRC of travel demand characteristics in which walking trips are often not included. Accordingly, despite the importance of walking as a mode of travel, walk trips are not featured in the majority of tables and figures in which travel data or analysis results are presented.

Rapid decentralization of land use activities is occurring due to an increasing demand for more spacious housing, modern offices, and industrial estates; and a shortage of reasonably priced land in and around the Fifth Ring Road. These trends are underpinned by the growth in private vehicle ownership and increased commuting distances. The built-up area has expanded by 40% since 2000 covering the period 2000–2013.

Vehicle availability and annual vehicle activity. Vehicle availability almost doubled from 2003 to 2013, with the rate of vehicles per capita[5] growing from 0.15 in 2003 to 0.26 in 2013. For private cars alone, there were 3.74 million cars owned by 21.1 million people and their 8.75 million households in 2010.[6] Therefore, car availability was about 0.35 cars per household, much lower than in the US, Europe, and Australia, where households have one or more cars on average; but not much less than Singapore where only 50% of households[7] have access to a car due to high costs of ownership and other disincentives to use. In Hong Kong, China, just above 21% of households had access to a car in 2013.[8]

Average annual car mileages are high in Beijing with private cars traveling an average of 19,600 kilometers (km) per year in 2010, and government vehicles traveling an average of 28,700 km per year.[9] The mileage for private cars indicates that cars are used intensively due to their still relatively low availability at the household level.[10] Official data shows that as car ownership increases, annual car mileages decline, as expected where car ownership rates per household are still low. From 2002 to 2008, the estimated growth in the private car fleet was 127%, but at the same time, annual average car mileages declined from 27,000 in 2002 to 21,600 in 2008, a reduction of 10%.[11]

C. Growing Congestion and Declining Accessibility

Traffic congestion impacts. Traffic congestion has a significant impact on public transport passengers, motorists, pedestrians, cyclists, and the community at large through excessive air pollution, GHG emissions, noise, and road trauma. Average peak period traffic speeds across all roads in the network in 2007 averaged 22 kilometers per hour (kph) in the morning, and 19 kph in the evening, similar to other global megacities. Experience in other cities indicates that traffic speeds tend to remain stable in the range of 15 kph to 20 kph (i.e., moderate to high congestion) in central activity areas, but congestion spreads outward geographically with urban area expansion, and also to the off-peak periods, including weekends. Hence, commuting times tend to increase and become less reliable. In Beijing, traffic speeds are understood to have declined during the period from 2000 to 2007 due to the car fleet more than doubling.

5 All vehicles including private and nonprivately-owned cars.

6 At 2.4 persons per household.

7 Singapore Government Data. In 2014, there were 1.2 million households, and in 2014, 600,176 private cars registered, indicating a car availability of 0.5 per household. http://www.singstat.gov.sg/statistics

8 Hong Kong, China Government Data. In 2013, there were 2.409 million households, and in 2010, 500,000 private cars registered, indicating a car availability of 0.21 per household. http://www.censtatd.gov.hk/hkstat/sub/sp150.jsp?tableID=005&ID=0&productType=8; http://www.td.gov.hk/filemanager/en/content_4441/table11.pdf (accessed 25 February 2015).

9 GIZ. n.d. Work in Progress. p. 10.

10 For example, average car mileage in Australia for urban and rural areas combined is 14,000 km per annum but where households owned two or more cars on average. http://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0 (accessed 25 February 2015).

11 H. Huo et al. 2012. Vehicle-use Intensity in China: Current Status and Future Trend. *Energy Policy* 43. pp. 6–16.

Changes in trip distance and commuting time, 2005–2010. Table 1 shows that, except for the bicycle, average trip distances by mode increased by 27% in 2005–2010. In 2007, BTRC's Traffic Performance Index for peak periods was regularly in the range of 6 to 8 by 2007; when "moderate jams" were common, travel times were typically twice as long as travel during noncongested periods.[12] With the introduction of TDM measures in 2008, traffic speeds and journey time reliability slightly improved since that time. However, despite these speed improvements, with the 27% increased average trip distance, trip times increased sharply in 2005–2010, contributing to the perception that congestion is very severe.

Table 1: Changes in Trip Distances in 2005–2010 and Trip Times by Mode, 2010

	Trip Distance (kilometer)		**Trip Time** (minute)	
Mode	**2005**	**2010**	**2005**	**2010**
Car	11.1	11.5	39.8	38.9
Taxi	8.6	9.3	37.7	39.2
Metro	14.5	18.0	67.3	77.3
Bus	9.5	10.8	62.5	65.4
Coach	12.3	14.8	56.4	52.0
Bicycle	4.2	3.7	27.1	21.5
Walk only	0.8	0.9	not available	not available
Average	8.7	10.6	43.2	48.0

Source: Beijing Transportation Research Center.

New design standards may contribute to better management of congestion. The Ministry of Construction develops standards for expressway and ring road design. As in many other countries, these designs assume the roads operate as high-speed roads that are relatively uncongested and designed using the concept of uninterrupted flow. In fact, the roads are congested during peak periods and the closely spaced entry and exit ramps (sometimes as close as 95 meters),[13] and limited lane and ramp control exacerbates congestion. Ramp spacing is also related to the absence of an effective network of connecting roads between the rings and radials that could, for example, efficiently distribute major road traffic even if on and off ramp spacing were considerably further apart.

Congestion affects the level of service offered to passengers and productivity of road-based bus transport. Excessive urban traffic congestion reduces the number of revenue-earning trips a bus can make per day, and the slower operating speeds make bus use less attractive due to increasing passenger trip distances and delays affecting bus lane operation, despite expansion of bus services from 775 routes in 2003 to 1,020 routes

[12] The index measures whether the traffic flows freely or is congested with a range of 0–10 points and consisting of five categories: "smooth" (0–2 points), "basically smooth" (2–4), "slight congestion" (4–6), "moderate congestion" (6–8) and "severe congestion" (8–10). Higher points mean more severe congestion.

[13] X. Zhao et al. 2014. Calibrating and Modeling Expressway with Different Ramp Distances on Beijing 3rd Ring Road. *Procedia – Social and Behavioral Sciences.* 138. pp. 37–44.

in 2013, and the designation of 366 km of special bus lanes. Nevertheless despite the share of total trips on bus declining from 29% to 25%, the total number of passenger trips on bus increased from 470,863 in 2008 to 484,306 by 2013.[14]

Congestion is inequitable. Poorer groups in society, who may not have access to cars, have less ability than wealthier people to select home and workplace locations to minimize commutes or to mitigate the negative impacts of transport. The direct effect of excessive congestion on transport users include a reduced ability to access workplaces, educational establishments, and community facilities; and increased exposure to the risk of traffic-related crashes. As shown in Table 1, average bus and metro trip times are over 1 hour or twice that by car. Where road networks experience undue congestion, improvements in road transport supply would in many cases result in further private motorized travel, increased travel distances, and, thus, ultimately aggravating congestion and accessibility problems, and related impacts.

Economic cost of congestion. There are two recent estimates of the cost of congestion in Beijing. A 2012 study estimates that traffic congestion imposes costs of about CNY58 billion (4.22% of GDP)[15] in Beijing in 2010, including time delay cost, vehicle operating costs, road injuries, and environmental impacts. A 2008 study estimated the cost of congestion in 2005 to be at least CNY55 billion (2005 prices) or around 7.5% of Beijing's GDP.[16] This study also estimated that an optimal congestion toll[17] could realize welfare benefits of CNY21 billion per year.

D. Air Pollution and Greenhouse Gas Emissions

Dominant motor vehicle pollutant. Motor vehicles are estimated to contribute about 31% of locally generated fine particulate matter ($PM_{2.5}$) that represents about 70% of all such pollution, a critical pollutant against human health. The remaining 30% of $PM_{2.5}$ is transmitted from the surrounding region where industrial sources of particulate matter are dominant as shown in Figure 3. Air (and noise) pollution is a critical problem for Beijing, as illustrated in Figure 4.

Intensive multisector actions are improving air quality. Compared to 2010, in 2011, the concentration of major air pollutants: total suspended particulate (TSP) matter at 114 $\mu g/m^3$, sulfur dioxide at 28 $\mu g/m^3$, and nitrogen dioxide at 55 $\mu g/m^3$, were reduced by 5.8%, 12.5%, and 3.5%, respectively. In 2011, 74 days had an air quality of Grade 1, an increase of 40% compared to 2010, which for key pollutants such as PM_{10} and nitrogen oxides is the equivalent of the European standard. For example, the European daily average PM_{10} standard corresponds to a Chinese Grade I standard of 50 $\mu g/m^3$. However, the number of days with air quality no lower than the Grade II standard did not change between 2010 and 2011, remaining at 286 days. Grade II standards for PM_{10} and other key pollutants mean much worse air quality. For example, the Chinese Grade II standard for average daily PM10 is 150 $\mu g/m^3$, three times higher than the Chinese Grade I standard. Significantly, 80 days per year had a lower than Grade II air quality standard (Figure 5).

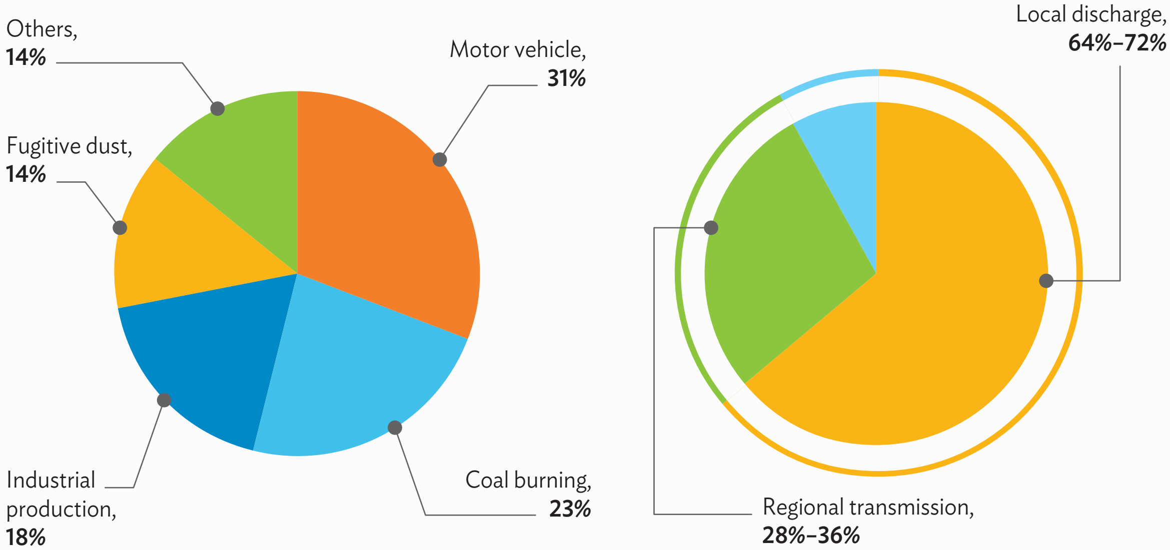
14 National Bureau of Statistics of China. 2014 and 2009. *China Statistical Yearbook.* Beijing.

15 L. Mao, H. Zhu, and L. Duan. 2012. *The Social Cost of Traffic Congestion and Countermeasures in Beijing Sustainable Transportation Systems.* pp. 68–76. doi: 10.1061/9780784412299.0010

16 F. Creutzig and D. He. 2008. Climate change mitigation and co-benefits of feasible transport demand policies in Beijing. *Transport. Res. Part D.* 2008. doi: 10.1016/j.trd.2008.11.007

17 This is the amount of congestion with optimal pricing of road use. Suggested by F. Creutzig et al. to be about RMB3 for congested inner zones of the city and RMB1 for less congested outer zones.

Figure 3: Sources of Particulate Matter (<2.5 microns) in Beijing, 2012–2013

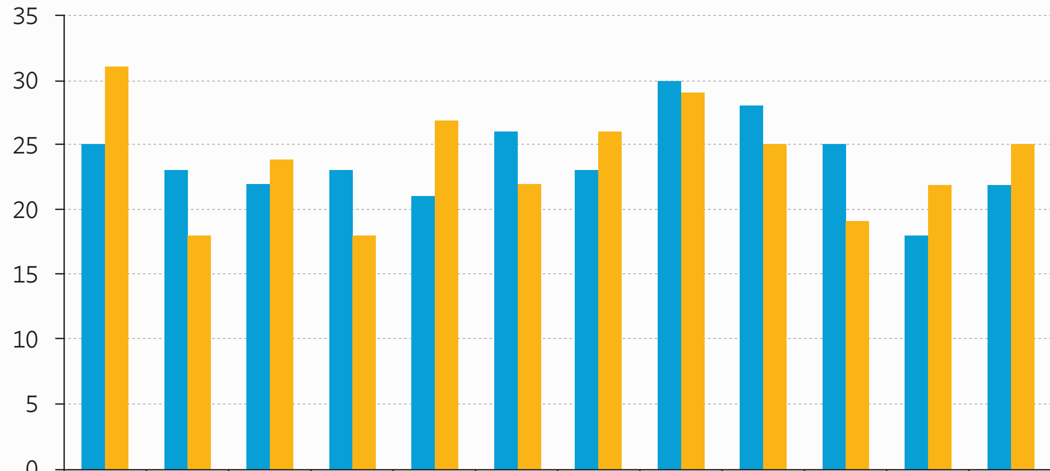


Source: Beijing Municipal Bureau of Environmental Protection. 2014. http://www.zhb.gov.cn/zhxx/hjyw/201404/t20140416_270592.htm (as reported by BTRC).

Figure 4: Air Pollution in Beijing

Source: Beijing Transportation Research Center.

Figure 5: Days with Air Quality No Lower than Grade II Standard



	1	2	3	4	5	6	7	8	9	10	11	12
2010	25	23	22	23	21	26	23	30	28	25	18	22
2011	31	18	24	18	27	22	26	29	25	19	22	25

Source: Beijing Municipal Bureau of Environmental Protection. 2012. *Annual Report.*

E. Compatibility of Institutional Arrangements

With a vast municipal land area, and as a premier region of the PRC, Beijing municipality has substantive control over transport policy, planning, and management within its boundaries. As in other cities, the institutional arrangements mirror the situation at the national level.

Overall responsibilities at national level. The National Development and Reform Commission (NDRC), under the Ministry of Finance, approves all expenditures, including for infrastructure, sets prices, and, in principle, has an important coordinating role across agencies. The Ministry of Construction (MOC) is the national level agency responsible for urban development and urban transport, except urban public transport services (rail, bus, and taxi) which have been the responsibility of the Ministry of Transport (MOT) since 2007. Despite the MOT's new role, a new policy on prioritization of public transport, including TDM, was issued by the NDRC as a Directive of the State Council in December 2012.[18]

[18] State Council Office. 2012. Directive 64 [2012]: State Council Directives on Prioritization of Urban Public Transport Development. 29 December.

National railways are the responsibility of the National Railway Administration (NRA) under the MOT. Planning and construction are the responsibility of the MOC, and operation, of the MOT. But responsibility for urban railways is not as clear-cut. Both the MOC and the MOT have limited staff resources assigned to urban transport, and so provide only limited policy guidance to municipal governments. Specialist Design Institutes attached to the MOC, the MOT, and the NDRC may be called upon to examine technical or policy questions. While it is broadly accepted that traffic management and road safety are multi-agency tasks, primary responsibility for this area rests with the Ministry of Public Security (MPS). Environmental management, including air quality management and control of vehicle emissions is the responsibility of the Ministry of Environmental Protection (MEP).

Key responsibilities within Beijing Municipality (refer to Table 2). This split of responsibilities for urban transport at the national level is reflected in the organizational structure at the municipal level. Economic policy and development and approval of infrastructure investment expenditures is the responsibility of the Beijing Municipal Commission of Development and Reform (BMCDR); urban planning and development control, of Beijing Municipal Commission of City Planning (BMCCP); infrastructure, of the Beijing Municipal Commission of Housing and Urban-Rural Development (BMCHURD); urban transport strategy, multimodal policy, planning and operations, of the Beijing Municipal Commission of Transportation (BMCT); traffic management, which includes traffic signals, area traffic control, pedestrian crossings, and on-street bus priority, of the Beijing Municipal Public Security Bureau (BMPSB) and its subordinate agencies; and emission control, of the Beijing Municipal Bureau of Environmental Protection (BMBEP). Implementation of land acquisition and resettlement is the responsibility of district level governments under the auspices of the BMCHURD. The railway operator is the newly-established Beijing Railway Corporation operating under NRA. Subways are operated by one municipal-owned operator and one municipal–private subway operator. Historically, horizontal coordination was poor but is improving through the BMCT's efforts.

A mapping of the key agencies by principal urban transport functions is shown in Table 3. Particular issues that affect effective urban transport provision and management are:

- **Horizontal coordination.** Although improving, effective horizontal coordination is challenging across multiple municipal institutions involved in transport. Priorities among the multiple municipal agencies may be different or sometimes even conflicting. Modal integration can be further improved. For TDM, for example, the Transport Team at the BMCCP does not work in close cooperation with those at the BMCT.[19] While the BMPSB has responsibility for pedestrian crossings and safety, it is not responsible for the design and implementation of pedestrian routes. This responsibility rests with the BMCC. Similar comments apply to the safety of cyclists and the provision of facilities for cyclists, including the creation of bicycle-dominant streets.
- **Design standards.** The MOC sets design standards for urban roads and public transport infrastructure, but these standards do not reflect how the roads are actually operated.

[19] Interview conducted by Royal Haskoning DHV. 2015. *Beijing Bicycle Strategy and Policy – The Way Back to World Bicycle Capital.* Prepared for ADB.

