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CONGESTION BUILDING: THE DYNAMICS BEHIND ANTI-CONGESTION POLICIES IN URBANIZING CHINA

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ABSTRACT

During the last decade, traffic congestion spread out quickly among Chinese cities, and today two thirds of them are suffering from congestion. Meanwhile, a variety of anti-congestion policies, with popular ones such as expanding infrastructures and restricting automobile ownership and use, have been searched and developed by city governments. The paper builds from the theory of system dynamics to establish a mental model of the congestion formation mechanism in China. Further, the paper categorizes anti-congestion policies into "road-building and similar", "imperative demand control", "redistribution of road supply", "demand management through pricing" and "transit oriented development", and introduces them into the mental model to analyze their respective consequences. Results show that 1) implementing "road-building and similar" policies in urbanizing China has been exacerbating the congestion situation; 2) the impact of "imperative demand control" and "demand management through pricing" tends to be limited or short-lived due to either leakage effects and/or poor government enforcement capacity; 3) "adjusting supply" can be more effective; and 4) "transit-oriented development", rarely proposed yet for the sake of congestion relief, turns out to be most promising in China for affecting traffic demand and supply simultaneously.

INTRODUCTION

In recent years, traffic congestion has attracted much attention in the Chinese society. After emerging first in mega-cities- like Beijing, Shanghai, Guangzhou, Chengdu, etc- only a few years ago, congestion quickly further spread out to almost every large city with more than one million people. According to the state media, today two thirds of cities in China, including even many middle-sized cities and small towns, are suffering from congestion in the peak hours (*1*). And the problem is believed to be worsening amidst the urbanization process. Congestion not only delays people's activities and hampers the function efficiency of the society and economy, but also leads to air pollution and wasted energy use and greenhouse gas (GHG) emission, all threatening the sustainability of Chinese urbanization in the coming decades.

Along with the spread of congestion, there have also been hot domestic debates on its causes and remedies. The lag of metro-line construction, shortage of intelligent transport system (ITS), poor disciplines of citizens' travel behavior, phase of transitional development, high population density, abuse of government vehicles, have all been blamed for causing congestion (*2-8*). From the central government level to the municipal level, a range of policies have been introduced to relieve congestion. For example, the ministry of transportation has emphasized on the investment of public transportation system and multi-mode hubs to solve the congestion problem (*9*). Beijing municipal government has proposed a bundle of 28 measures, such as improving urban planning, accelerating road construction, promoting transit, enhancing non-motorized transport system, enforcing vehicle management, etc (*10*). The Guangzhou city government has considered 30 measures including raising parking fee, congestion pricing and limiting non-local vehicles. The ultimate policy goal is to maintain rush hour speeds on major arterials over 25 km per hour by 2016 (*11*).

It seems that in China, anti-congestion policies developed so far is in rich diversity yet with a mixture of good and bad ones. Furthermore, the priority or urgency for those policy options is rarely discussed. City is like a human being; a city with traffic congestion is like a man with chronic vascular blockage. It is impossible to cure someone by using only one strong medicine, or by prescribing as many different medicines as possible at one time. Traffic congestion is a comprehensive system problem; therefore it cannot be solved by taking sporadic and piecemeal measures. The only solution is to carefully review the dynamics of the system, and suit the remedy to the real case.

LITERATURE REVIEW

System dynamics was founded by Prof Jay W. Forrester at Massachusetts Institute of Technology in 1956. Grounded in the theory of nonlinear dynamics and feedback control in mathematics, physics and engineering, system dynamics was developed to enhance the understanding of complex systems and to help managers and policymakers design and implement long-term effective policies while addressing leakage effects (*12*). In 1969, Prof Forrester published his book Urban Dynamics based on the study of urban problems in Boston. In 1971, Prof Forrester built the World Model III and published the books of World Dynamic and Limits of Growth, which soon became highly appreciated by the international community. In 1980, system dynamics was introduced to China. Since then, within the field of transportation, the method has been applied to research private automobile ownership (e.g., *13*), as well as traffic congestion (e.g., *14-17*).

In the literature, traffic congestion models are often macroscopic with complex framework containing numerous modules to capture as many aspects of the economic society as possible. The shortcoming is this approach is that modelers have to simplify the traffic generation module by ignoring some important potential factors (e.g., latent demand). In addition, previous modelers often emphasize much on data calibration (i.e., the capability of doing backcasting and forecasting), but provide little on detailed description of the model framework; model outputs become difficult to be interpreted. More importantly, all previous models neglect the active role of government fighting against congestion by designing and implementing relevant policies. As a result, most models are incapable of accommodating emerging anti-congestion policies, not to mention analyzing their consequences.

This paper calls for the return to the basic purpose of applying system dynamics; that is to improve the mental model and to investigate policy resistance. Through the development of causal loop diagrams around traffic congestion formation mechanism, the paper aims at answering the following questions: Why is traffic congestion getting worse in China? Among domestically debated anti-congestion policies, which ones are effective and sustainable, and which are not?

CONGESTION FORMATION MODEL

All dynamics arise from the interaction of just two kinds of feedback loops in any system- the self-reinforcing loop and self-balancing loop (*12*). Any single loop consists of two or more variables with casual relations in between. The polarity, either positive (+) or negative (-), indicates how the dependent variable changes when the independent variable changes. Reinforcing loop (identifier as R) is self-augmenting with positive feedback, characterized by even number (including null) of negative causal relations. A typical example is the chicken-egg interaction, as shown in Fig 1 left (Reinforcing loop: ①→②→①). Balancing loop (identifier as B) is self-correcting with negative feedback, characterized by odd number of negative causal relations. A typical example is goal-seeking interaction. A student decides the work load based on how far his/her exam score is away from the set target. And the iteration of such decision making process will help the student to be always approaching the score target, as shown in Fig 1 right (Balancing loop: ③→④→⑤). A first guess for the ever-worsening congestion problem in China is that self-reinforcing loops must dominate the congestion formation mechanism, causing a series of vicious circles.

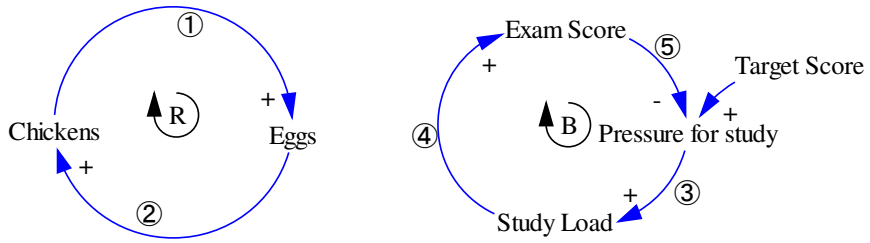

FIGURE 1 Example of Reinforcing Loop (left) and Balancing Loop (right)

Mental Model of Conventional Road-Building Policies

The direct reason for traffic congestion is simple: realized demand of automobile travel exceeds capacity of road supply. In recent decades, along acceleration of urbanization in China, more people migrate to cities. As life standards keep rising, private automobiles have gradually shifted from luxury goods to mass consumer products. Increase of urban population and automobile ownership both lead to surging growth of traffic demand whereas the road infrastructure development cannot catch up, thus causing the emergence of congestion.

