Discussion of Basic Elasticity Models Applied to Induced Traffic in China

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Abstract: This paper aims to further discuss basic elasticity models in China, using the panel data set of annual observations of China and six areas (North China, East China, Southwest China, South Central China, Northeast China and Northwest China) for the years 1990-2008. Based on the related foreign concept of induced traffic, autocorrelation model, autoregressive distributed lag model and dummy model are researched. According to the detailed analysis of empirical results, these models are available to China. Lane-kilometers are found to have a statistical relationship with VKT (vehicle-kilometers of travel) of 0.060-0.882 in short-term and 0.086-1.194 in long-term in China and six areas. These mean the necessary of considering induced traffic in China. About the basic elasticity models discussed in this paper, autoregressive distributed lag model is better suitable in China. It not only includes the time delay and cumulative effect but also brings more economic explanations than autocorrelation model.

Keywords: Induced Traffic, Elasticity Model, VKT, Lane-Kilometers

1. INTRODUCTION

Jorgensen (1948) attempts to estimate the traffic generated by the opening of the Merrit and Wilbur Cross Parkways. Since then on, the traffic-inducing effects of road improvements have been researched. The early researches all follow the same general approach. Traffic in the improved corridor is counted before and after project completion, and observed changes are compared with the change that would be expected without the improvement. Studies by the Cook County Highway Dept (1955) and Fry (1964), as well as several studies in Great Britain reported by Pell (1989), all follow this logic. The UK National Audit Office (NAO, 1988) suggested that considering induced traffic is essential to improve the prediction accuracy of transportation projects, based on the road planning report. This causes the extensive attention. The Standing Advisory Committee on Trunk Road Assessment (SACTRA, 1994) publishes a noteworthy report < Trunk roads and the generation of traffic >, which discusses the key issues of induced traffic systematically. This report recommended that elasticity-based model (the elasticity between vehicle miles of travel (VMT) and lane-miles) should be used in the trunk road traffic demand forecast, based on the analysis and comparison of traffic volume (before and after the 151 new or improved roads). In order to study on the relationship between VMT and lane-miles, there are many researchers started to work on elasticity models (Barr, 2000; Fulton *et al*, 2000; Hansen *et al*, 1993; Hansen and Huang, 1997; Heanue, 1998; Noland, 2001).

China's researchers have discussed the induced traffic with gravitational model, growth curves model, grey model, microscopic model and macroscopic model, and then gotten the prediction model in different roads, such as, one section of highway from Yichang to Lichuan (Zhang *et al*, 2006), Chengyu Expressway and Jing-Jin-Tang Expressway (Cen *et al*, 2006), one section of highway from Luoding to Cenxi (Xiang, 2007) and Sidao street in Harbin city (Ding *et al*, 2006). Some research is based on TransCAD to simulate the induced traffic (Zuo *et al*, 2010). According to the different methods in different countries, the advantages and disadvantages of those methods are shown in Table 1.

Table 1. Advantages and disadvantages of research methods

Research methods	Advantages	Disadvantages
Comparative analysis	Directed at specific cases, detailed analysis before and after road construction.	Hard to explain the mechanism of induced traffic and macro forecast.
Elasticity model	Consider demographic and cost factors, show the impact on land use and travel frequency of improving the traffic conditions; discuss the induced traffic with time effect.	High accurate requirement of data collection; calculation error exists in wrong data collection.
Gravity model	Consider land use and traffic attraction; easy to understand; more sensitive to infrastructure construction; wide usage in China; can predict future OD traffic.	Will lead to predict traffic too large in short distance travel and within the zone; have large calculation workload.
Growth curve model	Consider the lag effect of travel behavior change on improved traffic condition.	Not consider the impact on the early changes of traffic conditions, not apply to the rapid response city.
Grey theory systems	High accuracy of prediction.	Difficult to calibrate parameters.
Microscopic mathematical model	Reflect the mechanism of induced traffic.	Hard to parameter calibration; more complex of data collection.
Macroscopic mathematical model	Simple model.	Parameter calibration requires lots of survey data, hard to collect.