- **Goals for transport management.** The BMPSB is also responsible for policy on traffic management, and related local implementation of national policies, which tend to focus on smoothing traffic flow for motor vehicles. It appears the senior executives of these agencies do not give priority to pedestrians and nonmotorized transport. Furthermore, agencies of a lower level only report to their upper level departments that do not always coordinate well with others. Evidence of this is the lack of a cross-department action plan supporting nonmotorized or environmentally-friendly transport in Beijing.[20]
- **Regulator or operator division.** With the close relationship to the government of the limited number of subway and bus operators, there is little supervision of service level quantity and quality.
- **Transport pricing.** The BMCDR sets overall levels of fares, tolls, and charges, as influenced by national policy directives, not necessarily by the needs of local transport policy. Top-down control of prices hinders the introduction of market-based transport operations and services that could be facilitated with a more flexible approach to pricing with a policy change that encourages new entrants to the market. The 2011 parking reforms, by introducing differential prices by area, aimed for the first time to redirect motorists from the congested central districts. Parking management is devolved to the districts, with variations in actual prices, charges, and approaches, making systematic development of effective metro-wide parking problematic.[21]

Table 2: Policy, Regulatory, and Oversight Responsibilities

Agency	Responsibility
Beijing Municipal Commission of Transportation (BMCT)	• Provides leadership and coordination role in urban transport strategy, policy, planning, and operations. • Drafts transport strategy and master plan development, and integration with land use plans prepared by Beijing Municipal Commission of City Planning (BMCCP). • Provides long-term planning of the road and subway network. • Plans and manages public transport. • Prepares annual transport programs and funding requests. • Provides cycle sharing schemes and minor works. • Regulates the transport industry. • Develops policy, including for intelligent transport systems (ITSs). • Researches and prepares statistics, and evaluation of transport programs. • Its subordinate agencies below support the BMCT.
Beijing Municipal Roadway Administration Bureau (BMRAB)	• Administers and arranges maintenance of highways, city roads, railways, railway crossing, and facilities. • Implements and executes the laws, codes, and regulations on transportation facilities. • Manages safety of railway crossings, railways, highways, bridges, and supporting facilities. • Administers collection of highway tolls and fees.
Beijing Municipal Transportation Administration Bureau (BMTAB)	• Regulates traffic and transportation industry and water safety
Beijing Municipal Transportation Law Enforcement General Team (BMTLEGT)	• Enforces and monitors compliance of drivers and the transport operators and operations.

continued next page

20 Footnote 19, p. 10.
21 Institute for Transportation and Development Policy. 2015. *Parking Guidebook for Beijing.* Prepared for ADB.

Table 2: *Continued*

Agency	Responsibility
Beijing Municipal Public Security Bureau (BMPSB)	• Safeguards traffic security and order, and manages traffic incidents via its subordinate agencies, the main ones shown below.
Beijing Traffic Management Bureau (BTMB) – under Public Security Bureau (PSB)	• Licenses drivers. • Provides vehicle regulation; regulates vehicle use. • Manages roads and expressways. • Provides oversight and operation of traffic control system. • Provides oversight of static and real time transport information. • Ensures traffic safety; investigates, and researches.
Beijing Transportation Research Center (BTRC) – under PSB	• Researches urban transport development strategies, policies, and programs. • Studies urban traffic hotspots and bottlenecks. • Develops and maintains the traffic signal system and related ITSs. • Organizes and coordinates research. • Collects and disseminates urban traffic information. • Prepares annual report on major urban transport development.
Beijing Municipal Commission of City Planning (BMCCP)	• Prepares long-term land use master plans. • Prepares and implements municipal laws, regulations, and technical standards on urban and rural planning. • Provides oversight of plans, selects locations for construction projects, and issues permits for planned land use and planned construction projects; examines the initial design of construction projects, including transportation facilities.
Beijing Municipal Commission of Housing and Urban–Rural Development (BMCHURD)	• Plans, administers, coordinates, implements, and supervises comprehensive major projects (roads, subway, etc.). • Prepares standards for all construction works, including transport, • Responsible for land acquisition for infrastructure projects. • Regulates the construction industry. • Reviews and approves construction plans. • Facilitates provision of low-cost housing. • Responsible for guiding development of towns and villages around Beijing.
Beijing Municipal Commission of City Administration (BMCCA)	• Prepares municipal development strategies, annual, mid- and long-term programs for urban infrastructure, public utilities, and environmental sanitation; and organizes implementation. • Provides comprehensive management of the city's environment. • Guides urban infrastructure construction at the district and county levels (including sidewalks, parking management, associated facilities, and infrastructure).
Beijing Municipal Commission of Development and Reform (BMCDR)	• Approves investment expenditures, including for infrastructure. • Coordinates across agencies. • Sets, adjusts, and controls prices.
Beijing Municipal Bureau of Environmental Protection (BMBEP)	• Responsible for environmental protection of the city. • Oversees and manages the prevention and treatment of pollution of and/or from the atmosphere, water, soil, noise, solid waste, poisonous chemicals, and automobiles. • Drafts and implements local pollution emission standards and local environmental quality standards. • Coordinates enforcement of laws and regulations on environmental protection. • Monitors pollution and raises public awareness of environmental problems.

Sources: http://www.ebeijing.gov.cn/Government/Departments/t1024857.htm; http://www.bjtrc.org.cn/JGJS.aspx?id=2.1&Menu=JGJS; http://www.bjjtzf.gov.cn/english/ (accessed 26 February 2015).

Table 3: Mapping of Main Transport Agency Functions in Beijing

Function	Transport Sector Agencies			
	Rail, Subway	Other Public Transport	Roads and Road Vehicles	Traffic and Street Management
Policy and strategic planning				
	BMCT	BMCCP, BMCT	BMCT, BMCC	BMCT, BMCC
Program development and management				
Tactical planning	BMCT, BRC	BMCT, BTMB	PSB/BTMB	BMPSB/BTMB, BMCC for pedestrian, cycle facilities
Design	BRC	BMCHURD, Operators, BMCCA (sidewalk facilities)	BMCHURD, BMCCA	BMTB, BMCCA
Procurement of construction works, land acquisition	BRC	BMCHURD, BMCCA, Operators	BMCHURD, BMCCA	BMPSB, BMCC, BMCCA
Maintenance	BRC	BMRAB, BMCCA operator	BMRAB, BMCCA	BMCC, BMCCA
Financing	National budget	Municipal budget	Municipal budget	Municipal budget
Service delivery, including operations and maintenance				
Provision of services, operation	One municipal-owned and one municipal–private subway operator, one municipal-owned railway operator BRC	One municipal-owned operator, one independent operator	Contractors	BMTB for operation of traffic system, BTRC, districts manage parking
User fees and charges	BMCDR	BMCDR	BMCDR	BMCCA, districts for parking
Financing	Municipal budget, user fees	Municipal budget, user fees	Municipal budget, user fees and tolls	Municipal budget, user fees
Regulation and enforcement	BMCT/BMTAB, BRC	BMCT/BMTAB, BTMB	BMPSB, BMTLEGT	BMPSB, BMTLEGT, districts
Certification and safety regulation	BMRAB/MOT	BMRAB	BMRAB, BMPSB	BMRAB, BMPSB

BMCCA = Beijing Municipal Commission of City Administration, BMCCP = Beijing Municipal Commission of City Planning, BMCDR = Beijing Municipal Commission of Development Reform, BMCHURD = Beijing Municipal Commission of Housing and Urban–Rural Development, BMCT = Beijing Municipal Commission of Transportation, BMPSB = Beijing Municipal Public Security Bureau, BMRAB = Beijing Municipal Roadway Administration Bureau, BMTAB = Beijing Municipal Transportation Administration Bureau, BMTLEGT = Beijing Municipal Transportation Law Enforcement General Team, BRC = Beijing Railway Corporation, BTMB = Beijing Traffic Management Bureau, MOT = Ministry of Transport, PSB = Public Security Bureau.

Source: ADB.

CHAPTER II

Travel Demand Management Measures

A. Types of Travel Demand Management

Travel Demand Management (TDM) aims to reduce the usage by vehicles of the road system while providing a wide variety of mobility options for those who wish to travel. Early attempts at traffic management in Beijing prior to the 1980s generally sought to cater to demand, and to reduce peak period congestion. With the introduction of bus lanes in 1997 on Beijing's Chang'an Avenue on the Second Ring Road, and subsequent replication elsewhere in the city, there was formal recognition of the need to maximize person flows, rather than focusing solely on assisting car and low occupancy vehicle movements.

Figure 6: An Example of Bus Lanes in Beijing

Source: Beijing Transportation Research Center.

TDM may include measures to modify the time and place of travel, the mode used, or even the decision to travel at all. Ultimately, it may also be aimed at emissions reduction to improve local air quality and reduce global warming impacts. The range of transport infrastructure, traffic management, and TDM measures normally considered by transport authorities is extensive and includes:

- **Roadway capacity expansion.** New infrastructure and road widening in an attempt to reduce congestion and delays to traffic, although new infrastructure initially operating below capacity in peak periods would usually generate new demand.
- **Traffic management.** Traffic control system expansion, modifications to traffic signal cycle times and phasing, physical widening at intersections, providing "green waves" for cars to reduce vehicular delays.
- **Allocation of road space, and traffic signal cycle times, to favor bus, pedestrian and nonmotorized transport (NMT) movements.** Provision of High Occupancy Vehicle (HOV) lanes on major roads for vehicles with multiple occupants (e.g., buses and cars with three persons or more). Within traffic signal

networks, give preferential phases for buses at intersections or pedestrian movements in activity centers, such as shopping precincts and schools; and simplify intersection layouts to increase capacity.

- **Physical controls.** Road closures, reduced movements at junctions, and local area traffic restrictions to minimize traffic intrusion in residential zones, commercial areas, historic precincts, and in proximity to other sensitive land use.
- **Parking controls.** Physical, regulatory, and pricing measures applied to the ends of a vehicle trip that if implemented comprehensively across a metropolitan area, offers the potential to moderate or modify vehicular travel.
- **Public transport services.** Improved rail and bus services, vehicles and supporting facilities, ticketing and information systems may not only enhance accessibility, convenience of use, and reduce journey times to existing passengers, but may induce drivers and passengers from cars and other vehicles to switch to public transport, providing benefits to remaining road users.
- **Walkability and other NMT measures.** Improved sidewalks and road crossings for pedestrians and provision of lanes and other facilities to support use of NMT for passenger or goods movements. High quality walking environments are associated with vibrant cultural and commercial activity centers and may successfully substitute for short car trips.
- **Traveler information (pre- and during trip).** Information provided to car drivers and their passengers to avoid excessive nonrecurrent congestion by route planning, modifications to routes and time periods of travel, and use of alternative modes, and minimize parking search times at destinations. Similarly, pre- and during trip information assists public transport users to plan their journey, monitor journey times, and change routes and services, if necessary.
- **Behavioral measures.** Inform travelers, particularly car users, of the range of modes available and their time and cost characteristics, and environmental impacts, with the aim to encourage them to take car pools, shift to public transport, plan their trip itineraries to reduce unnecessary travel, or walk or cycle or change trip starting and finish times to avoid congested periods. Use new technologies to facilitate changes in travel patterns and trip frequency (e.g., telecommuting).
- **Administrative charges.** Road use charges are already familiar and come in the form of initial ownership charges, and annual vehicular registration charges that are usually based on engine displacement. These charges are used to fund the road system and cost of administration of vehicles and roads. Such charges typically do not vary with vehicle use.
- **Fuel taxes.** Usually levied by national governments for a variety of reasons but usually not to moderate vehicle use. There is a weak relationship between normal levels of fuel tax and vehicle use—high taxes tend to encourage consumers to choose fuel-efficient vehicles instead of moderating travel.
- **Pricing or charging of roads and other transport based on use.** Apply tolls or charges when crossing boundaries of congested or historic zones, or traveling within such zones, or according to distance traveled or amount of prevailing congestion on a network. In some cases, notably in the US, some lanes of key roads are tolled and in return offer a defined level of traffic service, i.e., value pricing. Tolling is often used as a financing strategy to provide funding for road infrastructure that may not otherwise be built. Charges on other modes such as public transport also influence road use.
- **Low emission zones (LEZs).** Limit entry of vehicles and/or vehicles which do not meet adequate emission standards in historic, sensitive, or other defined parts of cities e.g., in Berlin, London, or Milan. The London and Milan LEZs operate in conjunction with their Congestion Charging Zones.

- **Controls on vehicle ownership.** Quota systems through lottery or tendering, as applied in Shanghai and Singapore, aim to curb growth of the vehicle fleet. But these may have the reverse effect of ensuring that the available vehicles, usually more expensive with the ownership restriction, are used intensively by household members. For example, in Singapore, the Certificate of Entitlement (COE) whereby the right to own a passenger car is regularly auctioned approximately doubles the retail price of a car. As a result, the average car in Singapore, an island-state, logged more than 19,000 km per year in 2011.[22] This annual mileage is one-third more than the average mileage of 14,000 km for a passenger car in Australia in 2012 that is used in both urban and rural areas.[23] Fee or rebate systems apply taxes, or exempt taxes and charges on vehicles with low greenhouse gas (GHG) emissions, or meet other stringent emission standards. In 2010, electric vehicle manufacturers in the People's Republic of China (PRC) received incentives, which were passed on to consumers, of up to CNY60,000 for private purchase of new battery electric vehicles, and CNY50,000 for plug-in hybrids in the cities of Shanghai, Shenzhen, Hangzhou, Hefei, and Changchun.[24]
- **Controls on vehicle use.** Typically, the controls are based on the final digit of number plates as in Beijing since 2008 when vehicles entering or traveling within the Fifth Ring Road were not permitted to operate on 1 week day per week between the hours of 6 a.m. to 9 p.m. Similar controls were implemented in Manila, Philippines and many other cities with varying success. Such systems often favor wealthy households that can afford multiple vehicles. Another common criticism of such schemes, is that in some cases, the vehicle purchased for use on days of the restriction are often older, less energy-efficient and more polluting than the main vehicle.

B. Purposes of Travel Demand Management and Other Measures

The first three measures listed above: (i) roadway capacity expansion; (ii) traffic management; and (iii) allocation of road space and traffic signal cycle times have been commonly applied throughout cities in the PRC. The remaining measures—defined for the purposes of this study as TDM measures—have been implemented to some extent, or are being considered currently, in Beijing and other cities in the PRC. All the measures listed above have been classified in Table 4 according to what may be regarded as their principal purpose. In reality, measures often have multiple purposes or a particular measure, such as congestion charging, may rely on improved public transport to cater to former car occupants who decide to stop using private vehicles.

In Beijing, and other cities in the PRC, most of the preceding measures have been used. With the severe air pollution and congestion problems facing Beijing and other cities in the PRC, the potential for a more optimal pricing of roads, sometimes referred to as congestion charging, is explored in subsequent sections of this study.

22 Land Transport Authority. 2012. Singapore Land Transport. *Statistics in Brief*. Singapore. http://www.lta.gov.sg/content/dam/ltaweb/corp/PublicationsResearch/files/FactsandFigures/Stats_in_Brief_2012.pdf

23 Australian Bureau of Statistics. Survey of Motor Vehicle Use in Australia. http://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0 (accessed 12 February 2015).

24 New Energy Vehicles in China. http://en.wikipedia.org/wiki/Government_incentives_for_plug-in_electric_vehicles#China (accessed 12 February 2015).

Table 4: Travel Demand Management and Other Measures Classified by Main Purpose

Purpose	Type of Measure
Reduce delays to vehicles, expand vehicular capacity	Roadway capacity expansion, conventional traffic management, toll roads
Increase car occupancies (as an alternative to low occupancy private vehicles) or prioritize noncar movements	Allocation of road space, and traffic signal cycle times
Reduce or eliminate trips to reduce vehicle kilometers of travel (VKT) or to move trips to less congested periods, locations, or routes	Physical controls, parking controls, real time traveler information, behavioral measures, congestion charging, vehicle ownership and use controls
Substitute for car trips	Behavioral initiatives
Divert trips to more environmentally and socially-sustainable modes	Public transport, walkability, and nonmotorized transport
Improve air quality, reduce greenhouse gas emissions	Low emission zones, vehicle controls: fee or rebate schemes
Revenue raising to sustain the transport system and other needs	Annual road user charges, fuel taxes

C. Classification of Measures Using the Avoid–Shift–Improve Framework

The spatial pattern of economic activities is a key determinant of the demand for transport and its impacts. Through transport services, people can participate in activities at their destination and goods can be shipped from production zones to markets and international gateways. Transport is therefore often called a "derived demand" where the real demand is for the activities and services available at different locations in a nation or urban area.

In the development of transport infrastructure and services, there are three broad strategies to reduce air pollution, noise, GHG emissions, and at the same time, enhance welfare and social inclusiveness through reductions in congestion and improvements to accessibility enabled by transport, at the national or subnational scales:[25]

- **Avoid or reduce travel and travel distance by motorized modes.** This can be accomplished by a combination of influencing regional development at the national level and land use planning at the urban level. Better management of the demand for travel through the use of economic and informational policy instruments can also reduce the amount of travel;

[25] GTZ. 2007. *Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities* described the "Avoid–Shift–Improve" framework, although the concepts were articulated earlier, for example, by Thomson. 1974. *Modern Transport Economics.* Schipper et al. 1999 in *Carbon-Dioxide Emissions from Transport in IEA Countries: Recent Lessons and Long-Term Challenges* described this framework as "Activity, Share, Intensity, Fuel Mix." Both GIZ (2007) and Schipper et al. (1999) proposed their frameworks for consideration of travel with the main purpose being to reduce GHG emissions.

- **Shift to more environmentally and socially-sustainable modes.** The availability, quality, and quantity of environmentally sustainable modes (such as urban and nonurban) passenger transport systems and provisions for walking and cycling is important with significant beneficial additional impacts on economic welfare (e.g., lowering congestion and related loss of time and economic productivity) and social inclusiveness (e.g., access and road safety). In the case of freight transport, a greater share of goods being moved by well-used railways or inland waterways will reduce GHG emissions, air pollution, and traffic fatalities.
- **Improve the energy efficiency and environmental performance of transport modes and vehicle technology.** The performance of vehicles is important. The main impacts are usually environmental and possibly economic welfare through the choice of types of vehicles, fuel, fuel efficiency, and load factors of vehicles.

As shown in Table 5, the TDM and other measures classified using the Avoid–Shift–Improve (ASI) framework shows how the various measures: (i) improve travel efficiency and enhance accessibility; (ii) improve safety and security; and (iii) enhance local and global environmental outcomes.

Table 5: Classification of Travel Demand Management and Other Measures by Avoid–Shift–Improve Framework

Measures	ASI Category	Economic – Travel Efficiency/ Accessibility	Social	Environmental
Roadway capacity expansion	I	+, x, or –	+, x, or –	x or –
Traffic management	I	+	+	+, x, or –
Allocation of space or phase times, to favor bus, pedestrian and NMT movements	I	+	+	+, x, or –
Physical controls	A, S	+ or x	+	+
Parking controls	A, S	+ or x	+	+
Public transport	S, I	+	+	+
Walkability/NMT	S, I	+	+	+
Traveler information	A, S	+	+	+
Behavioral	A, S	+	+	+
Administrative charges	I	x	x	x
Fuel taxes	I, S	x	x	+
Pricing/charging for use	A, S	+	+	+
Low Emission Zones	A, S	+ or x	+	+
Controls on vehicle ownership	A	+	+	+
Controls on vehicle use	A	+ or x	+ or x	+ or x

+ = positive, – = negative, x = neutral, A = avoid, ASI = avoid–shift–improve, I = improve, NMT = nonmotorized transport, S = shift.