Under pressure from public, the government has been long-time prioritizing road-building as the major anti-congestion policy. It is so common to see road-widening projects, road-elevation projects and ring-road project under the theme of "smoothing traffic" in almost every Chinese city. Combined with the desire of creating impressive city image and collecting land lease revenue with expansion, municipal governments in China has spent billions of dollars on road network plan, construction and management annually; in addition, 70-80% of intelligent efforts by transportation engineers in the development of advanced technologies has been allocated to serve the automobile industry and users (*18*).

From the system dynamics perspective, the four causal relations (①→②→③→④) indeed close a self-balancing loop, indicating that road building can ease traffic congestion in the near term, as shown in Fig 2. If that were the end of story, as was expected by many officials and traffic engineers, then the congestion problem would not have been bothering us. Unfortunately, there must be a series of strong self-reinforcing mechanisms behind to play a more dominating role in shaping the congestion problem.

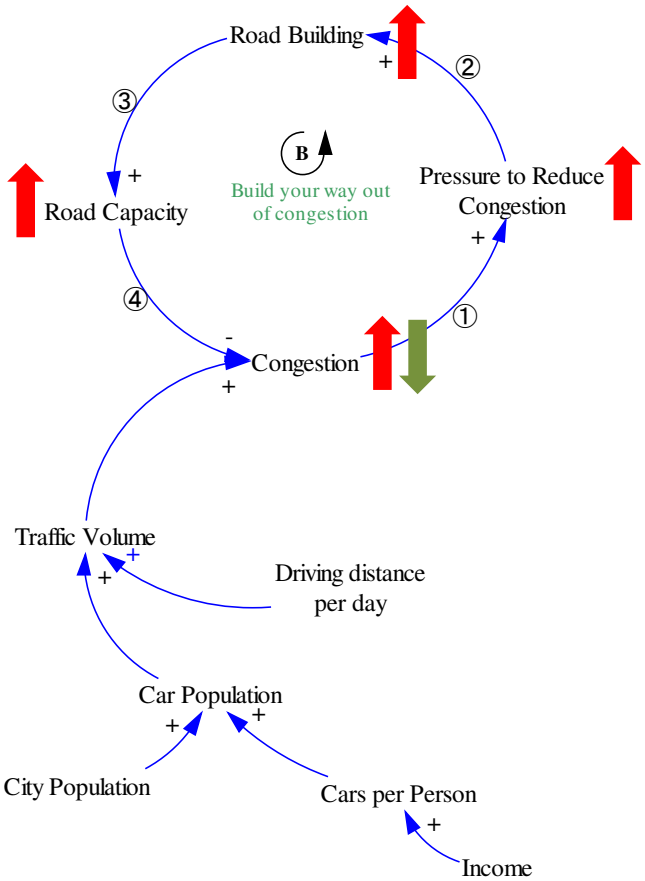

FIGURE 2 Mental Model of Conventional Road-Building Policies

Source: Adpated from (12):180

Post-Road Building Effect I: Release of Latent Demand

Probably when government officials are still excited at the immediate effect of traffic smoothing on the ribbon-cutting day, the new infrastructure has boost existing car owners to drive more frequently and in longer distance, therefore increasing the traffic volume and resume congestion at the newly built roads (Balancing loop: ①→②→③→④). On the other hand, mobility enhancement from adding supply gives strongest incentives for people purchasing cars (in addition to the rising income). The newly added automobile population also generates traffic volume, worsening the traffic congestion (Balancing loop: ①→⑤→⑥→⑦→④). As shown in Fig 3, there are two balancing loops killing the effectiveness of road-building policies in traffic congestion relief. The previously hidden travel demand can be promptly released after the opening of newly built roads, and such latent demand once revealed could easily overload the new road infrastructures.

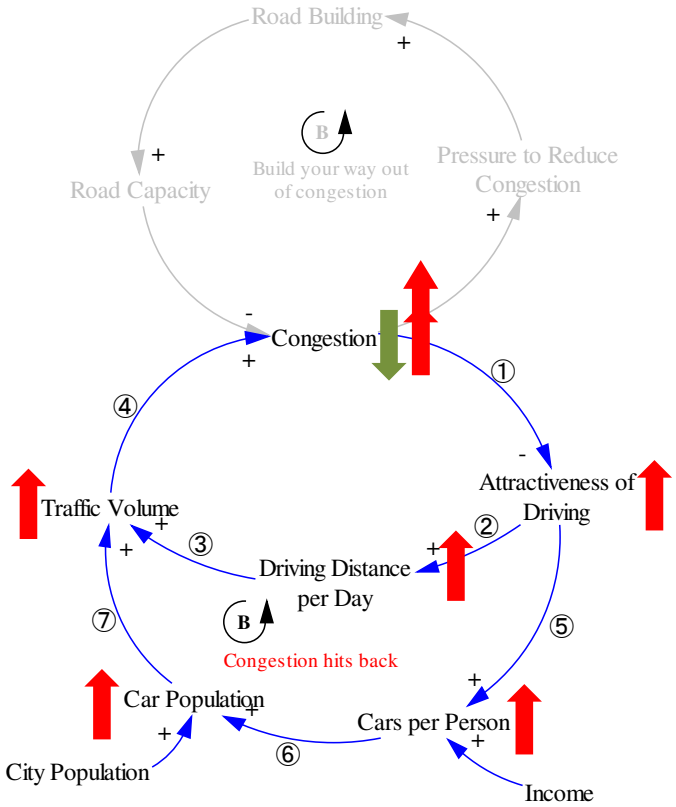

FIGURE 3 Release of Latent Demand after Road Building

Currently in the field of transportation, the conventional 4-step travel demand forecasting models (trip generation- trip distribution- mode split- trip assignment) are unfortunately not very capable of capturing this latent demand. As a result, many anti-congestion decisions derived from the complex models tend to be in favor of expanding infrastructures. In the scenario analysis, it is true that transportation modelers usually assume travel demand will grow in future years; however, the amount of additional demand is regarded simply as a function of economic growth and automobile population growth. In other words, expansion of road infrastructures or not does not affect the future increase of travel demand - the latent demand in this way is neglected.

Post-Road Building Effect II: Generation of Induced Demand

In the middle and long term, road building could trigger vicious circles of "congestion- road building- congestion again- more road building", as shown in Fig 4. The reason is that when roads are built into green fields, particularly combined with the de-densification of population strategy for the city core, it will encourage automobile-oriented superblock developments along those roads (Fig. 5), which generate huge induced demand in the following ways:
First, there is no job-housing balance in new town development (see Fig.6 for the Beijing case). The sleeping towns around city main area (such as Huilongguan and Tiantongyuan in Beijing) significantly increase the trip length of commuting residents and cause congestion. Unfortunately, government responded with building more roads outwards and facilitated spatial expansion, worsening the congestion problem (Reinforcing loop: ①→②→③→④→⑤→⑥→⑦→⑧→①).

