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Fuzzy Comprehensive Evaluation Research of Goal Attainment of Green Transportation Development Policy

—Take Dongguan "Motorcycle Ban" Policy as an Example

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Abstract

Launching the evaluation research of green transportation can grasp the green transportation implementation accurately and diagnose the existing problems. From the perspective of green transportation, this research chose Dongguan "motorcycle ban" policy as the research object, and constructed secondary evaluation index system in transportation and environmental harmony, transportation and future harmony, transportation and society harmony, transportation and resource harmony, four dimensions. Then it used fuzzy comprehensive evaluation model to do the evaluation and found that the policy's positive effect on the Dongguan green transportation development was average. Finally, based on the evaluation results, measures and advices were proposed.

Keywords

Green Transportation, Motorcycle Ban Policy, Fuzzy Comprehensive Evaluation

1. Introduction

The amount of private cars see a dramatically increase in Chinese large cities nowadays, especially in those metropolises that have more than two million population, which narrows the space of cities and deteriorates traffic congestion. Meanwhile, the excessive use of private cars has brought a series of problems, such as ecosystem deterioration, environment pollution, resources shortage, social crime and so on. As a result, how to guide the transportation system to enable it to coordinate with the environment, health, safety and efficiency has attracted

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the concern by government officers, professors and residents. Finally, green transportation appears when facing the urgent problems.

The idea of green transportation is introduced from oversea, but it is quite appropriate with our national conditions; specifically, green transportation emphasizes the eco-friendly of transportation, which means solving traffic congestion, reducing environment pollution, promoting social equality and controlling consumption of resources. The essence of this idea is to construct the sustainable system of city transportation, meet people's needs of traveling and spend least social cost to achieve maximum transportation efficiency. In recent years, quite a few scholars have carried out wide and deep research of green transportation, mainly focusing on the definition, importance, content of green transportation and construction of index of green transportation system. For example, Liu Dongfei believes that green transport is the key to building healthy and sustainable urban transport system [1]. Then domestic scholar Xu Fang took the principal component analysis to conclude the influencing factors of green travel behavior as five aspects: the idea of green travel behavior, family character, level of transportation management, level of travel service and travel character [2]. Besides, Jiang Yuhong *et al*. established a green traffic evaluation index system, and valued it by valuation function; also, they explained the feasibility of the presented urban green traffic planning evaluation system with an example [3]. However, there are few studies about the green transportation development policy, and the existed studies focus on the whole enforcing and implementing policies, lacking a comprehensive and completed study about one typical policy. Consequently, there are lacking cases to draw on and use as references when enforcing and launching transportation policies in some cities.

This paper took the perspective of green transportation and chose Dongguan "motorcycle ban" policy as the research object, then constructed secondary evaluation index system in transportation and environmental harmony, transportation and future harmony, transportation and society harmony, transportation and resource harmony, four dimensions. Next it used fuzzy comprehensive evaluation model to do the specific evaluation for providing governments with beneficial implication on how to promote the development of green transportation system and construction of ecological civilization.

2. The Method and Model of Evaluation

Public policy evaluation is a political behavior that uses to evaluate the benefit, efficiency and value of policies according to certain standard and procedure, which is considered as one of crucial stage in policies process [4]. The purpose of public policy evaluation is to examine the operation effect of policies, direct the future effort of policies and promote scientific policies enactment. Particularly, the operation effect of policies refers to the goal that whether one specific policy reach expected results [5].

2.1. The Models of Policy Evaluation

There are a variety of different evaluation models in the development of policy evaluation. According different evaluation objects, targets and methods, it should adopt different evaluation models, and the combination of several evaluation models has become the main trend. A Chinese scholar called Qiang Yan concluded ten evaluation models by the sequence in the evolvement of policy evaluation, such as measurement-oriented, goal-oriented, decision-oriented and etc. [6]. However, his conclusion was too wide and could not be distinguished different evaluation models accurately. On the other hand, foreign scholar William Dunn distinguished three evaluation models: pseudo-evaluation, formal evaluation and decision-theoretic evaluation by different value criteria. Apart from this, E. R. House also summarized eight models: systematic analysis model, behavior goal model, decision enactment model, non-goal model, technical comment model, expertise conclusion model, quasi-law model and case study model [7]. But his classification was so specific that it was difficult to find totally appropriate policies in the practice. Similarly, Vedung E conducted the evaluation models in detail by value criteria as well, but he proposed the concept of organizer and concluded three evaluation models in the effect of policies intervention by organizers: effective models, economic models and professional models. The effective models included goal-attainment evaluation, side-effects evaluation, goal-free evaluation, comprehensive evaluation, client-oriented evaluation and stakeholder model [8]. Comparing with other scholars, Vedung E's policy evaluation model achieved more recognition and was applied more extensively. This research will adopt Vedung E's goal-attainment evaluation to evaluate "motorcycle ban" policy.