Source: ADB consultants.

D. Beijing's Experience with Travel Demand Management

This section describes the TDM measures implemented between 2000 and the present day, their impacts to the extent known, and the most relevant prevailing policies.

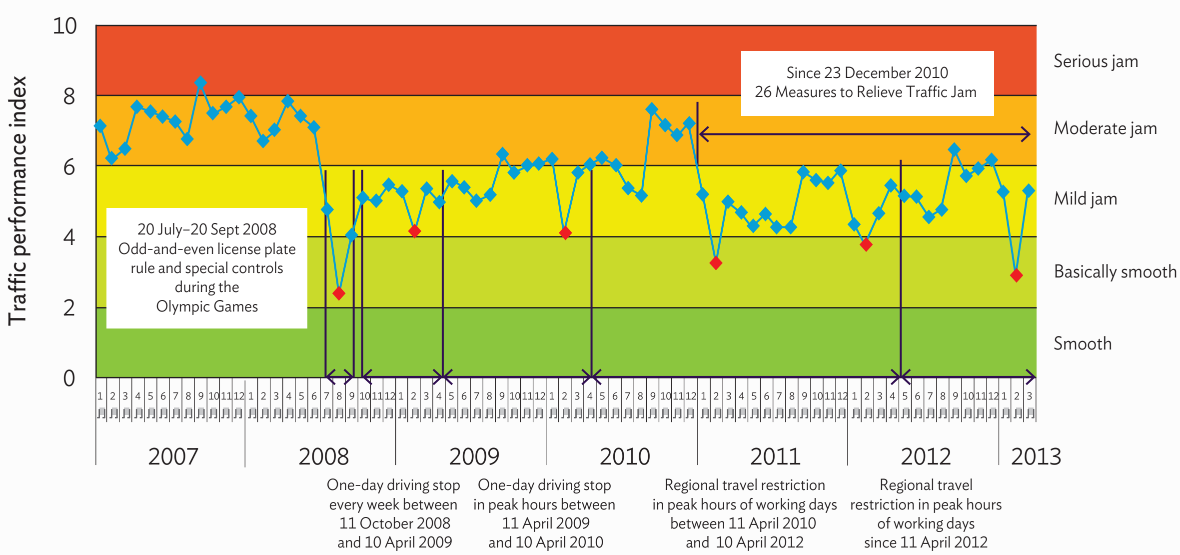
1. Preparation for the 2008 Summer Olympics

With the 2001 award of the right to host the 2008 Summer Olympic Games, Beijing's leaders promised to transform the city's transport system. In the period 2000–2008, the rail mass rapid transit (MRT) network was extended from 50 km to 200 km. Key policies released in 2005 and 2006 (Box 1) prioritized investments in all forms of public transport: rail, bus rapid transit, and on-street bus, often with dedicated lanes.

To cater to the "Games-family" traffic, 286 km of dedicated on-road lanes were introduced. But to provide these lanes, from the preopening of the Olympic Village to the closing of the Paralympic Village (20 July 2008–20 September 2008), a series of traffic restrictions were introduced that: (i) prohibited car use by private individuals and most government vehicles within Beijing, on alternate days, according to whether the number plates ended in an odd or even number; (ii) required trucks from other provinces to avoid the city; and (iii) required vehicles from other provinces traveling within Beijing to meet national second-class emissions standards.[26] More flexible office and retail shopping hours were introduced to spread traffic loads. The TDM measures functioned well and were well-accepted by the public. The Olympics experience provided practical experience and opportunities for the subsequent development of TDM policies since that time.

Figure 7 shows trends in the (weighted-average) Traffic Performance Index (TPI) by month from January 2007 to March 2013. The trends from 2007 to September 2008, at the end of the Paralympics, show that the combined effect of all temporary traffic restrictions during the period of the Games reduced the TPI to "below 4" characterized as "basically smooth."

Figure 7: Monthly Changes in Traffic Performance Index on Working Days, 2007–2013



Source: Beijing Transportation Research Center.

26 As applied to residential, commercial, industrial, and rural areas.

Box 1: Relevant Policies

Outline of Beijing Traffic Development (2004–2020). Released in April 2005, the Beijing Municipal Government (BMG) proposed to accelerate the construction of a comprehensive public transport system with rail transit and bus rapid transit as the backbone with on-street buses serving a major role.

Common ticket system for public transport. From 1 January 2007, Beijing switched the public transport ticket system to require a single ticket and one-time payment for travel from origin to destination irrespective of the number of modes or lines traveled. Deep discounts apply for regular travelers holding a common stored value ticket.

Opinions about Priority Development of Public Traffic. The BMG released this document at the end of 2006 that recognized the strategic importance of public transport for fostering sustainable urban development and for enhancing public welfare. Four priorities were identified: (i) priority for land for public transport facilities; (ii) priority for investment; (iii) allocation of right-of-way priority; and (iv) priority for public financial support.

Beijing's Action Plan for the Construction of Culture-Enriched Traffic, Technology-Empowered Traffic, and Environment-Friendly Traffic (2009–2015). The BMG released this document in July 2009 that focused on promoting the action plan for the construction of a "public transport city."

Opinions of Beijing about Further Promoting Scientific Development of Capital Traffic and Intensifying Efforts to Relieve Traffic Congestion. The BMG released this document in December 2010 that proposed 28 comprehensive measures to relieve congestion including scientific planning, construction, management, restriction, and other aspects. The "28 Measures to Relieve Traffic Jams" in 2010 pointed out the "high concentration of functions and population in central urban zones, rapid increase in inventory and intensive use of motor vehicles, public transportation's lack of attractiveness, comprehensive traffic management level not matching with the rapid increase of vehicle inventory and other problems," and proposed the following targets for 2015: (i) public transport should carry 50% of all person trips in central urban zones; (ii) bicycle travel shall be maintained at 18%; and (iii) the share of trips by passenger cars shall be controlled below 25%." It also proposed to control the increase of small passenger cars to less than 240,000 vehicles per year (through a free lottery) or less than one-third the rate of growth in 2009–2010. A differential parking charge policy was also proposed that mandated higher prices for central areas than the periphery, and for on-road parking than off-road spaces, and higher prices for aboveground parking places than underground spaces. Areas were defined as follows: (i) class I areas, within and adjacent to the Third Ring Road; (ii) class II areas, the balance of areas within the Fifth Ring Road; and (iii) class III areas, outside the Fifth Ring Road. Class I, II, and III areas were subject to progressively lower charges.

Implementation of National Public Transport City Construction Demonstration Project. In November 2011, the Ministry of Transport issued a Notice that proposed to organize the implementation of a national "public transport city" construction demonstration project to improve the urban public transport service level, meet the people's basic travel needs, and relieve urban traffic congestion and pressure on resources and the environment. Beijing was included in the first batch of "Public Transport City Construction Demonstration Projects" in 2012.

Opinions about Construction of Public Transport City and Improvement of Public Transport Service Ability. The BMG released this document in June 2012 that promoted the construction of a "Culture-Enriched Beijing, Technology-Empowered Beijing, and Environment-Friendly Beijing"—an international city with PRC characteristics—and proposed to further stick to public transport's important strategic status and public welfare positioning; stick to priority land for public transport facilities, investment arrangement priority, right-of-way distribution priority and financial and taxation support priority; and build a "public transport city."

Clean Air Action Plan of Beijing. On 12 September 2013, the State Council released the "Action Plan for Air Pollution Control." In response, the BMG released the "Clean Air Action Plan of Beijing for 2013–2017." It was proposed that by 2017, the average annual density of fine particles shall have reduced by over 25% compared to 2012, and shall be controlled at about 60 $\mu g/m^3$. To achieve this target, public transport was to be given priority along with across-the-board energy conservation, emission reduction, and air pollution control.

2. 2008 to Present

Following the Olympics, until early 2010, traffic congestion, as measured by the TPI, stayed in the range 4–6 or "mild jam" level as shown in Figure 7, due to the extensive investments in public transport and other initiatives, but also a continuation of milder forms of vehicle use restrictions that limited driving 1 day per week (from October 2008 to April 2009). Between April 2009 and April 2010, the restrictions were converted to a weekday driving ban.

With continued development within the Third Ring Road and continued urban expansion beyond the Fifth Ring Road, traffic congestion grew after the Olympics to the end of 2010. With the addition of 790,000 new vehicles to the fleet in 2010,[27] representing annual growth of 20%, traffic congestion sharply increased. By the second half of 2010, peak period traffic congestion, as measured by the TPI, was regularly in the 6–8 range or "moderate jam" having worsened over the year.

The extensive gridlock experienced regularly in late 2010, culminating with the paralyzing gridlock experienced on 17 September 2010 where trips took several hours longer than normal, led to the BMG issuing a new policy directive that set out 28 Measures (Table 6) designed to address congestion. Several targets and 66 specific measures were proposed to guide implementation of the 28 measures. Two quantitative targets proposed to measure performance in 2011 were the Traffic Performance Index to remain below 6 ("mild jam") and the share of trips using public transport should increase to 42% (up from 40% in 2010).

3. Key Measures

Of the 28 measures, several were implemented to restrain vehicle use during the Olympics. The expanded list of measures continued curbs on usage in a more stringent form, introduced restrictions on vehicle ownership, while others aimed to reallocate road space to favor high-capacity bus movement, and others to expand the range of transport services for short trips, or to provide enhanced "last mile" connections between residential areas and subway stations and regular bus stops. Other important measures are the expansion of subway lines and conventional bus services to provide sufficient travel opportunities for persons affected by vehicle restrictions, and complementary services for the "new" modes described below. In December 2014, the previous flat fare for metro (CNY2) was changed to a distance-based fare starting at CNY3 to address the substantial operating deficit of the metros but also to better distribute demand across the metro lines and bus services.

The measures discussed below, along with their impacts where available, are:

- Continuation of flexible working hours;
- Parking policy adjustments with differential parking pricing;
- Continuation of restrictions on vehicle use based on the final digit of the number plate;
- Controls on private vehicle ownership;
- Public bicycle sharing scheme;
- Dedicated bus lanes on the Beijing–Tongzhou Expressway; and
- Community bus and pocket buses.

[27] The exceptionally high growth in vehicle sales in 2010 was because consumers expected a quota to be applied and hence purchased preemptively.

Table 6: The 28 Measures

Category	Content
Further improve urban planning, disperse functions and population of central urban zones	1. Further optimize and adjust urban functional layout.
	2. Bring into full play traffic's guide and service role.
	3. Fully carry out the planning for supporting traffic infrastructure.
Accelerate the construction of road traffic infrastructure; increase carrying capacity	4. Fully promote the construction of trunk road network system in central urban zones.
	5. Accelerate the construction of microcirculatory road system in central urban zones.
	6. Build over 50,000 public parking places in central urban zones.
	7. Build over 200,000 basic parking places in accordance with local conditions.
	8. Fully complete national highway network and municipal trunk road network.
Make more efforts in priority development of public transportation, encourage to travel by public transportation	9. Accelerate the construction of rail transit in central urban zones.
	10. Renovate safe operation and service facilities of existing rail transit lines.
	11. Establish express shuttle network by public transportation.
	12. Further optimize and adjust ground traffic lines.
	13. Accelerate the construction of comprehensive passenger transportation hubs and public transportation sites.
Improve transfer conditions of bicycle, pedestrian traffic system, and parked conditions; advocate environment-friendly travel	14. Complete the public bicycle service system with the scale of 1,000 stations and over 50,000 bicycles.
	15. Actively develop school bus service system of primary and high schools and encourage units to establish company buses.
	16. Establish a park-and-ride space for parked cars with over 30,000 parking places.
	17. Vigorously advocate modern traffic concept and carry out civilized traffic activities.
	18. Advise to convene teleconferences and exercise flexible work system.
Further strengthen the management of motor vehicles; guide proper use	19. Implement inventory regulation and control for small passenger cars to relieve the excessive growth of motor vehicles.
	20. Continue to implement and improve the traffic management measures of regional travel restriction during peak hours.
	21. Motor vehicle owners shall assume reasonable use costs to reduce traffic flow in central urban zones.
Strengthen scientific management, improve the level of modern traffic management and transportation service	22. Continue to implement traffic congestion relief project and improve capacity of existing roads.
	23. Build a new intelligent traffic management system.
	24. Strengthen the management of traffic order.
	25. Strengthen the management of parking lots and their operation.
	26. Establish traffic information release, alarm, and forecast system and strengthen emergency management.
	27. Further improve traffic management system and fulfill responsibilities.
	28. Include traffic congestion relief into supervision and performance appraisal.

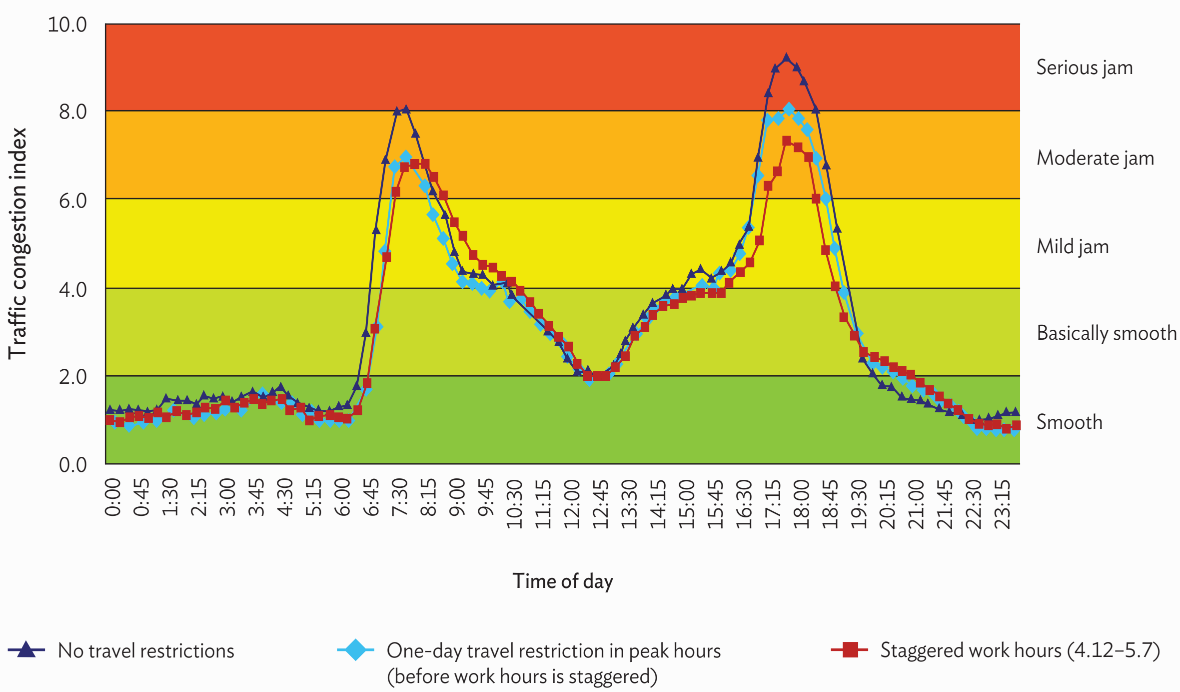
Source: Beijing Transportation Research Center.

Flexible Working Hours

Scope. The BMG first introduced staggered office hours during the Olympic Games and Paralympics. Flexible working hours, starting and finishing times between 8:30 a.m. and 5:30 p.m. for public enterprises, and 9 a.m. and 6 p.m. for private enterprises were introduced. These arrangements were continued following the Games period.

Effect. Although restrictions on car use were also introduced, more flexible working hours were introduced: (i) shifting the morning peak traffic demand to 8 a.m. from 7:45 a.m.; and (ii) not changing the time of occurrence of the maximum evening peak traffic demand, but lengthening the duration of both peak periods at a reduced level of intensity, even allowing for the effect of the restrictions on vehicle use as shown in Figure 8. Traffic congestion, as measured by the TPI, reduced by 3% in the morning peak and 14% in the evening peak period.[28]

Figure 8: Changes in Traffic Performance Index Based on Flexible Working Hours



Source: Beijing Transportation Research Center.

[28] BTRC. 2015. *Beijing Urban Transport and Travel Demand Management Report.* February.

Parking Policy and Differential Pricing

Scope. In April 2011, new parking reforms were introduced that aimed to limit parking in the old city and use differential parking pricing to redirect traffic away from the city center. There were approximately 530,000 on-street parking spaces and about 2.5 million off-street spaces in 21,200 parking facilities. The maximum parking prices were applied to on-street spaces in Zone 1 covering the area within the Third Ring Road and four other activity centers, i.e., the central business districts (CBDs), Yansha area, Zhongguancun core area, and Cuiwei business area). Progressively lower maximum parking prices applied to Zone 2 (area between the Third and Fifth Ring Roads) and Zone 3 (area outside the Fifth Ring Road). In all areas, pricing of parking was changed to vary by 15-minute periods with a higher charge to apply to the first 15 minutes as illustrated in Figure 9.

Effect. Many drivers were unaffected by the price increase as a 2010 survey showed that up to 90% of drivers do not pay for parking because they receive employer subsidies or find illegal spaces.[29] However, a survey conducted immediately after implementation of the policy showed there was an immediate 12% decrease of small cars entering the inner Zone 1 areas to park on-street. A decline of 19% was observed for off-street parking. The monitored traffic flow on roads surrounding Zone 1 declined by 12%. The average number of vehicles parked in off-street parking lots declined by 12% distributed as follows: (i) 19% decline in class I areas; (ii) 11% decline in class II areas; and (iii) 7% increase in class III areas. A survey of drivers in carparks who formerly parked in Zone 1 found 73% continued to drive but parked elsewhere, including continuing to parking in illegal spaces in Zone 1. The remaining 27% of drivers said they drove less and used other modes of transport (Figure 10). Subsequent surveys showed similar results but with lessened effects as drivers adjusted to the change.