Second, huge new development areas attract additional population, adding basic travel demand. These additional migrants are likely to live with cars in an automobile-oriented environment, increasing vehicle trip demand and worsening congestion (Reinforcing loop: ①→⑨→⑩→⑪→⑤→⑥→⑦→⑧→①).

Third, development of transit system often lags the new city area construction. Lengthening of per passenger transit travel distance lowers the service turnover of the transit system, making the transit itself congested and not comfortable. The superblock development pattern also causes low transit service penetration and serious last-mile access problem. As of the non-motorized transport environment, wide arterials are associated with long spacing of crossing facilities, thus becoming barriers for pedestrians and bicyclists who attempt to cross a street. Wide arterials also create large intersections with long signal waiting time; mix traffic at those intersections is often a big chaos. In addition, weak parking enforcement encourages illegal parking, especially on the sidewalk and bicycle lanes. Finally, the lack of bicycle parking facilities and poor safety management provide little security for bike users. All of these make biking and walking as an inferior option even for short or middle distance travel, shaping automobile dependence (Reinforcing loop: ①→⑫→⑬→⑭→④→⑤→⑥→⑦→⑧→①). For same reasons, the deterioration of transit and non-motorized travel environment causes the rise of automobile ownership. Many residents regard moving into a superblock and buying a car as a bundled decision for life-style changing (Reinforcing loop: ①→⑫→⑬→⑮→⑯→ ⑪→⑤→⑥→⑦→⑧→①).

The above four reinforcing loops sets the major reasons for worsening congestion in China. Take Beijing as an example. Along spatial expansion of the mono-centric city, the proportion of long distance trips has increased significantly, thus making bicycle difficult. According to local survey, the bike share dropped from 30.3% in 2005 to 17.9% in 2011. More surprisingly, over 40% of automobile trips are for short or middle distance travel (*19*), which could have been replaced by bike or walking. The only way to explain this is that the non-motorized transport environment has deteriorated so much because of the dispersion of automobile-oriented superblocks in the city.

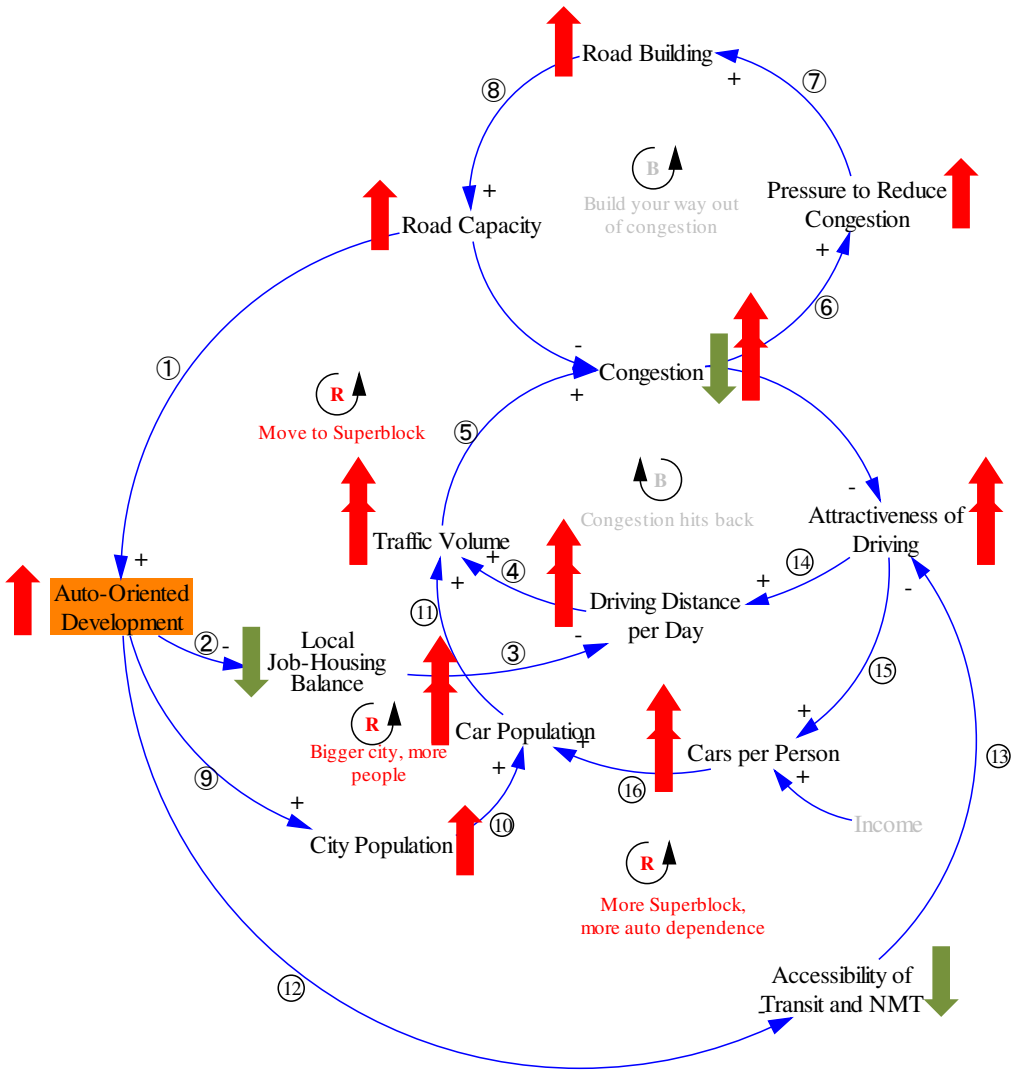

FIGURE 4 Generation of Induced Demand after Road Building

FIGURE 5 Superblock Development in Beijing (left) and Chongqing (right)