From Table 1, the elasticity model, which is widely used in foreign, can better explain induced traffic. Meanwhile, it has less been used in China. This is because of different understanding of induced traffic. Researchers in China would like to view induced traffic as one part of the total traffic volume. The measure employed is Passenger Car Unit/Hour (Cen *et al*, 2006). While induced traffic is measured with VMT in foreign. Zhao *et al* (2011) predict induced traffic using the elasticity-based model. The results confirm the existence of induced traffic and the elasticity model is available in China. In order to further study on the elasticity models of induced traffic in China, we adopt the similar concept of induced traffic in foreign researches. Therefore, any increase of VKT is considered induced traffic and is routinely used as such in this paper.

The rest of this paper is structured as follows. Section 2 shows the data collection in China, including 31 provinces and cities, which is the basis of following discussions. Section 3 proposes some basic elasticity models which are the key and groundwork in the model of induced traffic. Section 4 analyses the results of every model in China at present. Every conclusion is based on the actual results. The final section provides a summary of research.

2. DATA COLLECTION

Based on the foreign researches of induced traffic, demographic factors (Wang and Shen, 2003; Noland, 2001), fuel price (Goodwin, 1992; Oum *et al*, 1992), new or improved roads (Goodwin, 1996; Heanue, 1998; Barr, 2000; Fulton *et al*, 2000; Noland, 2001; Cervero and Hansen, 2002; Duranton and Matthew, 2011), income level (Wang, 2003) and public transport service level (Goodwin, 1993) are the influencing factors of VKT. According to China's situation, income level has to be replaced by GRP. Since it is difficult to obtain data of income level, and GRP is the good reflection. Fuel price and public transport service levels are not included in this paper. Because the data collection of public transport service levels are limited. The fuel price is decided by the China development and reform commission. Except Hainan, other cities and provinces have the same price. The State Council of China (2008) released the notice on levying the fuel tax on January 1st, 2009. So the influencing factors of VKT in this paper include population, GRP and lane-kilometers.

Panel data contain observations on multiple phenomena observed over multiple time periods for the same firms or individuals. It is effective for getting some unobserved characteristics of the observation unit; researching the significance of time delay and reducing the problem of simultaneity. Therefore, panel data at the city and provincial level for years 1990 - 2008 are collected through the national statistical databases (National Bureau of Statistics of China), which is the most reliable source of Chinese data. The details of each data collection are shown in Table 2. All data are organized by year. These 31 provinces and cities in China are divided into six areas based on geographic location and natural climate, namely North China (Beijing City, Tianjin City, Hebei Province, Shanxi Province, Inner Mongolia Autonomous Region), East China (Shanghai City, Jiangsu Province, Zhejiang Province, Anhui Province, Fujian Province, Jiangxi Province, Shandong Province), Southwest China

(Chongqing City, Sichuan Province, Guizhou Province, Yunnan Province, Xizang Autonomous Region), South Central China (Henan Province, Hubei Province, Hunan Province, Guangdong Province, Guangxi Zhuang Autonomous Region, Hainan Province), Northeast China (Liaoning Province, Jilin Province, Heilongjiang Province) and Northwest China (Shaanxi Province, Gansu Province, Qinghai Province, Ningxia Hui Autonomous Region, Xinjiang Uygur Auto). All data are organized by year. In addition, Chongqing city was omitted from the following model discussion, since it did not have any data before 1997 (Chongqing City became a separate, independent municipality in 1997, succeeding its former status as the sub-provincial city administration of Sichuan Province). In conclusion, the panel data of 30 provinces and cities, including 570 data, are the basis of further research.

Table 2. Details of national total data collection

Variable names	Years
VKT: the sum of passenger kilometers of transport and freight kilometers of transport	1990-2008
Lane-kilometers: the actual highway length at the end of year	1990-2008
GRP: Gross Regional Product	1990-2008
Population: the total of living individuals in a certain area within a given time	1990-2008

3. ELASTICITY MODEL

The elasticity of demand with respect to a certain variable is defined as the rate of change of demand with respect to that variable, normalized by the current levels of demand and the variable in question (Meyer and Miller, 2001). Elasticity is thus a measure of sensitivity to change in system conditions. Some basic elasticity models, such as elasticity-based model, lag model, distributed lag model and growth model have been discussed in early research (Zhao *et al*, 2012). On the basis of these models, the autocorrelation model, autoregressive distributed lag model and dummy model should be discussed below. The Granger test which can show whether lane-kilometers generate the VKT or not, has also been certified in early researches. It shows that the lane-kilometers generate the VKT.