Table 7: Current Parking Price Standard (values represent maximum prices)

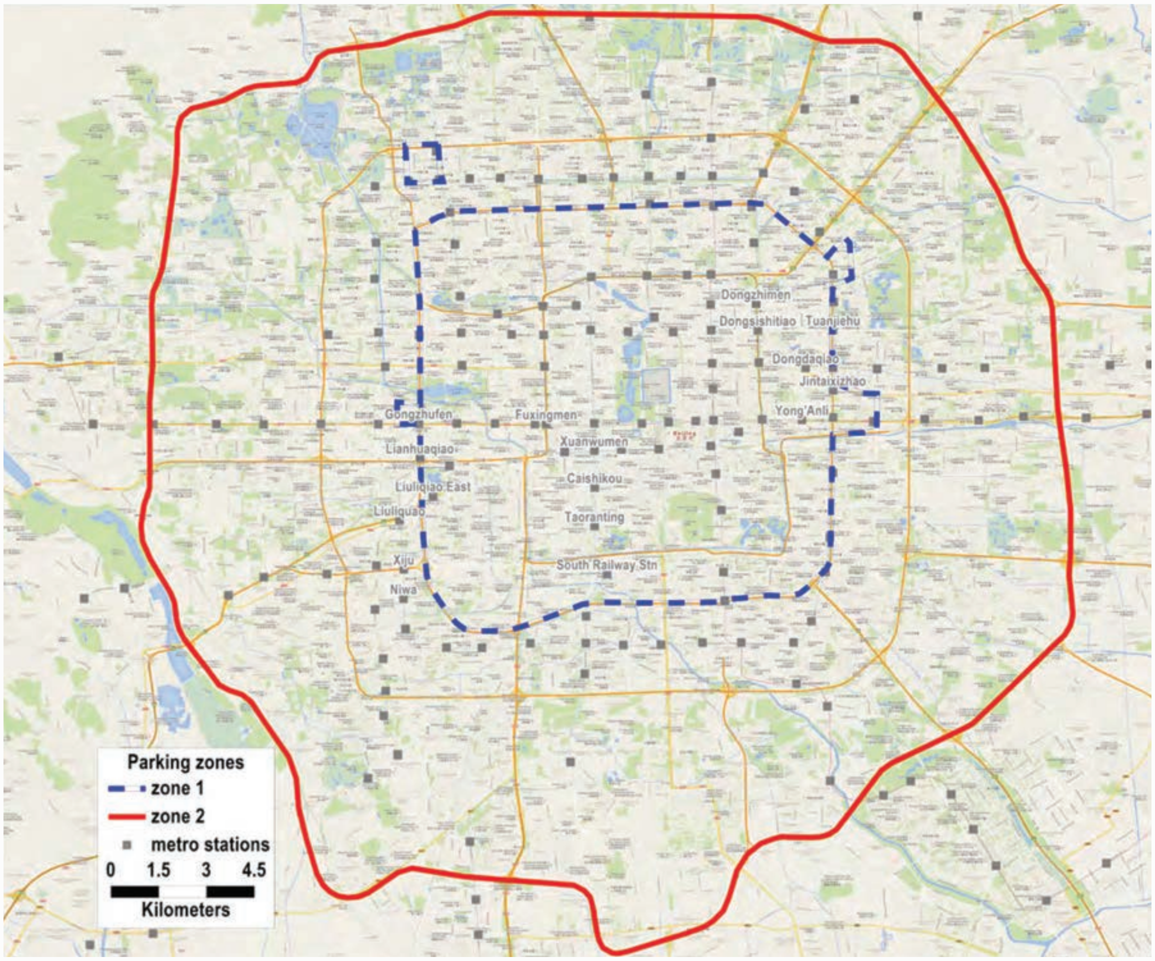
Maximum Parking Prices			Parking Price Standard					
			Daytime (7 a.m.–9 p.m.)				Nighttime (9 p.m.–7 a.m.)	
			On-Street		Off-Street			
			First Hour (CNY/15 min)	After First Hour (CNY/15 min)	Outdoor (CNY/15 min)	Indoor (CNY/15 min)	Outdoor (CNY/2 hours)	Indoor (CNY/30 min)
Non-residential area	Public hourly parking	Zone 1	2.50	3.75	2.00	1.50	1	2.5
		Zone 2	1.50	2.25	1.25	1.25		
		Zone 3	0.50	0.75	0.50	0.50		
	Outdoor public parking lots					< CNY150/month, CNY1,600/year		
	Indoor public parking lots (monthly/yearly)					Market price		
	Park and Ride					CNY2/entry		
	Independently operating parking facility					Market price		
Residential area	Outdoor parking lots hourly parking					CNY1 per 2 hours		
	Outdoor parking lots long-term parking					< CNY150/month, CNY1,600/year		
	Indoor, hourly parking					< CNY1 per 30 minutes		
	Indoor, monthly/yearlong parking					Market price		

CNY = yuan, min = minute.

Source: Institute for Transportation and Development Policy. 2015. *Parking Guidebook for Beijing*. Prepared for ADB.

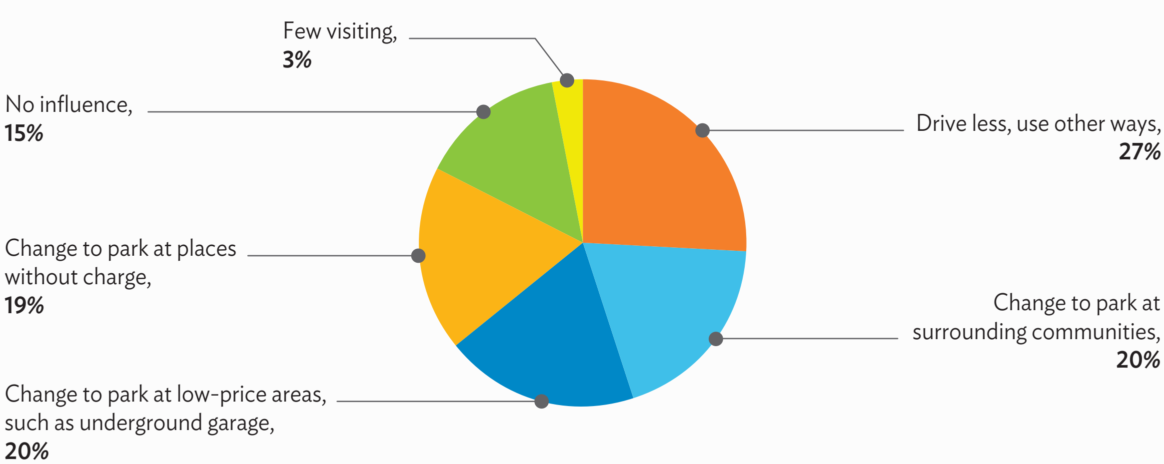
29 GIZ. n.d. *Travel Demand Management in Beijing – Work in Progress.*

Figure 9: Current Parking Zones in Beijing



Source: Institute for Transportation and Development Policy. 2015. *Parking Guidebook for Beijing.*

Figure 10: Effect of Parking Policy Change

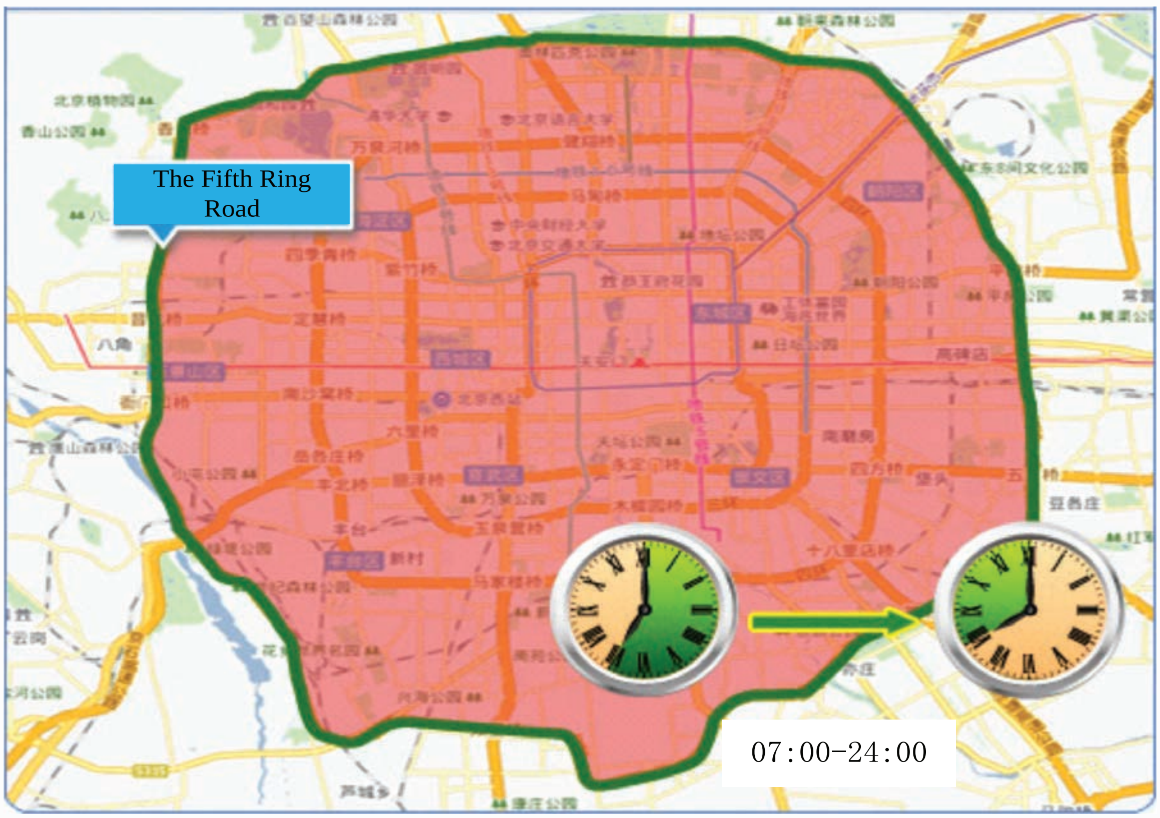


Source: Beijing Transportation Research Center.

Continuation of Restrictions on Vehicle Use

Scope. From December 2010, the BMG continued, but strengthened, the earlier traffic restrictions on use of government cars, regionwide restrictions during peak hours for local Beijing and nonlocal vehicles. Comprehensive restrictions applied to virtually all government vehicles (throughout the Beijing Administrative Area), on all roads on 1 working day per week. Restrictions on local and nonlocal vehicles also required cessation of travel on 1 working day per week (within the Fifth Ring Road as shown in Figure 11) between the hours of 6 a.m. and 9 p.m. Further, nonlocal vehicles were restricted to driving outside of peak periods on roads within the Fifth Ring Road on the 4 working days per week they were permitted to travel.

Figure 11: Geographic Extent of Private Vehicle Use Restrictions



Source: Beijing Transportation Research Center.

Effect of restrictions. After the traffic restriction policy was initially implemented following the Olympic Games in 2008, the average daily[30] TPI of the road network within and including the Fifth Ring Road dropped, that is, improved to 5.8 ("mild jam"), decreasing by 20.5% compared to the average TPI of 7.3 ("moderate jam") in 2007 (with no travel restrictions).[31] Peak hour traffic speeds increased by 7% in the morning peak and more than 13% in the evening peak period as shown in Table 8. It would be desirable to disaggregate the impacts of restrictions of households by income and car availability, however, the information is not available.

30 Weekday.

31 Recognizing at the same time that motorization and car use were increasing and that new subway lines, etc., were being implemented.

But with the 20% growth in the vehicle fleet over 2010, despite expansion of the subway and bus lines, the average TPI over the last half of 2010 averaged over 7.0 or higher, ("moderate jam"), and without intervention, was projected to rise. With the implementation of the more stringent form of vehicle restrictions, as set out by the 28 measures, congestion was greatly relieved with the TPI hovering just above 5.0 throughout the first half of 2011, although it increased to around 6.0 (limit of "mild jam") by the end of the year.

Table 8: Average Speed of Road Network

Average Speed of Road Network (km/h)	Morning Peak Hours	Evening Peak Hours
No travel restriction as at November 2007	21.8	18.7
29 March–2 April 2010	23.3	21.2
12 April–7 May 2010	23.2	22.2

km/h = kilometer per hour.

Source: Beijing Transportation Research Center.

Ticketing data for bus and subway systems, which were also expanding, showed that public transport use increased following the restrictions, with the share of public transport mode rising from 34% in 2007 to 40% in 2010. The share of trips by car grew from 33% in 2007 to 34% in 2008 and stayed constant to 2010, then declined to 33% in 2011, even with growth of 84% in the car fleet from 2007 to 2011.[32]

Controls on Private Vehicle Ownership

In 2010, 740,000 cars entered the vehicle fleet, about twice the number of new registrations in each of the previous years, in part because vehicle purchases were accelerated in anticipation of ownership restrictions. Following the sharp increase in congestion and air pollution, a quota system to limit the number of cars that could be registered each year was announced on 23 December 2010. In 2011, the quota for small passenger cars was set at 240,000 per year with 88% intended to be allocated to individuals, and 12% for other purposes through a public lottery.[33] Since the implementation of the policy the sharp growth in the vehicle fleet has been moderated with actual growth held to below 150,000 in 2011–2012 and 2012–2013. As the number of new vehicles entering the fleet each year was only 63% of the permitted limit it appears the quota system has had no effect on limiting the number of new vehicles in those years.

Figure 12 shows these trends with annual growth of the car fleet growing at below 5% in 2011. A survey of motorists conducted by Beijing News in 2011, found that 53% of respondents did not perceive any obvious speed improvements, likely because the fleet was still growing, though at a reduced rate.

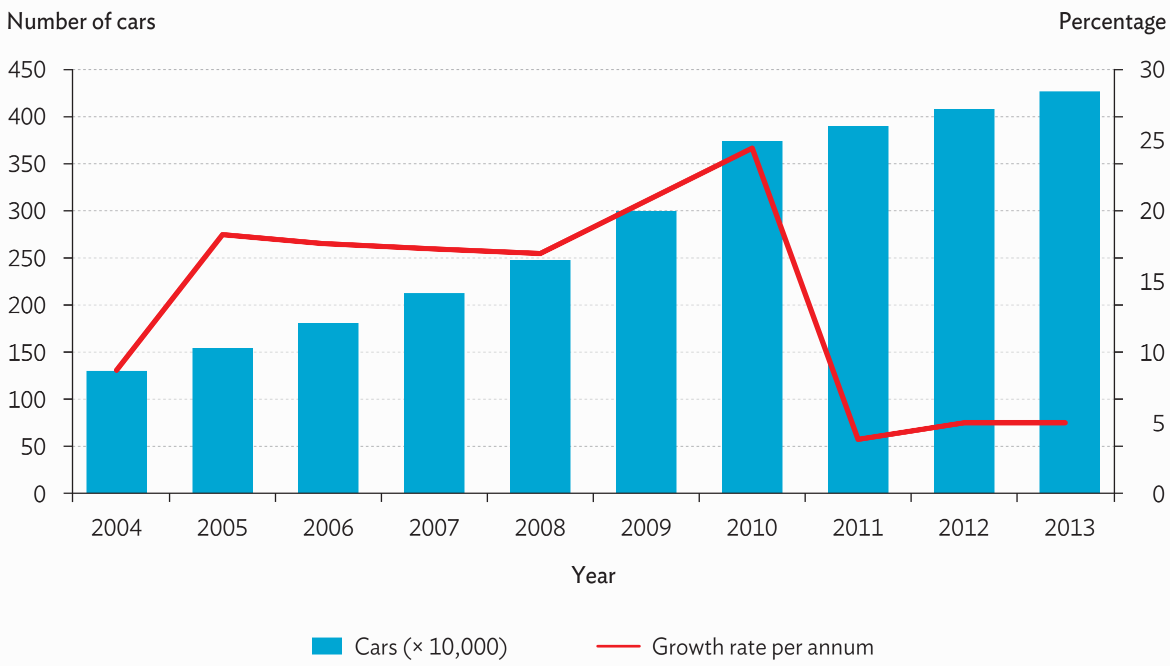
Public Bicycle Sharing

Scope. In response to the 28 measures, Beijing implemented a Public Bicycle Sharing (PBS) system in nine areas throughout the city. Interdistrict bicycle rental is only possible in the five central area districts. By the end of July 2014, the whole city had 27,000 public bicycles spread over 766 docking stations as shown in Figure 13. Rental is free for the first hour. After that, users are charged CNY1 to a maximum of CNY10 per hour.

32 Refer to Figure 3 for changes in share of mode.

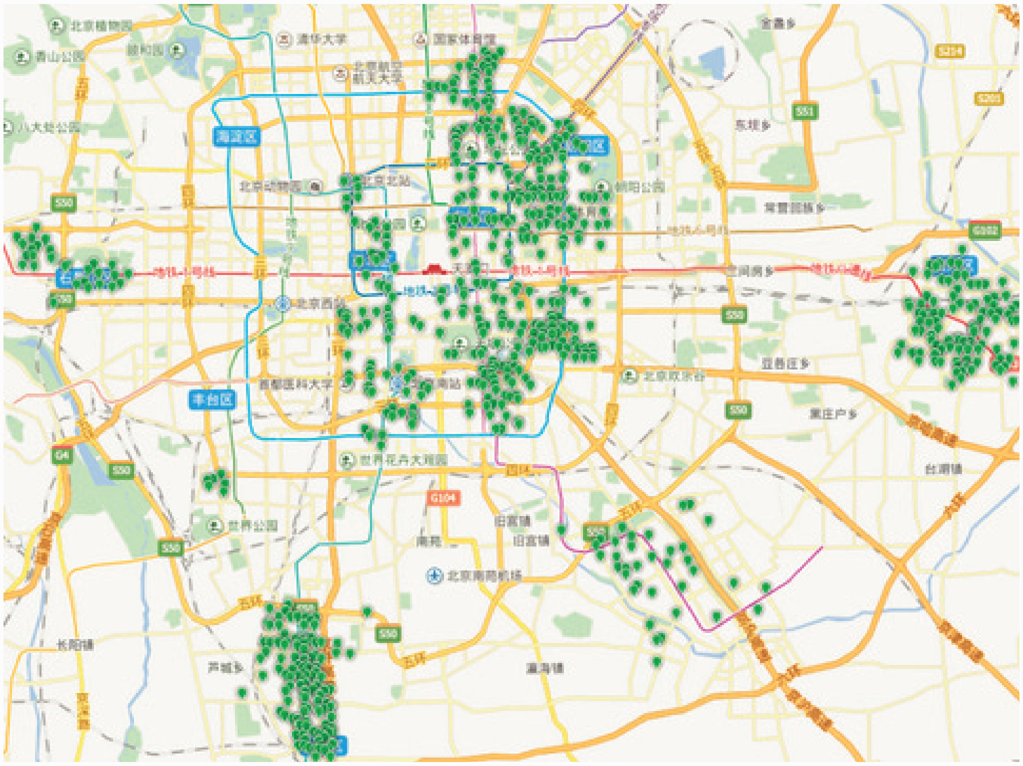
33 A lottery appears to be more equitable than Singapore's COE system, or Shanghai's 1986 and Guangzhou's 2012 vehicle license plate auction system, as low income purchasers have the chance as a wealthier person to be successful.

Figure 12: Annual Growth in Car Fleet



Source: Beijing Transportation Research Center.