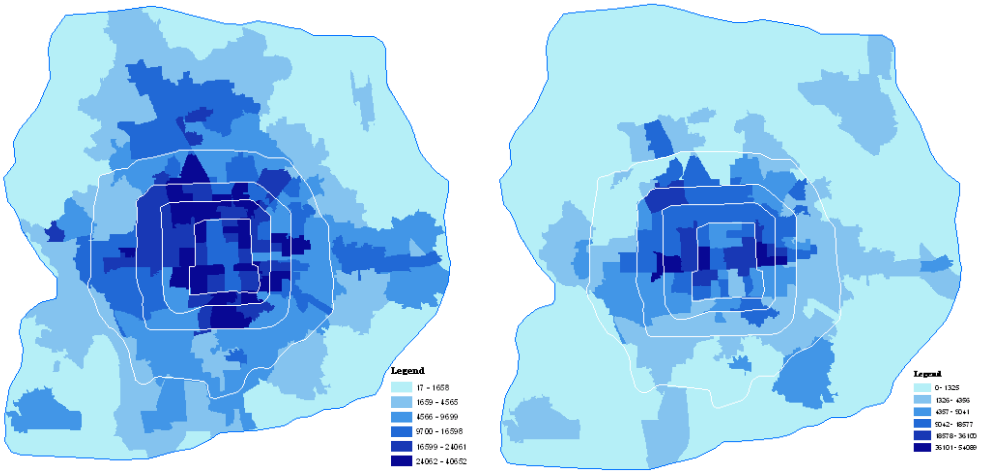

FIGURE 6 Population Distribution (left) vs. Job Distribution (right) within the Beijing 6th Ring Road
Source: Report on Beijing Transport and Land Use Relationship Study, Beijing Transportation Research Institute, 2012

The famous Downs Law says that without effective intervention from the government, newly built roads will cause induced traffic, and the total traffic demand tends to always exceed the road supply. Based on the analysis of the latent demand and induced demand in the post-road building era, we could predict that: as the income level of Chinese citizens continues to rise until the majority of families have the car purchasing power and the choice of driving, the congestion level will follow the "Buckets Effect" in which transit and non-motorized accessibility could be the shortest board. In other words, without appropriate interventions from the government, the traffic congestion will continue worsening until the cost of driving including time and monetary expenses reaches as high as the generalized cost of transit and non-motorized travels.

DISCUSSION OF ANTI-CONGESTION POLICIES AND THEIR CONSEQUENCES

Based on the mental model framework established in the last section, this section introduces 5 main kinds of anti-congestion policies into the model, and analyzes the consequences of adopting those policies respectively. The five kinds of policies are: road-building and similar, imperative restriction, adjusting supply, demand management, transit-oriented urban development policies.

Road-building and similar

Examples of this kind of policies are: increasing parking supply, adding interchange or pedestrian bridge to increase flow capacity of intersection, enhancing efficiency of road network (via ITS and signal progression), etc. These policies are similar to road construction, aims at expanding the capacity of road supply system, therefore called "road-building and similar". Implied from the name, the consequences of them are similar to that of road construction. As shown in Fig 7, they simply create another parallel short-term balancing loop to increase the vehicle network capacity, but the system will soon be overloaded by the released latent demand and induced demand, therefore worsening traffic congestion.

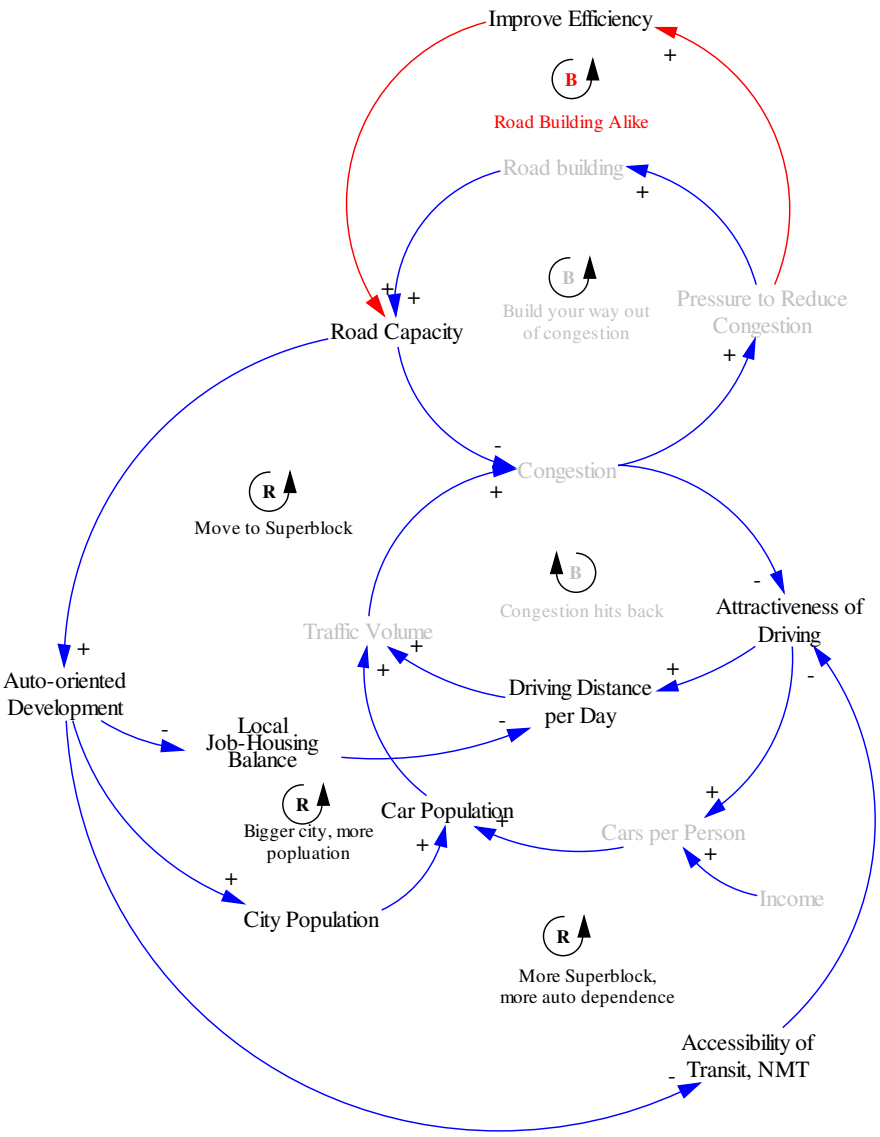

FIGURE 7 Consequences of Adopting "Road-building and similar" Policies

Imperative demand control

These polices include: urban population control, cap on vehicle population growth through number plate lotteries, cut vehicle use upon plate number, etc. The characteristic of such policies is that they directly restrict the growth of certain key variables contributing traffic congestion, such as population, automobile population and traffic volume. Although such polices will probably secure a positive immediate effect, the achievement must be at the cost of inconvenience for both individuals and the whole society. Sometimes "imperative demand control" policies are also criticized to be unfair because most benefits go to invested interest group (e.g., people who bought cars early). On the other hand, these policies can only repress travel demand but cannot eliminate them forever. Therefore, if the control policy is loosened, the

repressed demand will soon be resumed and can bring congestion back again and even exacerbate it.