According to Vedung E's explanation, goal-attainment evaluation is to examine traditional methods of evaluation problems and take policy goal as the only criteria that is made up of two parts: 1) Goal attainment—focusing on results whether are in conformity with policy goal or not; 2) Impact evaluation—focusing on the outcomes from policies. The application of goal attainment model has three stages: 1) Know the policy goal clearly (understand the real meaning, rank goals and transfer them into measurable objects); 2) Measure the extent on how goals can be achieved; 3) Figure out the extent on promoting policy or hindering goal attainment. There are three main points in the goal attainment model: the priority is democracy, which means that the policy takes the consideration of political democracy in the procedure of policy enactment fully as well as that they will give importance to people's interest because of the sense of responsibility. The second point is to offer objective evaluation criteria, because this model takes established policy goal to evaluate policy results to avoid value preference by those who do the assessment. The third point is simple and feasible. This model considers only two problems—whether results are in conformity with policy goal and whether the outcomes come from the policy. Although the above advantages of this model, the disadvantages is apparent—ignoring cost, difficult to apply in ambiguous goals, ignoring the unexpected effect, ignoring the impact of hidden agendas in the policy enactment and ignoring the policy implementation [8].

This paper chose the goal evaluation model mainly because the evaluation of Dongguan "motorcycle ban" policy only focused on the aspects of green transportation, which was explicit and enable the research to carry out conveniently, and the purpose of this paper was to assess the implementation effect of "motorcycle ban" policy.

2.2. The Methods of Policy Evaluation

In terms of different content of policy evaluation, we can choose different evaluation methods. The main policy evaluation methods include quantitative methods such as cost-effectiveness analysis, fuzzy comprehensive evaluation and so on, and qualitative methods such as value critique, causal analysis, goal analysis, policy Delphi, brainstorming and so on. Since the "motorcycle ban" policy has many ambiguous boundaries and involves various factors interaction that cannot be described precisely, this research takes the fuzzy comprehensive evaluation methods to quantify the ambiguous factors in the effect evaluation of "motorcycle ban policy" and do the assessment of existed fuzzy phenomenon and concepts of this policy.

3. Study Design

3.1. The Definition of Green Transportation

Green transportation refers to those travel modes that create no pollution or small pollution to our environment. It is not only a new transportation system, but also a new principle. This research adopted the definition of green transportation proposed by Professor Xiaoguang Yang of Tongji University, a theory that includes four aspects: 1) transportation and environmental harmony (ecological, psychological); 2) transportation and future harmony (appropriate of future development); 3) transportation and society harmony (safety, human-oriented); 4) transportation and resource harmony (spend least cost and resources to sustain transportation need) [9].

3.2. Sample Design

This paper chose Dongguan "motorcycle ban" policy as study object, because Dongguan is a typical second tier city that has a large population of migrant workers. After the global finance crisis in 2008, Dongguan city proposed the aim of economic and social reforming and started to explore the path of "accelerate reforming and upgrading", build "happy Dongguan". The reforming in this city may provide those developing cities with good reference and strong example.