Figure 13: Locations of Public Bicycle Sharing Docking Stations



Source: Royal Haskoning DHV. 2015. *Beijing Bicycle Strategy and Policy – The Way Back to World Bicycle Capital.* Prepared for ADB.

The district governments implement the PBS, determine the required criteria, and seek tenders from companies to operate the PBS system. The municipal government provides subsidies to the companies to buy bicycles, for docking stations, and servicing. Funds for land-use fees, construction, operation, and repair fees, as well as renewal, maintenance, and monitoring; and provided by the district governments.

Effect. Along with the public's current general reluctance to ride bicycles due to: (i) climate; (ii) air pollution, (iii) most trip lengths further than bikeable distance, (iv) traffic risk due to lack of facilities, and (v) potential theft of bicycles, the PBS system is underused. In 2014, the number of daily rides was 32,000 or a just over one ride per bicycle per day although there are 140,000 bicycle share card holders. The system is "not working well."[34] However, awareness of the PBS among general cyclists is high as shown in Box 2.

Box 2: Surveys of Public Biking Systems

Bicycle Traffic Willingness Survey Results:

- ☐ Public Biking System (PBS) system is well known (90%)
- ☐ Usage is low (11%)
- ☐ Willingness to use PBS overall 60%. Highest rates:
  - Among bicycle users: car drivers (73%) and public transport users (72%)
  - Among nonusers: public transport users (60%)
- ☐ Main reason to not use PBS: availability of own bicycle (31%–51%)
- ☐ Uncertainty how to use the PBS

Source: Royal Haskoning DHV. 2015. *Beijing Bicycle Strategy and Policy – The Way Back to World Bicycle Capital.* Prepared for ADB.

Several factors appear to contribute to the underperformance of the PBS to date:[35]

- **Unclear role in the larger urban transportation system.**
- **Connection with PBS systems in other parts of the city is not guaranteed.** Separate PBS systems in various parts of the city with different operators and without mutual interchange are in place. Most operators seem to not feel responsible for the maintenance and the promotion of the system.
- **Insufficient financial investment.** The operator is not ready for long-term investments. The city government does not provide adequate financial support to the PBS system.
- **Insufficient connection with public transport.** The PBS does not provide a faster, more convenient way to cover "the last mile" than walking does.
- **Unclear focus on target group.** Although focus is said to be set on providing "the last mile," potential users do not recognize it as such. Moreover, a PBS system has a much wider potential than only commuters for "the last mile."
- **Threshold to participation.** Due to the expense of a step-in deposit (relatively high compared to the public transport fare) and complicated application for a membership card, people are discouraged from trying to use the service.

34 GIZ. n.d. 2011. Op. cit. p. 25.

35 Royal Haskoning DHV. 2015. *Beijing Bicycle Strategy and Policy – The Way Back to World Bicycle Capital.* Prepared for ADB.

Dedicated Bus Lanes on the Beijing–Tongzhou Expressway

Scope. A lane reserved for buses during peak periods was introduced on 24 May 2011 on the Beijing–Tongzhou Expressway connecting Tongzhou in the east to central Beijing. The scheme was the first of its type in the PRC. The bus lane was placed adjacent to the median in the direction of traffic. After adjustments made in the first 5 months of operation, the morning inbound lane now extends over 11 km and the evening outbound lane for 8.8 km. The morning inbound lane to Beijing central area operates from 7 a.m. to 9 a.m. and the evening outbound lane from 5 p.m. to 8 p.m. (Figure 14).

Figure 14: Conditions Before and After Opening the Bus Lanes

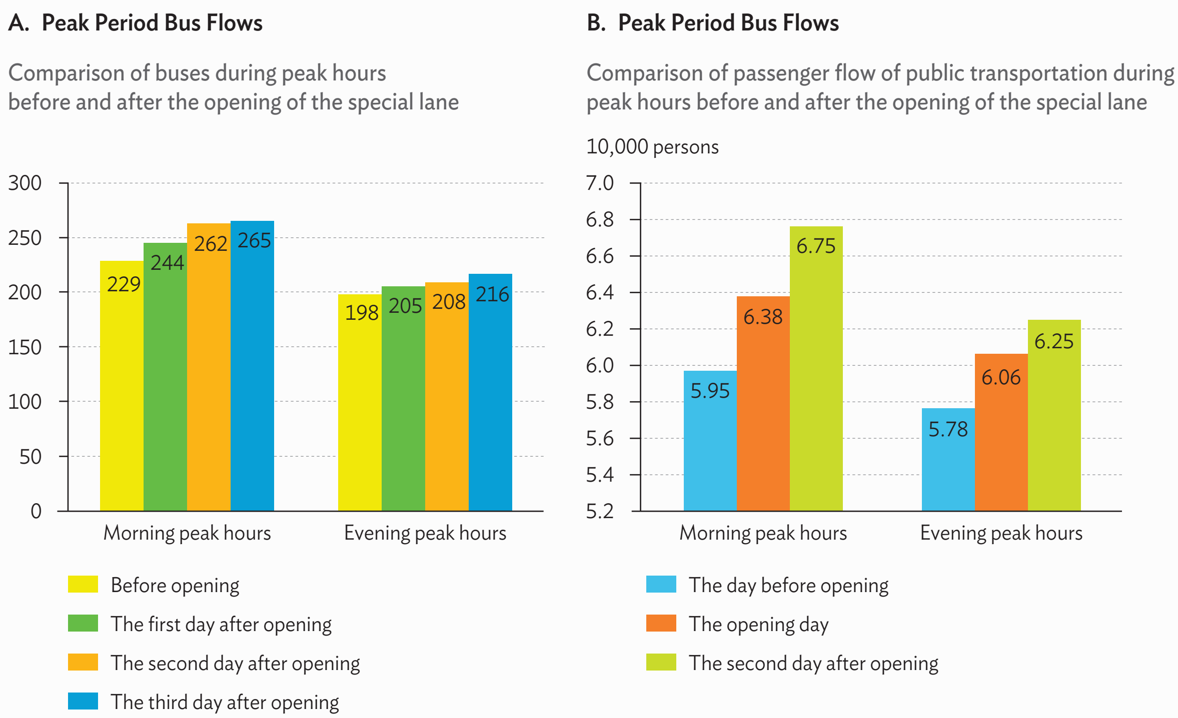
Source: Beijing Transportation Research Center.

Effects. A variety of positive effects were observed following implementation. Bus operational speeds doubled to 52 kph. As implemented originally, bus flows over the 2-hour morning peak period increased by 16%, and by 9% for the evening peak period by the third day of operation. Passenger flows in the morning peak period increased by 13% and by 8% by the evening peak period, as shown in Figure 15.

Passenger crowding on the nearby Batong Metro Line decreased to some extent. Between 24 May and 27 May, the average daily passenger volumes on the Batong Line during peak hours reached 100,000, reduced by 5,000 every day on average, compared to the same day of the week just before introduction of the special lanes on the Beijing–Tongzhou Expressway. The maximum morning peak hour crowding reduced from 130% to 120% of passenger carrying capacity (Figure 16).

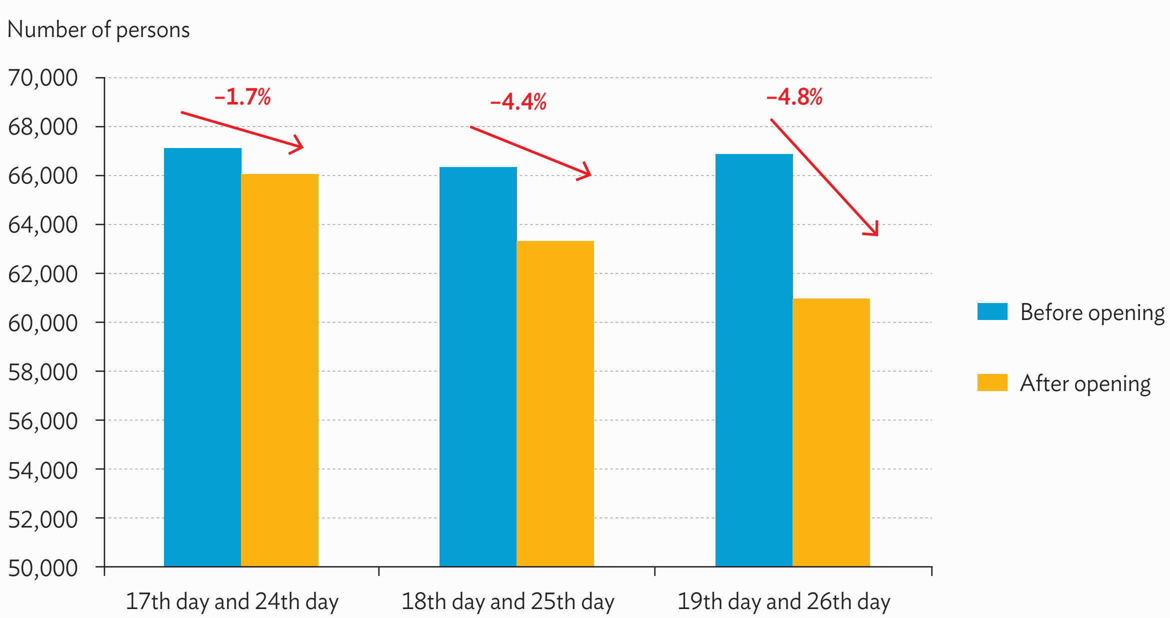
Traffic speeds on the nearby sections of trunk and secondary roads between the Third and outside of the Fifth Ring Road remained stable before and after the bus lanes were introduced on the Beijing–Tongzhou Expressway. However, it is likely that the general traffic experienced somewhat slower speeds on the expressway. But this effect would likely be low because bus flows of 100 per hour per lane would tend to create their own de facto lanes even without the introduction of the reserved lanes. However, the reserved

Figure 15: Peak Period Bus and Passenger Flows on Beijing–Tongzhou Expressway Before and After Bus Lanes



Source: Beijing Transportation Research Center.

Figure 16: Comparison of Changes in the Number of Passengers Using Batong Metro Line during Morning Peak Hours Before and After Opening the Special Lanes



Source: Beijing Transportation Research Center.

lanes eliminated the use of the lane by cars that even in small quantities of 200–300 vehicles per hour, slowed buses and increased the variability of their travel times. Speeds on trunk roads between the Third and Fourth Ring Roads increased. A survey of bus passengers conducted after the bus lanes were introduced showed that 15% previously used the subway, 10% previously used buses and metro before the opening of the special lane, 6% used small cars, and the balance were former bus users.

Overall, travelers, decision makers and the community at large viewed very positively the creation of reserved, with-flow bus lanes during peak periods on the expressway. The opportunity exists to replicate this measure in other locations in Beijing and other cities in the PRC.

Community Buses and Pocket Buses

Among the 28 measures, it was proposed to introduce shuttle buses connecting the main trunk bus lines and the metro stations to offer effective last-mile connections to residential areas. Two types were planned: (i) commuter buses connecting residential areas and metro stations with express services and offering guaranteed seats; and (ii) "pocket" buses connecting residential areas and major bus stations. On 28 March 2011, the first 12 commuter lines were launched. By the end of December, 57 lines were operational that transported 36,000 passengers per day. In 2011, 15 "pocket" bus lines were established and within a short time, were carrying 35,000 passengers per day.

E. Summary of Implementation Effects

The overall effect of all these measures on traffic congestion is shown in Figure 8. Between 2010 and 2013, the combined effect of expansion of the metro, expansion of bus lines, building of roads, introduction of the new vehicle quota, vehicle use restrictions, and other TDM measures was to maintain congestion (as measured by TPI) generally below 6.0, described as "mild jam" even with rapid growth in the vehicle fleet. Traffic speeds increased by about 15% in the morning and evening peak periods between 2010 and 2013 as shown in Table 9. Peak period bus speeds were fairly stable between 2011 and 2013, but by 2013, tended to slow slightly as seen in Figure 19 at the majority of representative locations. These improvements were reflected in the 20% decline in the proportion of vehicle–kilometers of travel at peak periods classified as "severe congestion" in 2011, compared to 2010, as illustrated in Figure 18.

The percentage of travel by public transportation increased from 40% of all daily person trips in 2010 to 46% by 2013. Bicycle share decreased from 16% to 12%. The share of trips by car declined from 34% in 2010 to 33% in 2013. Overall, the impact on traveler accessibility to jobs, education, and other opportunities has likely not reduced, and may have improved, given that the length of metro lines more than doubled between 2010 and 2013.

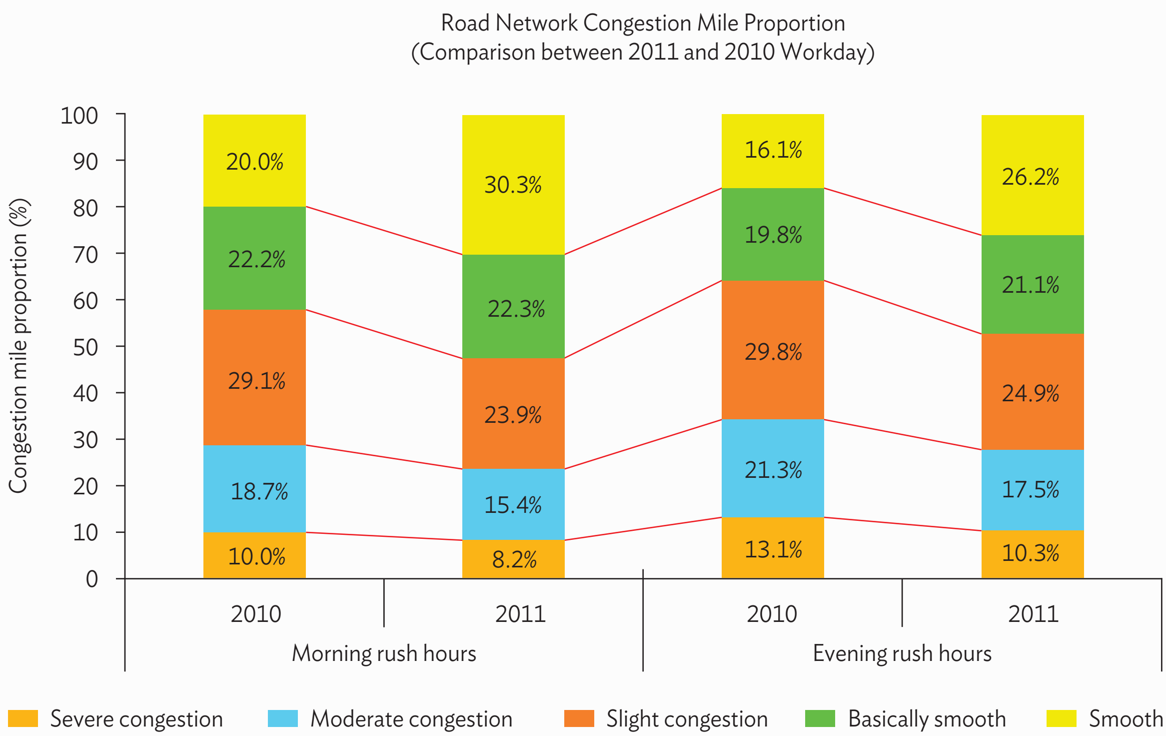
The impact on air pollution and GHG emissions is less clear since the vehicle fleet and total travel demand has grown since 2010. Given the impacts on travel speed, and the effect of complementary programs, since 2014, to scrap the most polluting vehicles, likely old and fuel-inefficient, transport's contribution to air pollution and GHG has been curbed to a certain degree.

Table 9: Average Speed of Roads at All Levels within the Fifth Ring Road (Including the Fifth Ring Road) (kilometers per hour)

Period	Road Type	2010	2011	2012	2013
Morning peak hours	Expressway	35.1	35.6	35.5	36.7
	Main road	22.2	23.4	23.3	22.9
	Secondary road	20.1	25.2	24.2	21.5
	Road network	23.9	26.4	26.0	27.4
Evening peak hours	Expressway	30.2	31.2	30.6	31.8
	Main road	19.7	21.5	21.4	20.7
	Secondary road	18.3	23.3	22.2	19.4
	Road network	21.2	24.0	23.5	24.2

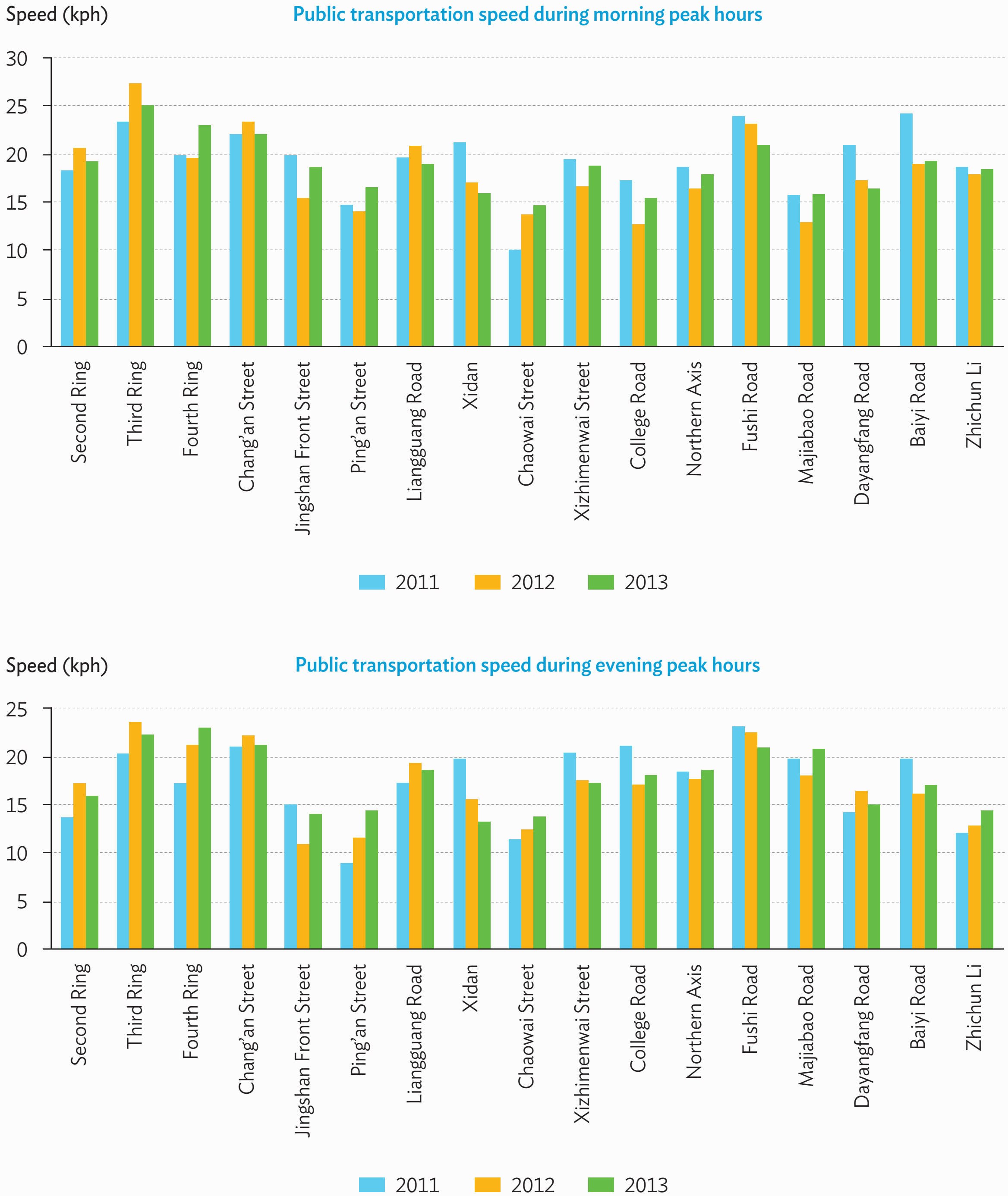
Source: Beijing Transportation Research Center.