Imperative control can also target on pedestrians and cyclists. Preventing jaywalking, the so-called "the Chinese-style street crossing", is possibly a unique measure newly adopted by the Chinese government. Many cities have assigned traffic police assistants at the intersections to monitor and educate pedestrians and cyclists (Fig. 8). In Beijing, one would be fined 10-yuan if caught by the police for jaywalking, a rule being effective since early May 2013. Many people, especially traffic police and drivers, have endorsed this policy and believed that the poor discipline of pedestrians is the most important reason causing traffic congestion. However, there are two issues weakening the effectiveness of this measure. First, it is very costly to fully implement due to the scale of problem in the society, and to correct well spread mal-behavior is never a short-term efforts. Second, jaywalking is partially a logic reaction by people to the poor physical setting and signal design at intersections. Even if pedestrians and bicyclists could follow the "bad" rules, the extra inconvenience (e.g., long-time waiting for green light) would encourage them to switching to driving, further contributing to congestion.

FIGURE 8 Traffic Management Assistants Correcting Jaywalking in Kunming (left) and Beijing (right)

Adjusting supply

This set of policies focuses on the supply side, adjusting them to make more space for non-motorized transport or transit. These policies can create a series of self-balancing loops to ease congestion, as shown in the diagram in Fig 9. By having road diet and removing unnecessary vehicle space- such as narrowing wide lanes, reducing corner radius and adding safety island at intersections- the policy can shorten crossing distance, slow down traffic, increase non-motorized travel safety and convenience, improve last-mile transit accessibility. Therefore, the policy can further reduce automobile dependence, shorten automobile average trip length, slow down the acceleration of automobile ownership, further decrease traffic volume and ease congestion (Balancing loop ①→②→③→④→⑤→⑥→⑦, and ①→②→③→④→⑧→⑨→⑩→⑦).

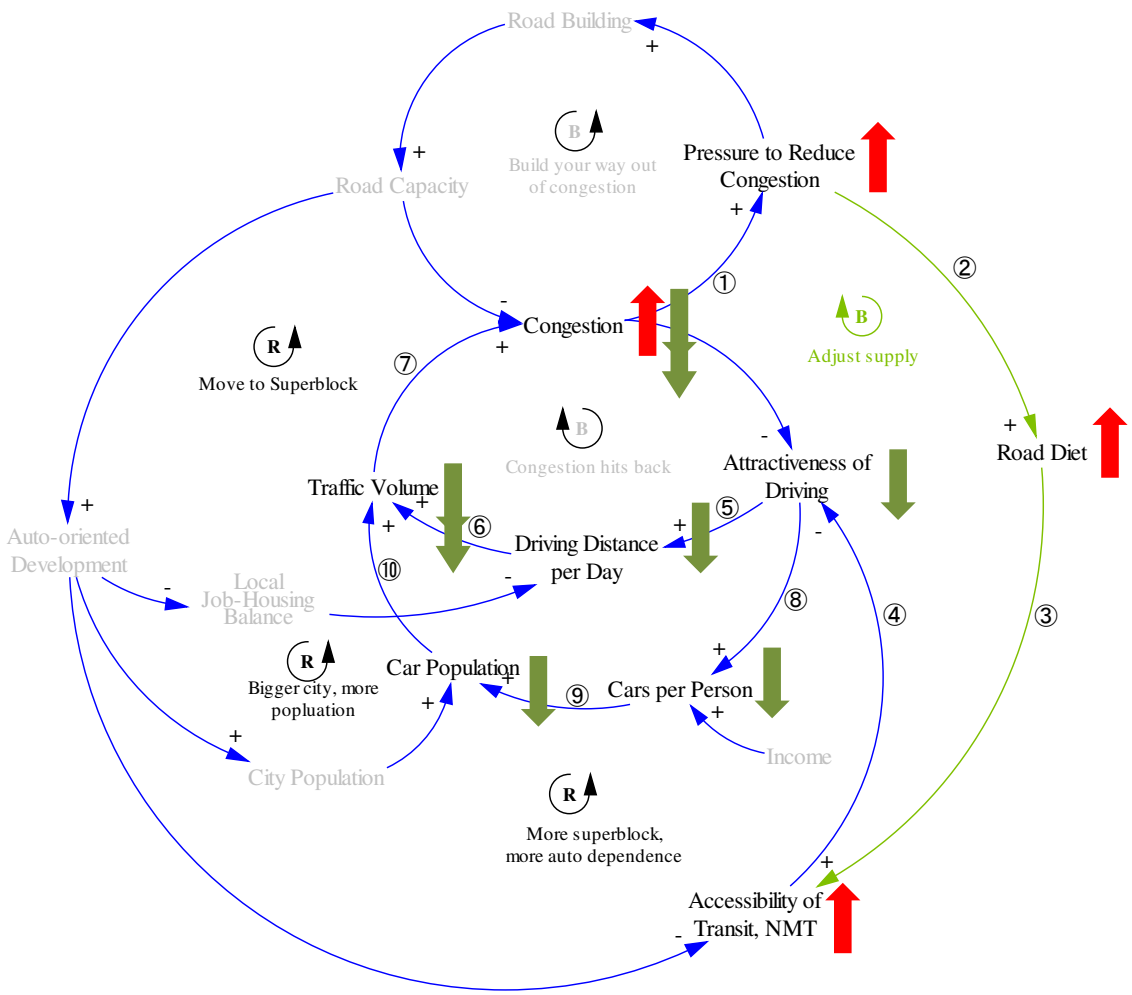

FIGURE 9 Consequences of Adopting "Adjusting Supply" Policies

It may be argued that removing some road space may reduce road capacity for vehicles. However, in many cases there can be a win-win situation because the retrofit can optimize the traffic flows and reduce conflicts from mix traffic. In recent year, cities like New York City, Copenhagen and Seoul have turned some vehicle lanes to auto-free or dedicated transit lanes, and they have all successfully enhanced the quality of public space while achieving the goal of traffic congestion relief. For example, the Broadway retrofitting project turned part of the congested vehicle lanes passing through Manhattan into an auto-free road which could accommodate pedestrians to walk and stay (Fig 10). According to a recent evaluation, the northbound traffic speed in the downtown area has been increased by 17% after project implementation (*20*).

FIGURE 10 New York Broadway Project Before-After Comparison
Source: Department of Transportation, New York City

Another good example is the Guangzhou BRT project which locates at the most congested area in the city. Prior to implementation, mix traffic, especially bus bunching, created a mess for all mode users. By allocating the central lanes to buses only, speed of both buses and automobiles were enhanced (Fig 11). After the BRT corridor began in operation in Feb 2010, the traffic speed along the Zhongshan corridor has increased by 28% (*21*).

FIGURE 11 Guangzhou Zhongshan Corridor Before-After Comparison
Source: Institute for Transportation and Development Policy

Demand Management through Pricing

Demand management through pricing uses economic leverage to rationalize the use of automobiles, including: raising parking fee, congestion pricing, and increasing penalty fee for illegal parking, etc. These measures could effectively prevent the abuse of automobile in the peak hour (Balancing loop: ①→②→③→④→⑤→⑥). Also, they can slow down the motorization, thus reduce traffic volume, easing congestion (Balancing loop: ①→②→③→⑦→⑧→⑨→⑥).