3.1 Autocorrelation Model

The previous models, including elasticity-based model, lag model and distributed lag model, assume that a single lag in VKT does not affect the current VKT. Johnston (1984) has certified that the effect of new or improved road on traffic is the same impact on gasoline price. Meanwhile, lag in gasoline price does affect the current price. In the beginning of new or improved road, the consumption of gasoline and VKT is reduced. While the total gasoline consumption and VKT will be increased some years later. So the autocorrelation model, which has been applied to shocks in the price of gasoline and its effect on consumption over time, is used here. The specification is set as:

$$\log(VKT_{it}) = c + \sum_{l=1}^{L} \gamma^{l} \log(VKT_{i(t-l)}) + \sum_{k} \beta^{k} \log(X_{it}^{k}) + \lambda \log(LM_{it}) + \varepsilon_{it} \quad (1)$$

Where,

VKT_{it} : VKT in region *i*, for year *t*,

$VKT_{i(t-l)}$: VKT in region *i*, for year *t-l*,

X_{it}^{k} : value of population and GRP in region *i*, for year *t*,

LM_{it} : lane-kilometers in region *i*, for year *t*,

C : constant term,

γ^{l} : coefficients to be estimated for the lagged VKT,

β^{k} : coefficients to be estimated for population and GRP parameter,

λ : coefficient to be estimated for lane-kilometers parameter, and

ε_{it} : random error term.

From the autocorrelation model, the present VKT is correlated with past ones. Short -term elasticities (short-term means to 1 year) of lane-kilometers with respect to VKT correspond to the coefficient on the lane-kilometers variable λ. Long-term elasticities (long-term means to more than 2 years, including 2 years) can be calculated as $\eta = \lambda \Big/ 1 - \sum_{l=1}^{L} \gamma^{l}$. This model assumes that the elasticity coefficient of different regions at the same time period is the same. Based on the data collection, correlograms in Eviews show the serial correlation. This is the standard of chosen year *l*.

3.2 Autoregressive Distributed Lag Model

At the case of the distributed model (Zhao *et al*, 2012) and autocorrelation model (discussed above) being available in induced traffic, the autoregressive distributed lag model is needed to evaluate. This model includes not only the lagged values of VKT, but also the current and lagged values of population, GRP and lane-kilometers. It allows us to determine what the effects are of a change in a variable. The model is set as:

$$\log(VKT_{it}) = c + \sum_{l=1}^{L} \gamma^{l} \log(VKT_{i(t-l)}) + \sum_{k} \sum_{m}^{M} \beta^{km} \log(X_{i(t-m)}^{k}) + \sum_{n=0}^{N} \lambda^{n} \log(LM_{i(t-n)}) + \varepsilon_{it} \qquad (2)$$

Where,

λ^{n}, β^{km} : coefficients to be estimated for the lagged lane-kilometers or other variables,

γ^{l} : coefficients to be estimated for the lagged PKT of *l* lag year,

$LM_{i(t-n)}$: lane-kilometers in region *i*, for year *t-n*, and

$X^k_{i(t-m)}$: GRP, population in region *i*, for year t-m.

The autoregressive distributed lag model considers the time effect on all variables. These show the cumulative effect, which improve the correction. Short-run elasticities of lane-kilometers with respect to VKT correspond to the coefficient on the lane-kilometers variable λ^n. Long-run elasticities can be calculated as $\eta = \sum_{n=0}^{N} \lambda^n \Big/ 1 - \sum_{l=1}^{L} \gamma^l$. This model assumes that the elasticity coefficient of different regions at the same time period is the same. Chosen year *l* is the same in autocorrelation model. The year *m* and *n* is decided in Almon polynomial lag model.

3.3 Dummy Model

Above models assume that the elasticity coefficients of lane-kilometers and VKT in different regions at different time or the same time period are the same. This assumption is inconsistent with the actual. Therefore, the time and region dummy variables in dummy model can explain some unscanned influencing factors in autocorrelation model and autoregressive distributed lag model. If two classifications (time and region) are existed, and each classification having *m* choices (different times and different regions), then there exist m^2 dummy variables. This is difficult to calculate. So in the below calculation, the time factor and region factor are separated. The separate model has only two choices. The specification for the time dummy model is set as:

$$\log(VKT_{it}) = c + \sum_k \beta^k \log(X^k_{it}) + \lambda \log(LM_{it}) + \alpha D + \sum_k \gamma^k \log(X^k_{it}) * D + \lambda' \log(LM_{it}) * D + \varepsilon_{it} \quad (3)$$

Where,

D : time dummy variable. When the time of explanatory variable is the time chosen, D is 1, or 0, and

α 、 γ^k 、 λ' : coefficients to be estimated.