As there were both subjective index and objective index in our evaluation system, we took questionnaire investigation and literature study methods to collect data. After the consultation of experts in the transportation field and pre-investigation in a town called Qiaotou in Dongguan, we modified related descriptions and items of the scale and got the formal questionnaire. There are mainly three parts of overall 37 questions in the formal questionnaire. The first part is about the basic information of respondents. The second part is the green transportation scale that uses Likert five-point scale that was made up of 19 descriptions about the impact of green transportation after banning motorcycles (the specific item can be seen in **Table 2**). There were 5 levels in each descriptions:

"strongly agree", "agree", "general", "disagree" and "strongly disagree", corresponding with the positive impact "strongly great", "great", "general", "weak" and "negative" respectively. The third part is about the comparison of transportation vehicles "before" and "after" the "motorcycle ban" policy. Then we adopted stratified sampling method to select Dongchen, Fenggang, Dalingshan, Qiaotou and Wangniudun five towns in Dongguan city by different economic growth to do the formal questionnaire investigation. After the data analysis by spss, the result shows in **Table 1**. The Cronbach's α of overall scale has high reliability, at 0.868. The Cronbach's α of other dimensions are above 0.7, which means their reliability is dependable. On the other hand, the objective data was acquired from 2005-2011 Dongguan statistical yearbooks (specific item can be seen in **Table 3**).

4. The Construction of Fuzzy Comprehensive Evaluation Model of the Impact of "Motorcycle Ban" Policy on Green Transportation

4.1. Construct the Evaluation Index System

According to the theory of green transportation development and the advice from transportation planning experts [10], it constructed the second level fuzzy evaluation index system in **Table 1**.

In the evaluation index system, part of the second grade impact degree index can be measured by objective index, such as the air pollution index, the traffic noise, the traffic accident and robbery of motorcycle. The other part of the secondary index can be only obtained by the citizens' subjective feelings, such as the travel modes and ideas, road environment. In order to ensure the accuracy of the policy evaluation, the fuzzy comprehensive evaluation of this study combines the objective and subjective index, above the evaluation index system, transfer the second index into measurable objective index, as **Table 2** shows.

4.2. Construct Evaluation Sets

V = {A, B, C, D, E| Strongly great positive impact, great positive impact, general positive impact, no positive impact, negative impact}. The dummy variable of evaluation sets need to quantify into hundred-mark system, specifically, A refers to strongly great positive impact (75 - 100 scores), B refers to great positive impact (50 - 75 scores), C refers to general positive impact (25 - 50 scores), D refers to no positive impact (0 - 25 scores), E refers to negative impact (below 0).

4.3. Construct the Weight Sets of Evaluation Factors

This paper chose multiple comparison to define weight. According to data from experts who graded each weight, we got the weight of first level index: A = (0.21, 0.27, 0.31, 0.21), the weight of second level index: A_1 = (0.23, 0.35, 0.19, 0.23), A_2 = (0.21, 0, 21, 0.16, 0.18, 0.14, 0.10), A_3 = (0.18, 0.16, 0.16, 0.18, 0.14, 0.18), A_4 = (0.32, 0.32, 0.36).

4.4. Construct Models of Fuzzy Comprehensive Evaluation

In order to unify dimension, we need to standardize the objective index. Among the 6 objective index in **Table2**, the air pollution index, the traffic noise, the amount of traffic accident, the amount of vehicles robbery and the consumption of fuels are inverse index, while the amount of public buses is forward index, so we chose linear interpolation method to standardize them, as follows:

$$X_{+} = \frac{X - X_{\mathrm{MIN}}}{X_{\mathrm{MAX}} - X_{\mathrm{MIN}}} \times 100 \qquad X_{-} = \frac{X_{\mathrm{MIN}} - X}{X_{\mathrm{MAX}} - X_{\mathrm{MIN}}} \times 100$$

Therefore, we acquired the objective index data from 2007-2011 Dongguan statistical yearbooks, and after standardizing them, we got the following results:

Table 1. The reliability of scale.

		Dimension of Each Scale			
Cronbach's Alpha	The Overall Scale	Transportation and Environment	Transportation and Future	Transportation and Society	Transportation and Resources
	0.868	0.877	0.810	0.733	0.779

Table 2. The index system of impact of "Motorcycle Ban" policy on green transportation.