An additional by-product of adopting such policies is collection of extra revenue for government. If the money is used to subsidize transit system maintenance or improve operating efficiency, or improve the non-motorized transport environment, then it can increase the attractiveness of non-motorized travel for short and middle distance, and the attractiveness of the transit travel for long distance travel. These will further decrease the automobile dependence, reduce automobile travel distance and ownership, reduce automobile traffic volume, and relieve congestion (Balancing loop: ①→②→⑩→⑪→⑫→④→⑤→⑥, and ①→②→⑩→⑪→⑫→⑦→⑧→⑨→⑥). For example, London started congestion pricing since Feb 2003 and the government used the collected revenue to improve local transit system. The outcome shows that the automobile volume entering downtown was reduced by 20%, whereas the bus speed was increased by 25%. The traffic delay time within the congestion pricing area was shortened by 30% in the peak hour (*22*).

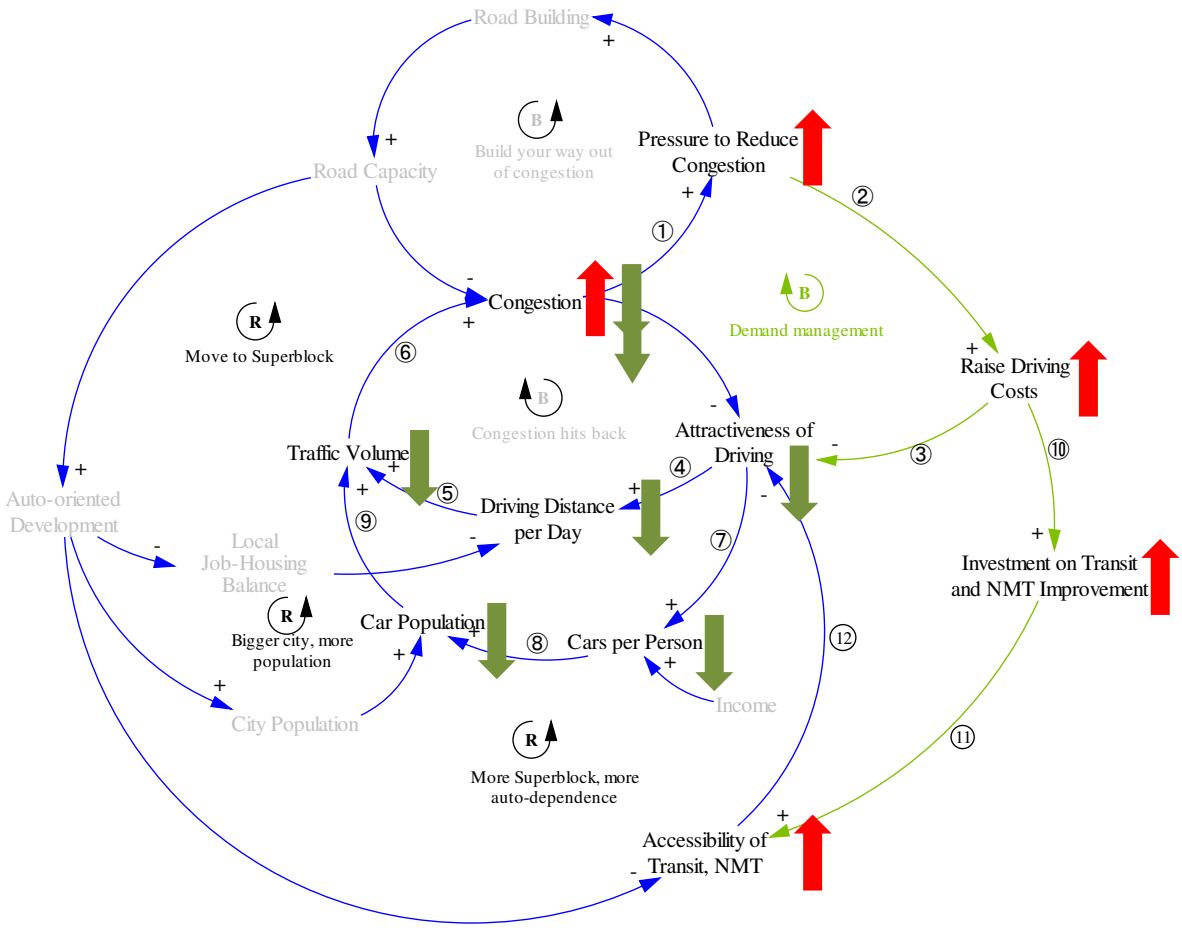

FIGURE 12 Consequences of Adopting "Demand Management" Policies

However, the actual effectiveness of implementing such policies in China may suffer from the problem of poor enforcement. Take parking policy as an example. In April 2010, Beijing raised

parking fee in downtown to reduce traffic[1] (*23*). However, only within 2 weeks after the policy was launched, the reported incidents of drivers refusing payment and fee collectors being abused or beaten increased dramatically, and nearly 30% of fee collectors had left parking management companies because of the dangerous working condition (*24*). On the other hand, the supply-to-demand ratio of parking spaces in Beijing decreased from 0.73 in 2004 to 0.58 in 2010. It is also true that the original design for many older districts and neighborhoods in Chinese cities provide too few parking spaces (Fig. 13), which means that in many circumstances car drivers can argue that they have to park illegally due to no alternatives, thus making the legitimacy of harsh parking policy damaged.

Table 1. Beijing parking supply and demand in 2004 and 2010

Year	Vehicles (10,000 vehicles)	Parking supply (10,000 parking lots)	Supply-to-demand ratio
2004	126	92	0.73:1
2010	303	177	0.58:1

Source: Data provided by Beijing Transportation Research Institute

FIGURE 13 Scarce Parking in Old Neighborhoods of Beijing

Transit-Oriented Urban Development Policies

This kind of policies emphasizes not only on expanding transit systems, but also adopting transit-oriented development around stations, including: 1) provide walkable streets and human scale blocks to enhance pedestrian flow, 2) configure building and uses to support pedestrian safety and convenience, 3) create transit-oriented streets and neighborhoods to enhance ridership, 4) create mixed-use blocks, neighborhoods and districts to increase local destinations, 6) integrate open space and public services at walkable distances, and 7) restrict car parking supply in residential areas (*25*).

[1] Daytime parking fees for roadside parking were raised to 10 yuan for the first hour and 15 yuan for each additional hour, and the underground car parks was charged 6 yuan per hour, and off-street parking spaces cost 8 yuan per hour.