The specification for the region dummy model is:

$$\log(VKT_{it}) = c + \sum_k \beta^k \log(X^k_{it}) + \lambda \log(LM_{it}) + \alpha D + \sum_k \gamma^k \log(X^k_{it}) * D + \lambda' \log(LM_{it}) * D + \varepsilon_{it} \quad (4)$$

Where,

D : region dummy variable. When the region of explanatory variable is the region chosen, D is 1, or 0.

When dummy variable is 1, the elasticity coefficient of lane-kilometers is $\lambda + \lambda'$. When 0, it is λ. This is the same with other variables, such as GRP and population. This is a fantastic way to separate the effect of different times or regions. This model assumes that at the chosen region or time, the elasticity coefficient is the same.

4. EMPIRICAL RESULTS AND ANALYSIS

There are three models discussed above. Each model has its economic meaning, which can solve some certain problems. Different models have their own calculating methods. The autocorrelation model uses the autoregressive model. The autoregressive districted model uses the Almon polynomial lag model and autoregressive model, which can reduce collinearity among variables. The dummy model uses the least square method of dummy variable. Based on the data collection and different calculating methods, the results of these models are present in Table 3-5 using Eviews software.

Table 3. Results of autocorrelation model

Independent Variable	LOG(*VKT*)						
	Whole China	North China	East China	Southwest China	South central China	Northeast China	Northwest China
Constant	0.623	0.744	0.695	0.141	1.922	-3.835	1.046
t value	4.490	1.639	0.383	0.606	6.150	-2.643	2.513
$\log(POP)$	0.215	0.534	0.294	0.315	0.294	0.749	0.095
t value	7.858	7.393	9.820	5.590	6.412	3.154	1.635
$\log(GRP)$	0.326	0.225	0.429	0.372	0.471	0.446	0.474
t value	21.974	8.040	8.613	6.182	11.035	5.615	8.372
$\log(LM_{it})$	0.824	0.359	0.157	0.323	0.136	0.197	0.060
t value	13.429	7.594	3.420	3.381	1.593	1.385	0.747
$\log(VKT_{i(t-1)})$	0.241	0.154	NA	0.157	0.046	0.250	0.300
t value	8.448	3.093	NA	3.420	1.049	3.303	5.426
$\log(VKT_{i(t-2)})$	0.069	NA	NA	NA	NA	NA	NA
t value	2.784	NA	NA	NA	NA	NA	NA
Sample size	510	540	540	540	540	540	540
R^2	0.917	0.943	0.919	0.972	0.945	0.839	0.912

NA=not available.

These results of autocorrelation model in Table 3 suggest that:

1. The good R^2 suggests that the usage of autocorrelation model is correct. The t-test shows that most of the coefficients are significant. These prove that the variable chosen is necessary, including the consideration of VKT in past years.

2. In the whole China, a 0.241% growth in VKT occurs for every 1% increase in 1 year lag VKT; a 0.069% increase in VKT occurs for every 1% growth in 2 year lag VKT. These effects on lag VKT is larger than population (0.215). These certify that the lag effect of VKT cannot be neglected.

3. The range of elasticity (between lane-kilometers and VKT) is 0.060-0.824 in short-term and 0.086-1.194 in long-term in whole China and six areas. The elasticity of whole China without the time delay is 0.824, suggesting that a 0.824% increase in VKT occurs for every 1% increase in lane-kilometers in short-term. Meanwhile, the elasticity of the whole China with the time delay is 1.194, suggesting that a 1.194% increase in VKT occurs for every 1% increase in lane-kilometers in long-term.

4. In North China, East China, Southwest China and South Central China, the effect of 1 year lag VKT is smaller than the effect of lane-kilometers, while in Northeast China and Northwest China, it is larger than the effect of lane-kilometers. This implies that new or improved road will generate more growth of VKT in the economy developed areas, while, the lag VKT affects the present VKT in the economy lags behind relatively.