Figure 17: Proportion of Road Network Congestion During Morning and Evening Rush Hours



Source: Beijing Transportation Research Center.

Figure 18: Recent Trends in Bus Speeds



Source: Beijing Transportation Research Center.

CHAPTER III

Assessment of Travel Demand Management Scenarios for Beijing

To capture the potential demand response of a transport improvement, "variable demand" modeling was used as recommended by the UK Department for Transport[36] for most situations. Variable demand modeling aims to employ techniques to simulate changes in: (i) car availability, (ii) travel route, (iii) travel mode, (iv) travel location, (v) time of travel, (vi) car occupancy, including changes between traveling as a car passenger and driver, (vii) trip frequency, (viii) generated trips (i.e., the making of entirely new journeys due to improved accessibility), and (ix) land use as people choose to undertake their activities in different locations. To simulate the impacts of travel demand management (TDM) is particularly complex and requires that virtually all the key behavioral aspects are addressed. Consequently, the Beijing Transport Demand Model was enhanced so it could adequately simulate items (i) to (vii). The effects of land use changes did not have to be modeled because the TDM measures were assumed to be implemented in the very short term, where land use effects were not significant.

The following TDM scenarios were assessed, with the first two types using the Beijing Transport Demand Model:

- Bus Rapid Transit (BRT) improvement strategy; and
- Road charging scenarios.

A. Bus Rapid Transit Network Plan Scenario Analysis

There are four existing BRT corridors in Beijing. In this section, two BRT scenarios are investigated.

1. Bus Rapid Transit Scenarios

Scenario 1: One New Bus Rapid Transit Corridor

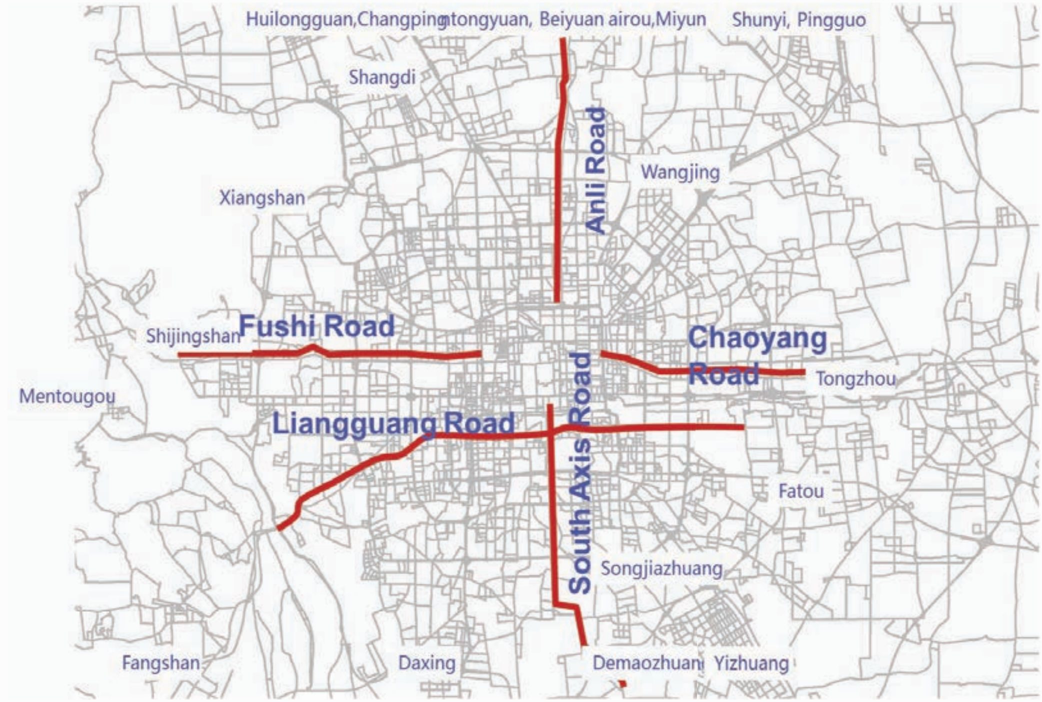
Scenario 1 shown in Figure 19 includes the four existing BRT corridors. In this scenario, one more BRT corridor, the Liangguang Road BRT, is added to the network. This new 27-km corridor starts at Fifth Ring Road and links to Gaobeidian Road between the eastern section of the Fourth Ring Road and the Fifth Ring Road. It has a relatively high possibility of being launched in the near future.

Scenario 2: 16 New Bus Rapid Transit Corridors

Scenario 2 excludes the five BRT corridors covered by Scenario 1 and is shown in Scenario 1: 12 new BRT Corridors. Taken together, Scenarios 1 and 2 cover virtually all the potential BRT corridors for Beijing.

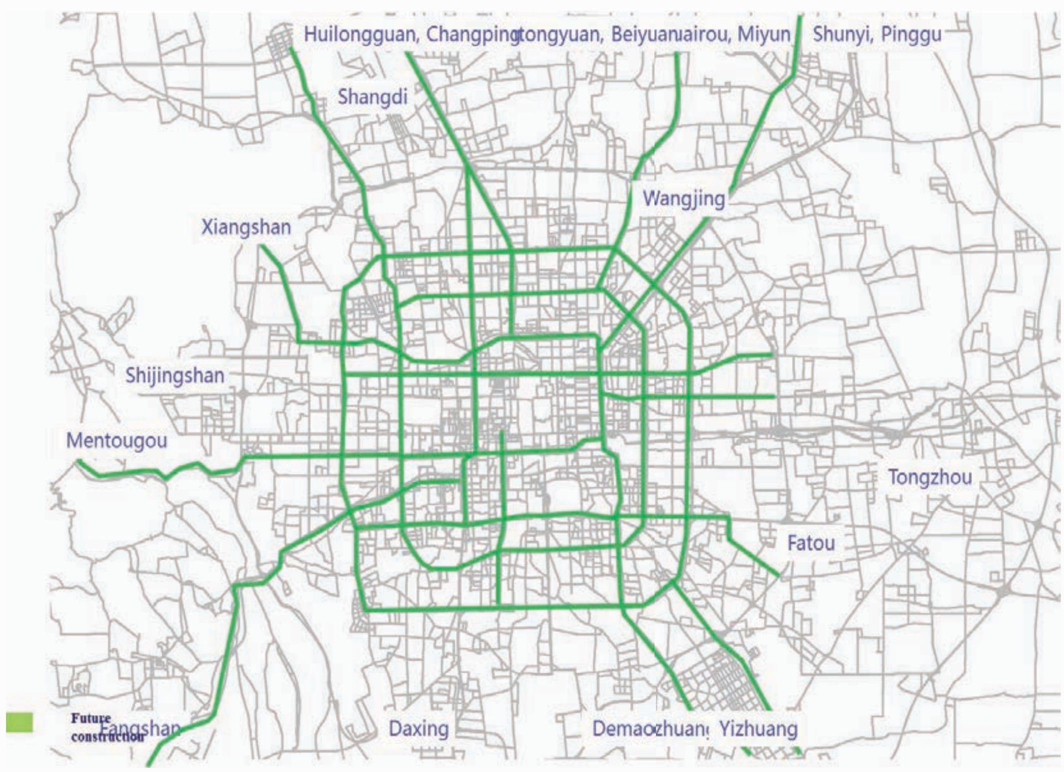
[36] UK Department for Transport. 2006. *An Introduction to Variable Demand Modelling. TAG Unit 2.9.2.* UK. 2006.

Figure 19: Scenario 1: One New Bus Rapid Transit Corridor



Source: Beijing Transportation Research Center.

Figure 20: Scenario 1: 12 New Bus Rapid Transit Corridors

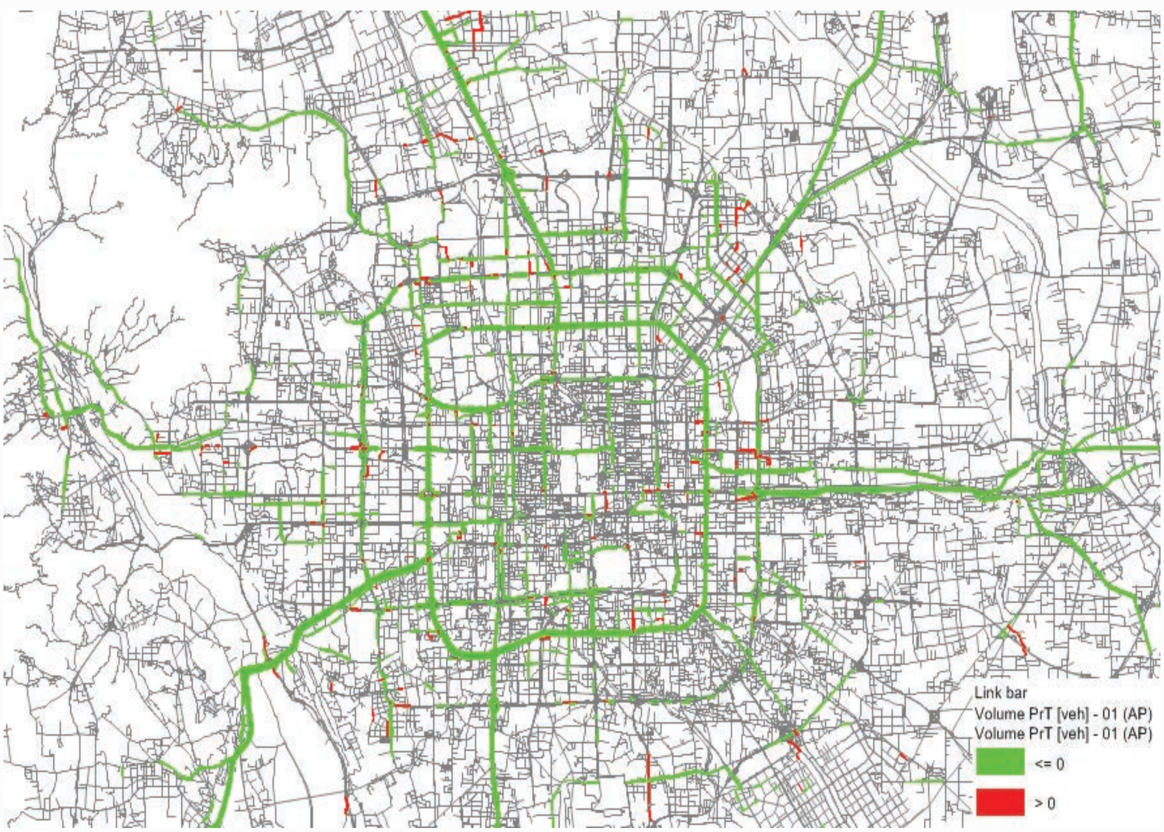


Source: Beijing Transportation Research Center.

2. Assessment of Bus Rapid Transit Scenarios

Transport modeling was carried out to test the possible effects of the two BRT network scenarios. All the BRT lanes in both scenarios were added to the current simulated road network. The effect of each BRT scenario on traffic volumes is shown in Figure 21 for Scenario 1 and Figure 22 for Scenario 2. The green color displayed on a road link means at least one vehicle was offloaded from the roads after the introduction of BRT. Trips by bus are encouraged while private car and taxi trips are minimized to some extent. Bicycle and other modes experience slight variations. The more comprehensive Scenario 2 reduces traffic on more road links. Implementation of all BRT corridors in both scenarios is expected to have more extensive impacts. Scenario 2 shows an increase in public transport usage (BRT, MRT, and bus) of 0.19% compared to the existing mode share of public transport. Compared to the 2010 daily total trips of 41.2 million, 0.19% represents 78,000 additional public transport trips per day instead of traveling via cars, taxis, and bicycles. Just under one-third of the total trips are drawn from cars, leading to a decline in private vehicle kilometers of travel (VKT) of 3% within the Sixth Ring Road, as shown in Figure 21.

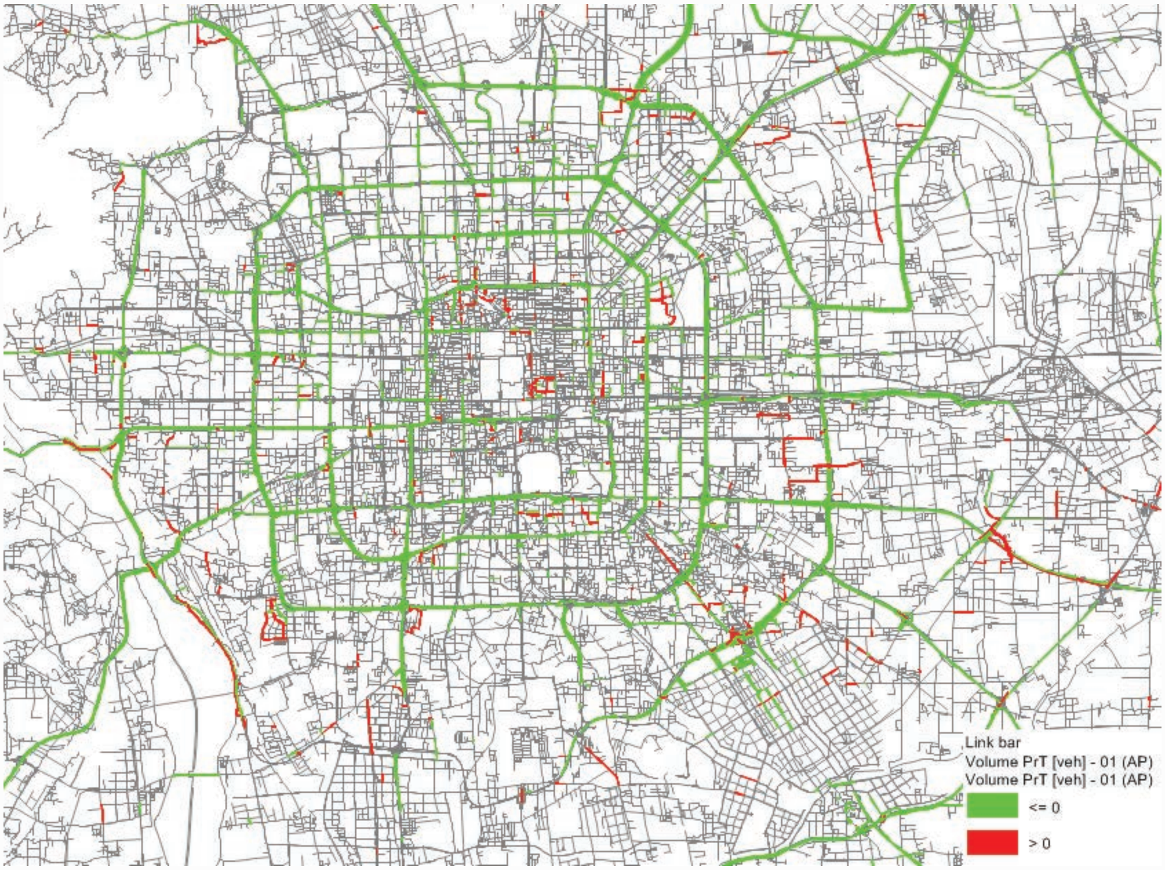
Figure 21: Traffic Volume Change with Scenario 1



Volume Prt [veh] – 01 (AP) = volume of private vehicles in Scenario 1.

Source: Beijing Transportation Research Center.

Figure 22: Traffic Volume Change with Scenario 2



Volume Prt [veh] – 01 (AP) = volume of private vehicles for Scenario 2.

Source: Beijing Transportation Research Center.

Table 10: Model Test Result—Mode Share Changes within Sixth Ring Road

Mode Share within Sixth Ring Road	Current Daily (%)	Scenario 1 (%)	Scenario 2 (%)
Car	33.40	33.19	32.34
Taxi	6.40	6.39	6.02
Public transport	43.20	43.43	45.39
Bike	14.00	13.99	13.94
Others	3.00	3.00	2.90

Source: Beijing Transportation Research Center.

Table 11: Model Test Result: Vehicle Kilometers and Bus Rapid Transit Passenger Kilometers in Morning Peak

Morning Peak within Sixth Ring Road	Scenario 1 (%)	Scenario 2 (%)
Private vehicle kilometer of travel	–0.96	–2.91
Bus rapid transit passenger kilometer	4.41	19.67

Source: Beijing Transportation Research Center.

B. Charging for Road Use

The economic rationale for charging for the use of roads is no different from the general rationale found elsewhere for setting prices appropriately so consumers will make sound decisions about what and how much they consume. Therefore, charging for road use would be expected to result in more efficient road use. The revenues raised from road users can then be used to fund the ongoing provision of the transport network.

Therefore, the rationale for road pricing clearly includes two quite separate objectives. The main objective is to encourage consumers to make economically optimal transport decisions and the second objective is revenue generation. Road use charges may be a powerful revenue-raising device, hence, there is potential for road use charges to generate revenue to fund significant government expenditure in both the transport sector (e.g., new roads and road maintenance) and in other sectors. However, if such expenditure is not economically justified, it follows that charges used to support that expenditure are excessive. The influence of particular levels of charge on driver behavior depends on how they perceive their travel costs. Transport planners and economists normally study motorists' perceptions of the cost of their time, and some or their entire car operating costs, such as the fuel cost and perhaps part of the maintenance cost. A road use charge applied across a cordon, or in any other way, is intended to directly impact on the perceived costs of their travel.