The consequences of adopting such policies can be explained by the following balanced loops (see Fig 14):

- Mixed-use blocks make job-housing more balanced. It can shorten commuting distance, reduce traffic demand. Because there are more short and middle distance trips, a shift to walking and biking is encouraged. This will further reduce automobile traffic and ease congestion (Balancing loop: ①→②→③→④→⑤→⑥).
- Expanding transit facilities can enhance the attraction of transit and reduce the automobile dependence. Because major destinations are dispersed along transit nodes, very inefficient tidal flows will be avoided. The shortening of per passenger travel distance enhances the capacity of the same transit line in terms of passengers carried per hour. Small block development makes transit system with better penetration, solving the last-mile problem. These will all decrease the attraction of automobile travelling, and then lower the private car ownership and reduce the intensity of car use. Two effects all lead to fewer traffic and thus ease congestion (Balancing loop: ①→②→⑦→⑧→⑨→⑤→⑥, and ①→②→⑦→⑧→⑩→⑪→⑫→⑥)
- Limiting the parking ratio can effectively maintain the automobile ownership of the residents in the TOD areas at the reasonably low level, thus reducing the automobile traffic and relieve congestion (Balancing loop: ①→②→ ⑬→ ⑭→ ⑪→⑫→⑥).

Compared to previous anti-congestion policies, transit-oriented urban development policies are revealed to be able to shift original automobile travel demand to other modes, and to reduce the amount of basic travel demand (regardless of modes). As supported with empirical evidences in Chinese cities (*26, 27*), these policies are likely to deliver far-reaching impacts and reliable outcomes.

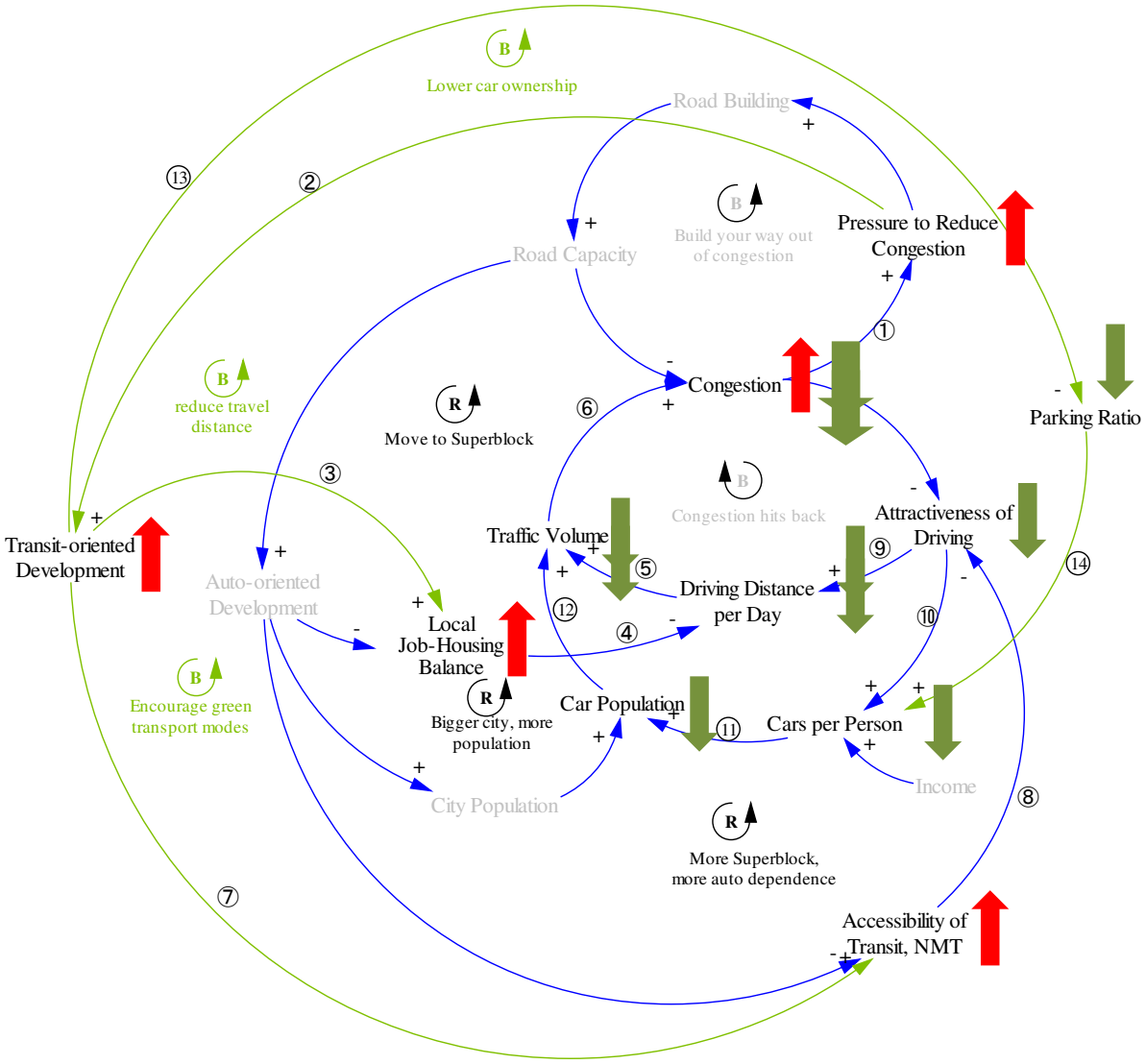

FIGURE 14 Consequences of Adopting Transit-Oriented Urban Development Policies

CONCLUSION

This paper uses the method of system dynamics to build a mental model representing traffic congestion formulation mechanism under the China's context. There are three major implications out of this research. First, it illustrates that conventional road-building policies can mitigate congestion only in the short term, but will soon be overloaded by extra latent demand and induced demand generated from the automobile-oriented urban development. These two types of demand are most relevant in developing countries like China, where the urbanization is still moving rapidly and the automobile culture is quickly evolving due to spatial and socioeconomic transformation. Unfortunately, traditional traffic models have not been capable enough of simulating and predicting such demands. Thus policymakers should not rely on transportation engineers alone to solve traffic congestion.

Second, the paper discusses a range of debated anti-congestion policies contrived by Chinese government. The policies can be grouped into five categories: road-building and similar, imperative demand control, adjusting supply, demand management through pricing, and transit-oriented urban development policies. Based on the mental exercise using system dynamics, we conclude that 1) implementing "road-building and similar" policies in urbanizing China has been exacerbating the congestion situation; 2) the impact of "imperative demand control" and "demand management through pricing" tends to be limited or short-lived due to either leakage effects and/or poor government enforcement capacity; 3) "adjusting supply" can be more effective; and 4) "transit-oriented development", rarely proposed yet for the sake of congestion relief, turns out to be most promising in China for affecting traffic demand and supply simultaneously. It is worth noting that to make a pattern break away from superblock development is not a solely technical or mindset problem. It requires policy reform on planning codes, capacity building of government managing small blocks, and profit demonstration for the real estate market and developers. In the Kunming Chenggong new town and the Chongqing Yuelai eco-town, for example, such pilot projects are being undertaken and tested for successfulness in the real local contexts.