5. The short-term population elasticity in different area has a broad range 0.095-0.749; the long-term has 0.136-0.999. The elasticity of China's population is about 0.312 in long-term. It is less than the foreign coefficient 1 (Noland, 2001). There are two reasons for such a difference. In the first place, the aging problem is serious in China, where the elderly travel less. In the second place, there are a lot of people and remarkably little land. So people's travel is restricted. However, the population elasticity in the Northeast China is 0.999. The growth of population and VKT is similar. This indicates that people travel in the Northeast China has not been limited.

6. The elasticity coefficient of GRP 0.225-0.474 in short-term and 0.266-0.677 in long-term is lower than the foreign research (about 1). This indicates that the growth of income cannot attract more leisure travel than thought. People like to savings in China (Ma and Wang, 2010).

These results of autoregressive distributed model in Table 4 suggest that:

1. The good R^2 and significant coefficients certify the proper usage of autoregressive distributed lag model in China. These prove that the variable chosen is necessary, including the consideration of VKT, lane-kilometers, population and GRP in past years.

2. Based on all coefficients calculation, the sum of coefficients in VKT, lane-kilometers, population and GRP is positive. These imply the growth of lag VKT, lane-kilometers, population and GRP will increase the present VKT. While in South Central China, the coefficient of lag VKT is negative, and the coefficient in Southwest China and South Central China is not 80% significant. These all imply the multicollinearity may exist in the autoregressive distributed model, due to the lag influencing factors.

3. The multicollinearity is the disadvantage of autoregressive distributed model. This leads to a negative effect on VKT with some years lag in VKT, lane-kilometers, population and GRP. Meanwhile, the short-term elasticity is larger than long-term elasticity. In whole China and six areas, the long-term lane-kilometers elasticity is 0.174-0.517, the long-term population elasticity is 0.171-1.150 and the long-term GRP elasticity is 0.292-1.054. The short-term lane-kilometers elasticity is -0.208-0.882, the short-term population elasticity is 0.259-1.457 and the short-term GRP elasticity is 0.087-0.294. Therefore, in the autoregressive distributed model, the cumulative effect with every variable is important to consider, which reduce multicollinearity and improve the correction. The short-term elasticity in the elasticity model with lag will lead to be wrong with multicollinearity. The long-term elasticity may provide the accurate guideline for transportation planning.

4. Autoregressive distributed model can yield better and more explanations on different cases and time delay on every variable considered. In the whole China, the coefficient of 1 year lag on VKT is 0.149, 2 year lag is 0.320. It certifies that the elasticity of lane kilometers with respect to VKT maybe smaller in the first year than for subsequent years.