The starting points for developing suitable congestion charging scenarios are the objectives and constraints. Beijing suffers substantial economic losses because of both congestion and air quality problems, and reducing these would make suitable policy objectives, even if targeting congestion may lead to a different design than reducing air quality problems. In testing the congestion charging scenarios, the objective was set to reduce the overall working day congestion index within the Fifth Ring from 5.5 to 5, a reduction of 9%. Furthermore, constraints were put on the maximum charge level of CNY40. In addition, the political opinion is that congestion charging cannot be introduced without removing the existing license plate ban policy so the congestion charging policy needs to generate similar effects as the existing license plate ban plus a reduction of the congestion index by 9%.

Given the political objectives, it immediately becomes apparent that a policy is needed that affects the travel behavior of a large quantity of drivers in Beijing. Replacing the 1-day-a-week license plate ban with a small cordon will never achieve the same effects as the license plate ban, let alone achieve additional positive effects on congestion. The downside of a policy with wider coverage is that it comes with additional political risk and public opposition. Given this tension between policy objectives and political risks with larger congestion charging policies, three different types of congestion charging were tested.

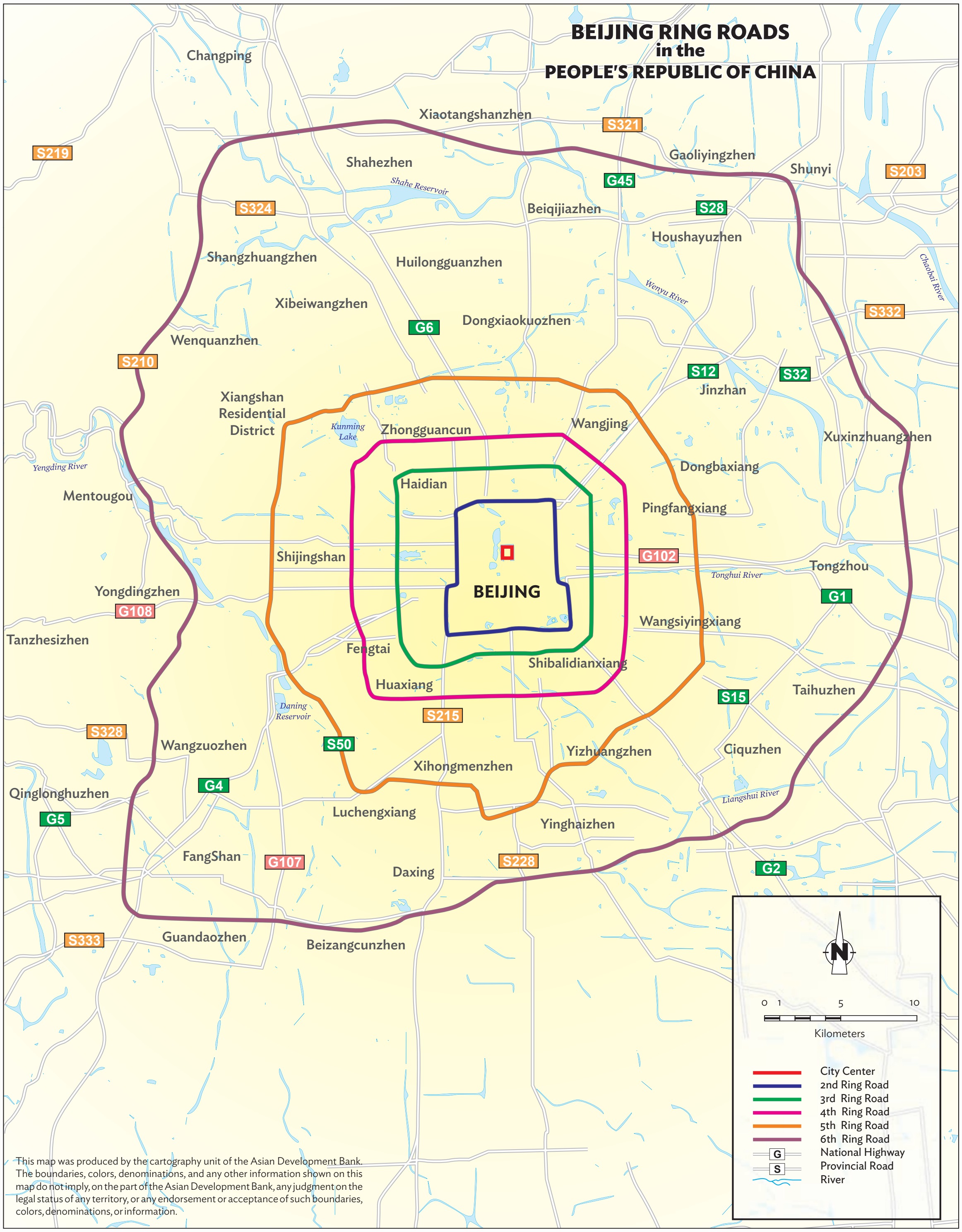
(i) **Distance-based charge.** Most likely will meet the policy objectives and constraints, but is not feasible to implement in the short term. A distance-based charge does not account for the spatial and temporal aspects of congestion but may be designed to reflect "a certain average level of congestion";

(ii) **Area and cordon charging scenarios around ring road structures.** These will provide socioeconomic benefits, but will not meet the 9% reduction in congestion index set as an objective and maximum charge of CNY40. These systems can be implemented in the medium term; and

(iii) **Cordon-based charging scenarios around smaller specific zones in Beijing.** These systems provide minimal socioeconomic benefits for Beijing, and do not reduce the congestion index by 9%, but these can be introduced in the short term and may be a stepping-stone for a larger introduction of congestion charging.

The charging scenarios are applied to the Beijing ring roads. Figure 23 shows the different ring roads in Beijing.

Figure 23: Beijing Ring Roads



Source: ADB.

1. Overview of Scenarios

The objective of the scenario analyses is to find the best alternative within each of the three typologies. This is an iterative process in which scenarios are implemented in the transportation model, the effects of the scenario are analyzed, and new adapted versions of the scenario are identified, implemented, and evaluated again. However, as a starting point, the first scenarios to evaluate were determined as presented in Table 12. Within each typology of congestion charging policies, the scenarios differed in geographic scope as well as charge levels. In total, 18 initial model runs were identified.

Table 12: Overview of First Set of Scenarios

	Charge Level (CNY)		
	Per Day for Area Charging	**Per Passage for Cordon**	**Per Kilometer for Distance-Based**
Third Ring Road cordon, including Third Ring Road	20	40	
Third Ring Road area, including Third Ring Road	20	40	
Third Ring Road area, inside only (Ring Road free of charge)	20	40	
Central business district	20	40	60
Financial street	20	40	60
Zhong Guan Cun	20	40	60
Central business district–Financial Street–Zhong Guan Cun together		40	
Kilometer charge within Fifth Ring Road	2	4	

Source: Beijing Transportation Research Center.

Because of resource constraints, six different scenarios were tested: one distance-based policy, three cordon/area charging policies around the Third Ring Road, and two CBD cordon charging scenarios. The distance-based charging policy looked at a flat kilometer charge of CNY2 on all roads within the Fifth Ring. For the charging policies surrounding the Third Ring Road, two different area charging alternatives were investigated where only the charge level was changed from CNY20 to CNY40. In the third alternative for the Third Ring Road, cording charging replaced area charging. Lastly, two alternatives were tested for the CBD alternative, one with a CNY20 charge and the other with a CNY40 charge.

2. High-Level Evaluation of Scenario Results

To quickly compare the effects of different policies on a high level, three different indicators were used. All three indicators are simplifications of more complex calculations, but they provide a usable base for indicative appraisal of "good" and "bad" alternatives. First, a proxy for the societal benefits was used by calculating the changes in consumer surplus for car travelers only. The societal benefits should be one of the key drivers in decision making. Second, the changes in the congestion index for the morning peak were calculated using a method based on the volume–capacity ratios from the transportation model. These changes in congestion index provide a direct link to the political objectives. The third indicator is the reduction in vehicle kilometers traveled which is a simplified indicator for environmental effects.

The performance results for each of the scenarios for the three indicators are provided in Table 13. Clearly, and as expected, the kilometer charge provides the highest societal benefits, reduces the congestion index the most, and has the highest effect on vehicle kilometers traveled. The area charging around the Third Ring Road is second, where either CNY20 or CNY40 is better depending on how societal benefits are weighed compared to the other indicators. The lower societal benefits for the CNY40 alternative are mainly the result of further reduction of car trips. The societal costs for this is about three times higher than for the CNY20 alternative, while the benefits are only about 30% higher. Charging around the CBD area does not affect the traffic conditions or the environment, but has a slightly negative social benefit.

Based on these results, the detailed analyses of one alternative for each of the solution directions are as follows:

- **Distance-based charging of CNY2/kilometer (km) within Fifth Ring Road.** This was the only kilometer charge scenario available;
- **Area charging of CNY40 within Third Ring Road.** Even if the social benefits of the system are lower than the CNY20 alternative, these may be mitigated in future improvements to the scheme. The higher effect on the congestion index, which is the main political objective, was considered more important in this case;
- **CBD cordon charging CNY20.** Congestion charging in the smaller areas needs to be seen as a pilot to something bigger. Therefore, it is important that the benefits inside the zone are higher than the potential deterioration outside the zone. The current negative social benefits show that this is not the case. Therefore, the CNY20 scenario is chosen, because improvements to that scenario are most likely to result in societal benefits.

3. Distance-Based Charging

In the distance-based charging alternative, a flat kilometer charge of CNY2 within the Fifth Ring Road was tested. Since the average trip distance is about 12 km, this charge level corresponds, on average, to the CNY20 charge levels used on other scenarios. A distance-based charging policy is attractive as it not only decreases the negative side effects of boundary problems that occur in area and cordon charging schemes, but it also charges more for longer distance trips than shorter trips. This type of charging policy is more in line with the economic theory on congestion charging.

Traffic Effects

Table 13 presented that the kilometer charge provides the highest societal benefits of all the scenarios considered. The policy generates about CNY8.84 million in revenues per morning peak period. The average paid charge is CNY14. This seems low compared to the average trip distance, but inside the Fifth Ring Road, the trip distance for car users is only about 7 km.

The kilometer charge substantially reduces the congestion index. Table 14 shows that the total reduction in congestion index is distributed somewhat unevenly among the different ring roads. The largest reductions are further away from the central area. Using detours on these ring roads becomes more expensive.

Table 13: Overview of Performance of Scenarios on Key Indicators

Scenario Description	Societal Benefits (Million CNY per Morning Peak)	Congestion Index (%)	Environmental Effects (Reduced Vehicle Kilometers per Morning Peak) (%)
Kilometer charge CNY2 per km within Fifth Ring	5.15	–11	–10
Area charging Third Ring Road CNY20	2.27	–5	–3
Area charging Third Ring Road CNY40	1.37	–9	–5
Cordon charging Third Ring Road CNY20	0.82	–2	–1
CBD cordon charging CNY20	–0.22	0	0
CBD cordon charging CNY40	–0.37	0	–1

Source: Beijing Transportation Research Center.

The improvement in congestion index is the result of reductions in car demand. Overall, car demand decreased with 8%, but inside the Fifth Ring Road (the charging area), the demand drops about 15%. This decrease in car demand also leads to changes in mode shares. These are presented in Table 15. The changes in mode shares are somewhat unexpected. The decrease in taxi shares is a direct result of the unintended charging of taxis. This needs to be adjusted in future scenario analyses. The second unexpected issue is the shift to coach, but since the absolute demand for coach is low, higher relative changes can be expected.

Table 14: Changes in Congestion Index

Area	Change (%)
Entire network	–15
On Second Ring Road	–9
On Third Ring Road	–6
On Fourth Ring Road	–16
On Fifth Ring Road	–36

Source: Beijing Transportation Research Center.

The traffic conditions change substantially as a result of the changes in demand, also obvious from improvements in the congestion index. In Figure 24, green roads mean that flows decreased there, while red roads mean increases in flows. The thickness of the bars indicates the size of the change in flow. The charging area for the kilometer charge is large, but still there are some route adaptations around Beijing to avoid paying. Within the Fifth Ring Road, only reductions in flows can be detected.

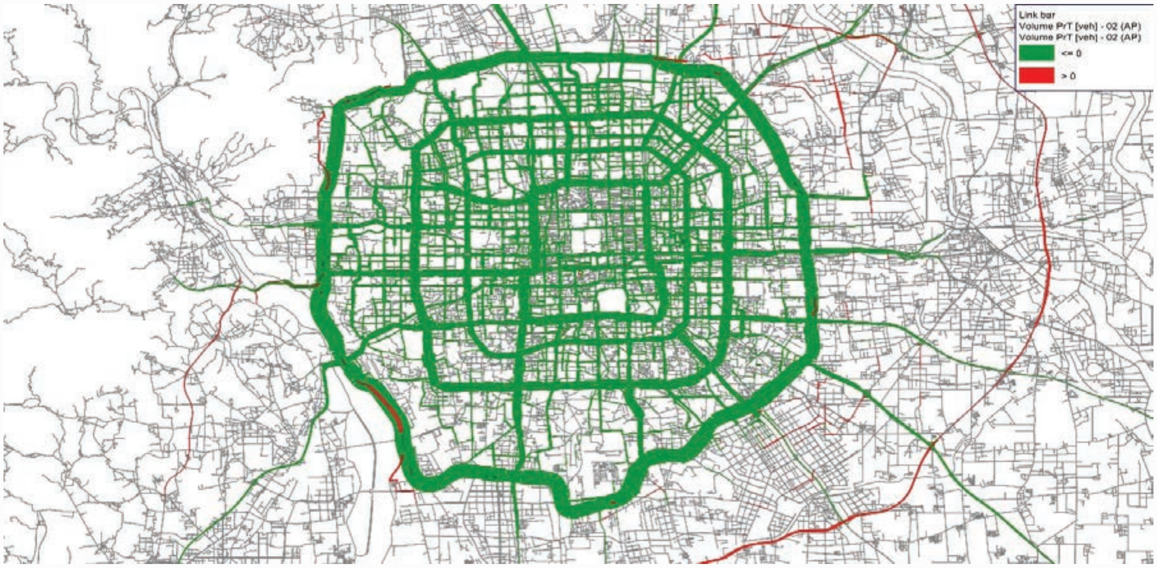
Table 15: Changes in Mode Shares (Trips)

Mode	Change (%)
Car	–5
Taxi	–13
Coach	21
Public transport	2
Bicycle	3

Source: Beijing Transportation Research Center.

The changes in flows will have consequences on the speeds in the network as well, and Figure 25 shows the relative change in speeds compared to the reference in different categories. Since the speeds in the reference situation are extremely low, with many roads having volume–capacity ratios above 1 (traffic volume assigned to a road is higher than the capacity of that road), the relative speeds increases can be high even if conditions are still congested in absolute terms. As a consequence, substantial speed increases are to be expected inside the Fifth Ring Road. The increases in flows resulting from rerouting do seem to result in speed decreases in the North–East and West of Beijing, and these need to be investigated.

Figure 24: Changes in Flows Using Distance-Based Charging Scenario



Volume Prt [veh] – 02 (AP) = volume of private vehicles for distance-based charging scenario.
Source: Beijing Transportation Research Center.

Figure 25: Relative Changes in Network Speeds Using Distance-Based Charging Scenario

Volume Prt [veh] – 02 (AP) = volume of private vehicles for distance-based charging scenario.
Source: Beijing Transportation Research Center.

4. Area Charging around the Third Ring Road

In the area charging scenario, car drivers pay when entering the area within and including the Third Ring Road. Even travelers who travel inside the area are charged, in contrast to cordon charging where only those who travel over the charging boundary are charged. For the area charging scenario, a charge level of CNY40 per day is used. Even if the societal benefits were lower compared to the CNY20 scenario, the effects on the congestion index were higher. When this scenario is further developed in more detail, the aim should then be to increase the system's societal benefits.

Traffic Effects

The overall reduction in the congestion index for the area charging scenario is about 9%, which is sufficient to reach policy objectives if the license plate ban remains in place. The total revenues generated by the scenario are about CNY7.77 million per morning peak. The reductions in car demand are substantial within the entire Fifth Ring, with its highest reductions within the Second Ring Road. Table 16 shows the changes in car demand levels (number of travelers) for the area within each ring road as well as the total network.

Table 16: Changes in Car Demand Levels for the Area Charging Scenario

Area	Change (%)
Second Ring Road	–58
Third Ring Road	–51
Fourth Ring Road	–38
Fifth Ring Road	–24
Total	–9

Source: Beijing Transportation Research Center.

These numbers seem unexpectedly high, so the model for the scenario may need to be checked again (coding, charge correctly converted to time, right value of time [VoT], etc). The results are also high in the CNY20 alternative, so, potentially, the short-distance trips in these areas are affected significantly by the charges. However, Table 17 does not show significant reductions in car shares.

Table 17: Changes in Mode Shares for the Area Charging Scenario

Mode	Change (%)
Car	–7
Taxi	–18
Coach	21
Public transport	5
Bicycle	2

Source: Beijing Transportation Research Center.

If the changes in mode shares are investigated in more detail, then the car shares are reduced by half (Table 18). The question remains if these changes in mode shares are realistic. They could be, but the size is reason to investigate the model further.

Table 18: Changes in Car Shares for Trips between Different Areas (%)

	Inside Second Ring Road	Inside Third Ring Road	Inside Fourth Ring Road	Inside Fifth Ring Road
Inside Second Ring Road	–54	–45	–47	–44
Inside Third Ring Road	–44	–47	–48	–46
Inside Fourth Ring Road	–33	–39	–1	6
Inside Fifth Ring Road	–31	–38	6	2

Sources: Beijing Transportation Research Center; ADB consultants.

The reductions in car demand, resulting in improvements in the congestion index; as shown on the road network in Figures 26 and 27, flows clearly decrease within the charging zone (green) and increase on the outer ring roads. The speeds on these outer ring roads do not seem to decrease much, however, single bottleneck points can be identified and mitigated.

Figure 26: Changes in Flows Using Area Charging Scenario

Volume Prt [veh] – 02 (AP) = volume of private vehicles for area charging scenario.

Source: Beijing Transportation Research Center.