A third implication from the modeling process is that fundamentally any kind of effective anti-congestion policies should focus on human beings, rather than the traffic or vehicles. It is true that the mobility and freedom of driving seems to be an important right of citizens; however, constrained by the size and density of urban population in China and the scarcity of oil supply, it is simply impossible to allow every person to drive. The only way to solve this puzzle, as suggested in some literatures (e..g, *28-30*) is to distinguish between mobility and accessibility, and to understand that enhancing accessibility is what the government should ultimately target their efforts on, not mobility. It is most likely that one travels because he/she wants to access goods, services, education, job or other opportunities at the destination, not to enjoy the travel part itself (*31*). Therefore, the focus should be delivering what people truly want at lowest cost. Easing traffic congestion (i.e., improving mobility) is only one alternative to many other solutions or at least part of the solution to the real problem. Unless better accessibility is provided, people will always stick with congested traffic simply because there is no better option to them.

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REFERENCES

1. "Congestion has dispersed quickly among 2nd and 3rd-tier cities in China". *Xinhua News*, 2010-12-2. http://news.xinhuanet.com/fortune/2010-12/02/c_12840525.htm. Accessed July 16, 2011.
2. GAO Ming-hua and ZHANG Zheng-he. Resolution to metropolitan traffic congestion. *Urban Problems*, Vol. 10, 2009, pp.75-78.

3. HUANG Wei. What Can be Done for Urban Congestion. *Urban Transport of China*, Vol. 1, 2011.
4. WANG Yuan-qing, SUN Lin-yan and SUN Chuan-jiao. The systematical cause and countermeasures to transportation problems in metropolises in China. Urban Problems, Vol. 5, 2007, pp.75-80.
5. HAN Xiang-lin, JIANG Chang-yuan, GE Hong-xia and DAI Shi-qiang. A modified coupled map car-following model based on application of intelligent transportation system and control of traffic congestion. *Acta Physica Sinica*, Vol. 8, 2007, pp. 4383-4892.
6. "The two sessions in Shenzhen: NPC member said that vehicles are not the root cause of congestion". *Nanfang Daily*, 2011-2-19. http://news.cntv.cn/china/20110219/102377.shtml. Accessed September 16, 2012.
7. LIU Feng, HUANG Run-long, DING Jin-hong and DUAN Cheng-rong. Population Control in Megacities. *Population Research*, Vol. 1, 2011, pp. 29-43.
8. LIU Xian-teng, SHEN Qing and ZHU Li. Imbalanced transport demand-supply and measures in metropolitan areas of China: A case study of Nanjing. *City Planning Review*, Vol. 1, 2009, pp. 80-87.
9. "Ministry of Transportation: To solve the congestion, we need to spare our efforts to build the urban public transport system". *People's Daily*, 2010-12-24.
10. Beijing Municipal People's Government. *Suggestions on further promoting scientific development of Beijing transportation and easing traffic* congestion. Publication 42 [Z]. 2010.
11. Guangzhou Municipal People's Government. Traffic congestion relief program for Guangzhou central area after the Asian Games (draft) [Z]. 2011.
12. Sterman JD. Business Dynamics: Systems Thinking and Modeling for a Complex World [M]. Boston: McGraw-Hill. 2000: 180
13. LIU Li and ZHOU Ya-ping. A Study of Urban Transportation Based on System Dynamics Model on Private Vehicle Consumption in Beijing. *Urban Studies*, Vol. 6, 2008, pp. 24-28.
14. FAN Jie and YAN Guang-le. Simulation and Control of Amount of Private Cars in Beijing Based on System Dynamics. *Journal of Highway and Transportation Research and Development*, Vol. 12, 2009, pp. 120-125.
15. WANG Ji-feng, LU Hua-pu and PENG Hu. System Dynamics Model of Urban Transportation System and Its Application. *Journal of Transportation Systems* Engineering *and Information Technology*, Vol. 3, 2008, pp. 83-89.
16. ZHU Xiao-ning. *Mechanism and Empirical Analysis on the Evolution of Urban Traffic* Structure *Based on System Dynamics*. Beijing Jiaotong University, 2009.
17. ZHANG Yi-mei and ZHANG Yi. System Dynamic Model of Traffic Congestion. *Computer and Communications*, Vol. 2, 2008, pp. 94-101.
18. LI Xiao-jiang. Thoughts on Urban Transportation Policy. *Urban Transport of China*, Vol. 1, 2011, pp. 7-11.
19. QUAN Yong-shen *and* SUN Ming-zheng. Noticeable Problems of Transportation Development in Large Metropolitan Areas in China. *Urban Transport of China*, Vol. 2, 2011, pp. 1-6.
20. The New York City *Department* of Transportation. Green Light for Midtown Evaluation Report[R]. January, 2010: 37

21. XIAN Wei-xiong. Action Plans for Improving BRT Passenger Flow during Morning and Afternoon Peak *Hour* in Guangzhou. *Urban Transport of China*, Vol. 2, 2011, pp. 26-33.
22. Victoria *Transport* Policy Institute. London Congestion Pricing [R]. 2006: 5
23. "Beijing raises parking fee to reduce traffic". *China Daily*, 2011-4-1. http://www.chinadaily.com.cn/china/2011-04/02/content_12265738.htm. Accessed September 16, 2012.
24. "The number of parking fee collectors being beaten has increased dramatically since the fee was raised". *China News*, 2011-4-13. http://www.chinanews.com/auto/2011/04-13/2968713.shtml. Accessed September 16, 2012.
25. ZHOU Feng-yue, SU Zhen-yu, WANG Zhi-gao and HE Dong-quan. Low-Carbon *Transport*: Chenggong New Area in Kunming. In *China low-carbon eco-city development report*, 2011. *Construction Science and Technology*, Beijing: China Architecture & Building Press, 2011: 174-181.
26. PAN Haixiao, SHEN Qing, ZHANG Ming. Influence of Urban Form on Travel Behaviour in Four Neighbourhoods of Shanghai. *Urban Studies*. 2009 (46): 275.
27. JIANG Yang.. Does Transport Energy Follow Urban Form? An Examination of Nine Neighborhoods in Jinan, China. Unpublished Master Thesis, (2010), Massachusetts Institute of Technology, Cambridge.
28. Salomon, I.., Mokhtarian, P.L., What happens when mobility-inclined market segments face accessibility-enhancing policies? *Transportation Research D*, 1998, 3(3):129-140
29. J Levine, Y Garb. Congestion pricing's conditional promise: promotion of accessibility or mobility. *Transport Policy*, 2002, 9 (3): 179-188
30. Handy, S. L. Accessibility- vs. Mobility-Enhancing Strategies for Addressing Automobile Dependence in the U.S. 2002. *European Conference of Ministers of Transport*, Paris.
31. K.J. Button. *Transport Economics*. Beijing: The Commercial Press, 2002: 26.