Table 4. Results of autoregressive distributed lag model

Independent Variable	LOG(*VKT*)						
	Whole nation	North China	East China	Southwest China	South central China	Northeast China	Northwest China
Constant	1.200	0.312	0.959	3.057	0.385	-1.941	0.998
t value	7.691	0.688	1.683	6.796	1.537	-1.329	2.560
$\log(VKT_{i(t-1)})$	0.149	0.442	0.362	-0.163	0.429	0.555	0.593
t value	4.201	4.169	4.043	-1.858	4.151	3.779	6.867
$\log(VKT_{i(t-2)})$	0.320	NA	NA	NA	NA	NA	NA
t value	8.831	NA	NA	NA	NA	NA	NA
$\log(LM_{it})$	0.349	0.539	0.535	0.298	0.882	-0.208	0.611
t value	12.570	5.561	4.973	2.882	6.903	-1.461	5.612
$\log(LM_{i(t-1)})$	0.139	-0.287	-0.205	0.094	-0.653	0.065	-0.540
t value	12.351	-2.573	-1.669	2.094	-4.673	1.411	-5.028
$\log(LM_{i(t-2)})$	-0.071	NA	NA	-0.110	NA	0.338	NA
t value	-5.833	NA	NA	-1.102	NA	2.518	NA
$\log(LM_{i(t-3)})$	-0.281	NA	NA	NA	NA	NA	NA
t value	-9.725	NA	NA	NA	NA	NA	NA
$\log(POP)$	0.468	0.329	0.734	0.262	0.259	1.457	0.266
t value	10.380	3.437	2.064	4.319	3.248	3.247	2.417
$\log(POP_{i(t-1)})$	0.090	NA	NA	0.146	0.130	-1.381	0.025
t value	8.072	NA	NA	5.550	3.817	-2.976	1.322
$\log(POP_{i(t-2)})$	-0.288	NA	NA	0.031	0.001	NA	-0.217
t value	-5.983	NA	NA	1.272	0.040	NA	-2.001
$\log(POP_{i(t-3)})$	NA	NA	NA	-0.084	-0.128	NA	NA
t value	NA	NA	NA	-1.448	-1.852	NA	NA
$\log(GRP)$	0.087	0.280	0.203	0.294	0.135	0.294	0.203
t value	7.550	5.161	5.541	6.445	1.999	6.965	4.010
$\log(GRP_{i(t-1)})$	0.063	-0.108	0.062	0.175	0.074	0.175	0.071
t value	7.800	-1.75	4.364	6.567	2.506	-2.337	2.597
$\log(GRP_{i(t-2)})$	0.038	NA	-0.079	0.057	-0.013	NA	-0.061
t value	7.418	NA	-2.193	2.758	-0.263	NA	-1.298
$\log(GRP_{i(t-3)})$	0.013	NA	NA	-0.062	NA	NA	NA
t value	3.007	NA	NA	-1.773	NA	NA	NA
$\log(GRP_{i(t-4)})$	-0.012	NA	NA	NA	NA	NA	NA
t value	-1.826	NA	NA	NA	NA	NA	NA
$\log(GRP_{i(t-5)})$	-0.037	NA	NA	NA	NA	NA	NA
t value	-3.723	NA	NA	NA	NA	NA	NA
Sample size	420	540	480	480	480	510	510
R^2	0.900	0.948	0.921	0.911	0.948	0.891	0.930

NA=not available.

5. Compared the elasticities in different regions, GRP elasticity is larger than population

elasticity and lane-kilometers elasticity in Southwest China, Northeast China and Northwest China. Population elasticity is larger than GRP elasticity and lane-kilometers in North China, East China and South central China. Due to China's path of opening up and economic reform, the economy in North China, East China and South central China is better than Southwest China, Northeast China and Northwest China. Therefore, in the economic low-developed area, GRP plays the more important role in VKT. In the economic developed area, population plays the more important part in VKT.

Table 5. Results of dummy model

Independent variable	LOG(*VKT*)							
	Whole China		North China	East China	Southwest China	South central China	Northeast China	Northwest China
	Region	time						
Constant	2.235	1.515	2.302	1.365	-0.091	2.062	-5.145	2.138
t value	9.566	7.297	3.713	1.917	-0.232	5.844	-2.175	4.015
$\log(POP)$	0.366	0.492	0.902	0.451	0.545	0.256	2.691	-0.160
t value	9.685	10.058	8.455	4.121	6.409	2.723	4.743	-1.063
$\log(GDP)$	0.290	0.353	0.050	0.315	0.347	0.462	0.229	0.675
t value	14.754	11.376	0.891	5.723	4.040	7.237	1.956	7.560
$\log(LM_{it})$	0.492	0.277	0.188	0.481	0.524	0.293	-1.600	0.440
t value	16.302	6.710	2.598	6.717	3.754	1.496	-3.108	2.267
D	-0.455	1.302	-1.590	0.362	1.892	0.339	0.141	-1.062
t value	-1.533	0.972	-1.642	0.290	2.924	0.600	0.044	-1.123
$\log(POP)*D$	-0.052	-0.087	-0.330	0.050	-0.073	0.057	-1.773	0.186
t value	-0.983	-1.265	-2.212	0.290	-0.497	0.460	-2.519	0.925
$\log(GDP)*D$	0.226	-0.011	0.236	-0.075	-0.111	0.003	0.427	0.097
t value	6.016	-0.238	2.693	-0.838	-0.621	0.026	1.695	0.517
$\log(LM_{it})*D$	-0.383	0.108	0.313	0.035	-0.019	-0.168	1.812	-0.335
t value	-6.695	2.004	3.205	0.333	-0.097	-0.754	3.264	-1.460
Sample size	570	570	570	570	570	570	570	570
R^2	0.906	0.890	0.939	0.911	0.972	0.944	0.813	0.900

Based on the data collection, 2000-2008 is the chosen time period as time dummy variable and Southwest China, Northeast China and Northwest China are the chosen region as region dummy. These results of dummy model in Table 5 suggest that:

1. The good R^2 suggests that the dummy model is suitable to our country on the basis of chosen dummy variables.

2. In the whole China, the lane-kilometers in 2000-2008 induce more 0.108 VKT than 1990-1999. This implies that more VKT is generated in the 2000s than 1990s.