Figure 27: Changes in Speeds Using Area Charging Scenario

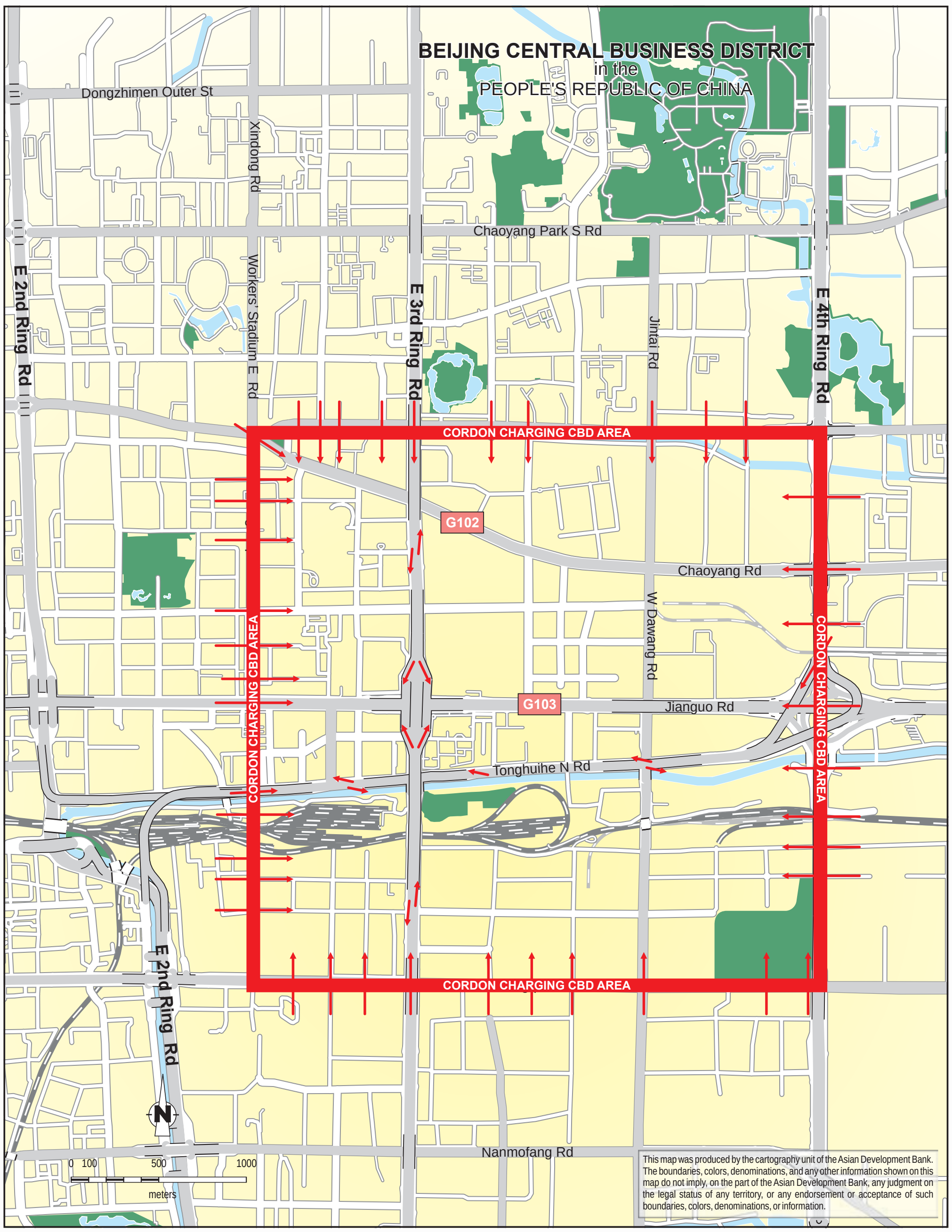
km/h = kilometer per hour, vCur-PrtSys – 02 (Car) = car speed for area charging scenario.

Source: Beijing Transportation Research Center.

5. Cordon Charging in Central Business District Area

Charging in the CBD area (Figure 28) may make a substantial difference to local traffic, but it will not benefit Beijing's population in general. In the CBD area two new metro lines will be opened (lines 7 and 14), and together with the existing metro lines, the CBD will have above average public transport availability. Apart from this, the area has focused on promoting walkability and cycling. Parking is also being addressed within the CBD area. Congestion charging could contribute to turning this area into a sustainable transportation zone for Beijing.

Figure 28: Cordon Charging Central Business District Area



Source: ADB.

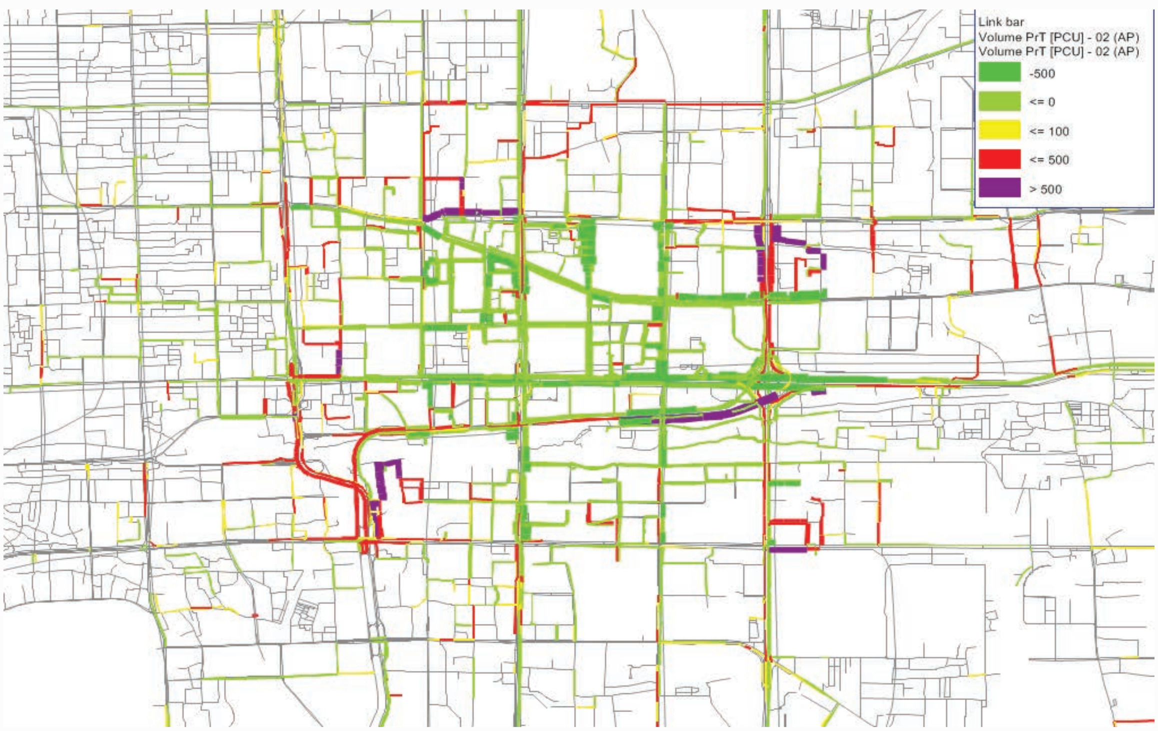
Table 13 already showed that the overall societal benefits are nonexistent or even slightly negative, and the scenario generates about CNY0.31 million per morning peak. It is good to note that the current model does not incorporate the new metro lines yet. A larger share of the riders will already be using public transportation, but even shifting to public transportation will be easier than is currently modeled.

Traffic Effects

In the previous scenarios, changes in demand levels and mode choice were presented, but for the CBD scenario, these are all zero, as is the change in the congestion index. This implies that the CBD system has no impact on the Beijing transportation system overall. But locally, there are both positive and negative effects.

Figure 29 shows the changes in flows on the network for the CBD scenario. Inside the CBD area are clear reductions in flows (green), while on the boundaries are clear increases in flows (red and purple). Rerouting around the small zone may cause deteriorating traffic conditions just outside the zone, which offset the potential benefits. Thus, the exact boundary of a CBD zone needs to be studied in more detail, and mitigating measures should be found that can reduce these negative effects.

Figure 29: Changes in Flows for Cordon Pricing in the Central Business District Area



Volume Prt [PCU] – 02 (AP) = volume of vehicles in passenger car unit for cordon pricing scenario.

Source: Beijing Transportation Research Center.

The modeling results show the congestion charging scenario that produces the highest benefits to society is the distance-based charge imposed on the Fifth Ring Road. However, the number of scenarios is mainly limited by available modeling resources within the study period, and many other alternatives and adaptations to existing alternatives should be investigated. All of the tested scenarios are first-test scenarios which likely can be improved upon.

Transition Implementation Strategy

The objectives of the congestion charging policy are ambitious, and affect many, if not all travelers. This congestion charging policy requires political support, partly because of the high political risks and the lack of congestion charging examples in the PRC. To overcome the political barriers to introducing congestion charging, a transition strategy should be considered where, first, a pilot policy is implemented in small areas, followed by an area charging policy 3 to 5 years later, leading to a distance-based policy in 10 years. The charging infrastructure for the area charging scheme can be partially reused for enforcement.

CHAPTER IV

Future Policy Challenges and Improvement Directions for Travel Demand Management

Beijing is a modern, sophisticated metropolis that is often a role model for what other cities in the PRC may adopt. Since 2003, the Beijing Municipal Government has increasingly comprehensively addressed the growth in travel demand and associated motorization in Beijing. Initially, the main concern was traffic congestion, but today vehicle-related air pollution is an equally prominent issue. Rising GHG emissions from transport are also a concern.

However, though car ownership is still below 0.5 cars per household today, congestion and associated emissions are high despite recent relief provided by TDM measures introduced since 2008. Despite annual caps on the number of vehicles introduced in 2011, the car fleet continues to grow at just below 5% per annum.

Beijing's policy makers understand the concept of building more roads is not a solution to congestion as evidenced by the recent focus on TDM measures. While roads and streets are essential to supporting development and road-based public transport use, building major road infrastructure that facilitates traffic access to already-congested major activity centers is likely to be counter-productive, and will lead to losses of community welfare.

A. Challenges

Three key policy challenges can be determined from Beijing's extensive experience with the expansion of multimodal transport infrastructure, introduction of TDM, and changes in the organizational arrangements for urban transport:

Travel demand continues to grow rapidly, as does motorization. Current TDM measures appear to be fairly effective as these tackle both the ownership and use of vehicles, but much more remains to be done. Recent improvements to parking pricing changes are just the beginning of a needed major system-change in the parking system that has been acknowledged by the BMG. While the car ownership quota on the surface is quite equitable, the 1-day-a-week vehicle use restriction based on the number plate's final digit, is likely to be circumvented by wealthy people who own more than one car.[37] The current restrictions are based on time periods and geographic areas and not where congestion may actually or will occur in the future.

[37] It is likely that some wealthy people may have circumvented the quota prior to its introduction by buying cars in advance.

Continued improvements to public transport alone are insufficient in addressing Beijing's transport challenges. The quadrupling of subway length and bus services since 2003 has been extremely beneficial in providing an alternative to private vehicle use and acts as a relief valve to congestion. Nevertheless, while combined subway and bus usage has increased by more than 50%, much of this growth was apparently diverted from bicycle use. With the introduction of the vehicle quota and the 1-day-a-week driving restriction and other measures, car use has apparently peaked and slightly declined as a proportion of daily trip making that is growing.

Effective management of the direction, pace, and density of urban development is critical. While population and household income growth have been key drivers of travel demand, the demand for affordable housing and modern commercial offices has driven much new development to the edge of the expanding urban area. The building of new large roads on the fringes of the urban area too far in advance of urban development may contribute to urban sprawl. The current institutional responsibilities for urban development, transport infrastructure provision, TDM and provision of public transport have improved in recent years at city level but there is room for further coordination improvements.

B. Directions for Improvement

The current study has identified several directions for improving Beijing's approach to TDM:

A multipronged suite of measures continues to be necessary. Beijing has already demonstrated a comprehensive approach to addressing congestion, accessibility, road safety, and emissions is essential to merely keep pace with growing demand. This has involved provision of public transport infrastructure and services, enhancement of conditions for walking and cycling, restrictions on car ownership and use, and pricing measures for parking and public transport. Greater research and careful planning of measures is needed to ensure the most beneficial are implemented. In the past, not all TDM measures were subject to detailed study prior to being proposed.

Congestion charging offers the opportunity to manage demand, and associated congestion and emissions, where and when they occur and to selectively address particular travel segments (e.g., vehicle, trip, and traveler types). Various forms of congestion charging appear to offer significant traffic congestion relief, and reduction in emissions, and do so in an equitable and transparent manner. In contrast to other types of transport improvement, charging of road use tends to minimize the potential to create new demand as a result of reduced traffic congestion. With the ability to optimize tolls over time, by vehicle type, and by geographic area, far greater selectivity in managing demand would be possible. Congestion charging appears to offer the following advantages compared to the current 1-day-a-week usage restriction measure or the situation that may exist without the current usage restriction:

- Discourages low-value (i.e., of low importance to the person making the trip) road use, particularly at peak times when usage charges would (arguably) be at their highest.
- Reduces peak period vehicle travel, and, hence, peak period congestion, congestion delays, and travel time uncertainties.

- Reduces the need for additional expenditure to cater to peak period demand (as a result of reduced peak period travel).
- Increases the cost of peak period travel (but with potentially offsetting reductions in other costs).
- Encourages increased off-peak travel, as some users change trip times to avoid peak period use charges.
- Encourages increased vehicle occupancy rates and public transport use, as a means of avoiding and/or minimizing the effects of any peak period road use charge.
- Has some impact on property values, with a distance-based charge favoring properties closer to the central area, and a cordon charge probably favoring properties within that cordon.
- Results in a reduced need for additional road expenditure and reduced costs to road consumers overall, than would otherwise be the case.

Have a clear objective for congestion charging. The objectives for congestion charging can vary considerably and the choice of objective(s) will influence the form of the congestion scheme adopted. For example, a focus on optimizing congestion across the urban area would likely feature efficiency and equity more than congestion reduction or reduction of air pollution in a major activity center. A dual focus on environment and revenue raising may lead to a different form of congestion scheme and associated measures with targeted use of revenues for public transport and other urban realm improvements.

A comprehensive approach to congestion charging is essential. To create sufficient benefit so travelers on all modes, as well as Beijing's citizens in general, can perceive the beneficial impact, a comprehensive congestion charging policy is required to cover the majority or all roads within Beijing. While a limited form of congestion charging could be implemented initially in a small part of Beijing, this needs to be seen as a transition to a larger scheme, that ultimately could be a distance-based charge (where the distance-based charge could vary to reflect congestion at different periods of the day).

Retention of the vehicle ownership quota and progressive reforms of parking and other TDM measures would be essential even if a form of congestion charging is pursued. Experience shows that the demand for car ownership and use of cars is extremely high. Congestion charging alone cannot reasonably curb this demand. Significant "quick wins" are available to enhance the TDM apart from the planned rail MRT:

- Develop new extensive bus lanes and BRT corridors;
- Strategically extend an improved public bike sharing scheme primarily within the Fifth Ring Road, and enhance opportunities for use of individually owned bicycles to access rapid transit stations (bus and rail) and bus stops;
- Improve the efficiency of traffic management, including urban expressways based on how these actually operate;
- Enhance sidewalks and pedestrian facilities throughout the city, in particular, connecting to rapid transit stations and bus stops or linking activity areas to residential areas; and
- Continue to rationalize the pricing and management of parking cars throughout the city.

Other matters worthy of consideration should congestion charging be pursued are:

- **Revisions to current road use charges.** The current system of road use charges does little to moderate use of vehicles during congested times and at congested locations; registration charges are a fixed charge that does not vary with distance (or time of travel) and encourages extensive vehicle use once these charges are paid. Fuel excise charges do not vary by time of travel. A suitable congestion charging scheme could allow some existing charges to be reduced (e.g., motor vehicle registration and driver license fees) so these charges may recover their ongoing administration costs. Such an approach may be useful in convincing car and fleet owners of the merits of congestion charging.

- **Sophisticated travel demand forecasting tools.** Development of an explicit congestion charging scheme requires careful preparation, sound feasibility assessments, and a robust transport modeling capability sensitive to the critical policy issues. The Government of the People's Republic of China (PRC), with GIZ and ADB support, already uses a very advanced and sophisticated transport model, but further refinements are possible, for example, to include time period modeling. The London congestion charging scheme shows the impact a charge can have: far-reaching short- and medium- to long-term effects. The short-term effects include changes in travel patterns manifested in traffic diversion (time, location, and route), modal switching, and so on. In the medium to long term, changes in land use effects, including impacts on the property market and business could all be significant. The impact of charges can have quite different effects on cars, trucks, and other vehicle users (and revenue expectations).
- **Monitoring impacts of a road use charging scheme.** If it is decided to proceed with an explicit road use charging scheme, a suitable monitoring program is needed to respond to all stakeholders' concerns, to measure actual outcomes, and to identify needed management interventions. Even with the most sophisticated forecasting and planning tools, it is important to monitor the actual impacts on traffic, public transport, business, and other stakeholders. Many of these impacts will be quite subtle and may only be discernible in the medium to longer term. Monitoring of the effects of any major transport change requires the establishment of a suitable base line and a monitoring program, and defined survey methods that can be implemented at an appropriate time. Adequate budgets are also needed.
- **Impact of congestion charging on BMG and related organizational arrangements.** If it is decided to proceed with an explicit congestion charging scheme, an important consideration is to define what the scheme entails, including the various functional requirements of planning, design, operations, monitoring, and enforcement. The impact of these functions on BMG and other relevant agencies should be defined in staffing, skills, budget, and necessary practical enforcement powers. If it is decided to proceed with a charging scheme, a review of all relevant legislation is needed to ensure that BMG has the power to set and apply charges, enforce the scheme, and implement any other relevant actions needed to support the scheme's implementation and operation.
- **Optimal level of congestion charge.** A technical review would be desirable to establish the optimal charge and structure of charges. An optimal charge implies maximizing benefits to the community. The setting of higher charges, even if practically possible, would reduce community benefits compared to the optimum, and may lead to reverse effects, which may not be immediately apparent.
- **Review of implementation and recurrent costs, and continued review of advances in technology.** Detailed estimates of implementation costs need to be made based on promising feasible options. Recurrent operation and maintenance cost estimates need to be made, as well as demand and associated revenue forecasts. Technological advances should continue to be monitored, but it is clear from the work undertaken for this study, that a range of technology providers would be able to implement even the most advanced charging scheme using proven technology and components.

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Travel Demand Management Options in Beijing

Rapid urbanization and motorization combined with high population density have led to serious congestion and air quality problems in the People's Republic of China capital of Beijing. While Beijing accounts for less than 2% of the population, more than 10% of the country's vehicles ply the city's roads. This study is part of the Asian Development Bank's initiative to support greener and more sustainable transport systems that are convenient and lessen carbon dioxide emissions. Read how congestion charging, vehicle ownership quotas, and progressive parking reforms can improve Beijing's approach to travel demand management.

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