3. In East China, Southwest China, South Central China and Northwest China, time dummy variables in population, GRP and lane-kilometers are not significant. These imply that the time variable does not cause the effect. Meanwhile in other areas, the time dummy variable brings the difference. In North China and Northeast China, the coefficient of population in 2000-2008 is less than in 1990-1999. These are because that China family

planning policy has fewer young people and more old people than past. In North China and Northeast China, the coefficient of GRP in 2000-2008 is larger than in 1990-1999. These are due to the fast growth of economy, policy of Chinese mainland applying reforming and opening. In North China and Northeast China, the coefficient of lane-kilometers in 2000-2008 is larger than in 1990-1999. These are the same with the whole China.

4. At the chosen time, the growth of population, GRP and lane-kilometers will increase VKT in most areas. In Northeast China, the coefficient of lane-kilometers is significant negative. And the population elasticity is larger than 2. All these imply that the collinearity exist in northeast China.

5. From the region dummy model, it suggests that the different areas have different coefficients. The elasticity coefficient of lane-kilometers in North China, East China and South Central China is 0.492. However, the elasticity is just 0.109 in Southwest China, Northeast China and Northwest China. The elasticity coefficient of GRP in North China, East China and South Central China is 0.290. Meanwhile, the elasticity is 0.516 in other areas. These all confirm that in economic low-developed area, the economic stimulus will generate more VKT than road improved and vice versa.

From all these models, autocorrelation model, autoregressive distributed lag model and dummy model are all good both in R^2 and t-test. However, different models have their own disadvantages. The data structure, panel data, is required in autocorrelation model and autoregressive distributed lag model. The inclusion of lag year may cause multi-collineary. In the dummy model, dummy variables are difficult to determine the setting standard and overlook the cumulative effects. So the dummy model has weaker transplantation. It is correct with complex assessment and dummy variable chosen. Based on the panel data collection in this paper, autoregressive distributed lag model is the better choice, which considers the lagged values of VKT, current values and lagged values of population, GRP and lane-kilometers. Autocorrelation model are good, which can be represented with autoregressive districted lag model.

Some researchers study on induced traffic with more advanced models, such as 2SLS (two-stage least squares) and 3SLS (three-stage least squares). However, it is difficult to obtain the related data and get a good instrumental variable for lane-kilometers, which is correlated with lane-kilometers but not correlated with VKT. Some researchers use the growth in lane-miles by using growth in lane-miles over two or three year periods as the instrument in 2SLS (Fulton *et al*, 2000). However, it is not a suitable instrument variable in China, which is correlated with VKT. Some researchers use 3SLS to study on the induced demand (Hymel *et al*, 2010). It is impossible to collect the data like average fuel intensity for the fleet of passenger vehicles, total annual hours of delay, index of new vehicle prices and other parameters in China. Therefore, more advanced models used are a significant research in future study. So far, all these basic elasticity models certify that the elasticity model is suit in China, and induced traffic also exist in China.

5. CONCLUSION

The elasticity model is the useful instrument of predicting induced traffic. Based on the data collection, three different elasticity models are measured in whole China and six areas. The six areas constitute the whole China. However, no coefficient of any variable is the same. From the dummy model, different regions have the individual coefficient. So the results will be more correct in six areas. Without these basic elasticity models, there are other advanced models existing in the foreign research. But the basic elasticity model is important groundwork in induced traffic model. This is good for the initial study to discuss the induced traffic effect in China. The 2SLS and 3SLS are more advanced models, which are used by many researchers. However, it is difficult to find a good instrumental variable for lane-miles in 2SLS regression and collect enough data in 2SLS and 3SLS. Therefore, more advanced models are a good research in future study. It will be immensely helpful that the relevant departments can cooperate to obtain the enough data. Based on more data collection, different advanced elasticity models will be discussed in the future research. In summary, it is necessary to further explore the advanced elasticity models in line with China's situation, which can provide a reliable method for the prediction of future road traffic, and put forward the practical proposals for the future urban transportation planning.

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