Evaluation	1st Index	2nd Index
Impact of "Motorcycle Ban" Policy on Green Transportation	B1 Transportation and Environment	B11. After banning motorcycles, the local air quality improved
		B12. After banning motorcycles, the local vehicle noise reduced
		B13. After banning motorcycles, the local roads condition improved
		B14. After banning motorcycles, the local traffic congestion reduced
	B2 Transportation and Future	B21. After banning motorcycles, your family and you prefer to travel by public buses or bicycles
		B22. After banning motorcycles, your family and you prefer to travel by private cars
		B23. After banning motorcycles, the local public buses speed improved
		B24. After banning motorcycles, public buses paths increased and extended
		B25. After banning motorcycles, it was beneficial to city sustainable development
		B26. After banning motorcycles, the local green coverage of roads increased
	B3 Transportation and Society	B31. After banning motorcycles, the traffic accidents reduced significantly
		B32. After banning motorcycles, your family travel fee increased
		B33. After banning motorcycles, your commuting time increased
		B34. After banning motorcycles, your travel safety increased
		B35. After banning motorcycles, your concept of green travel strengthened
		B36. After banning motorcycles, your expectation of public traffic increased
	B4 Transportation and Resources	B41. After banning motorcycles, your family fuel fee per month increased
		B42. After banning motorcycles, your local parking spaces increased
		B43. After banning motorcycles, city spaces became more spacious

Table 3. Second level index transfer into objective index.

2nd Index	Objective Index
B11. After banning motorcycles，the local air quality improved	The Air Pollution Index
B12. After banning motorcycles, the local vehicle noise reduced	The Traffic Noise
B24. After banning motorcycles, public buses paths increased and extended	The Amount of Public Buses
B31. After banning motorcycles, the traffic accidents reduced significantly	The Amount of Traffic Accident
B34. After banning motorcycles, your travel safety increased	The Amount of Vehicles Robbery
B41. After banning motorcycles, your family fuel fee per month increased	The Consumption of Fuels

Sometimes it is possible to meet many quantitative indexes that cannot be used in Likert scale directly, so we need to transfer these indexes to meet the requirement of Likert scale [11]. The method is to divide the value of indexes into five intervals and each interval corresponds to five value of Likert scale, thus it complete index conversion. We can divide the objective indexes into the following five intervals by the above evaluation grades.

From **Table 4** and **Table 5**, we got the membership matrix of objective indexes, while the membership matrixes of subjective indexes come from the data of questionnaire investigation. Eventually, the R_1, R_2, R_3 and R_4 evaluation matrix of four dimension are as followings:

$$R_1 = \begin{bmatrix} 0.75 & 0 & 0 & 0.25 & 0 \\ 0.5 & 0.25 & 0 & 0.25 & 0 \\ 0.106 & 0.215 & 0.331 & 0.273 & 0.076 \\ 0.129 & 0.217 & 0.293 & 0.235 & 0.126 \end{bmatrix} \quad R_2 = \begin{bmatrix} 0.192 & 0.351 & 0.255 & 0.134 & 0.068 \\ 0.073 & 0.177 & 0.328 & 0.301 & 0.121 \\ 0.104 & 0.247 & 0.374 & 0.202 & 0.073 \\ 0.75 & 0 & 0.25 & 0 & 0 \\ 0.177 & 0.364 & 0.298 & 0.126 & 0.035 \\ 0.114 & 0.253 & 0.361 & 0.184 & 0.088 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0 & 0.25 & 0.25 & 0 & 0 \\ 0.023 & 0.134 & 0.333 & 0.293 & 0.217 \\ 0.033 & 0.205 & 0.338 & 0.26 & 0.164 \\ 0.75 & 0 & 0 & 0 & 0.25 \\ 0.167 & 0.301 & 0.414 & 0.091 & 0.028 \\ 0.179 & 0.381 & 0.301 & 0.111 & 0.028 \end{bmatrix} \quad R_4 = \begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ 0.035 & 0.179 & 0.28 & 0.301 & 0.202 \\ 0.146 & 0.255 & 0.278 & 0.225 & 0.096 \end{bmatrix}$$

Table 4. The standardization of Quantitative Index.

Quantitative Indexs	2007	2008	2009	2010
The Air Pollution Index	0.034	0.827	1	0.862
The Traffic Noise	0.023	1	0.955	0.068
The Amount of Public Buses	0.266	0.787	0.940	1
The Amount of Traffic Accident	0.466	0.714	0.907	1
The Amount of Vehicles Robbery	0.848	1	0.829	0
The Consumption of Fuels	−1	−0.316	−0.02	0

Table 5. The evaluation criteria of standardization value of Quantative Index.

Standard Value	Evaluation Criteria
$0.75 < X \le 1$	**Strongly Great Positive Impact**
$0.5 < X \le 0.75$	**Great Positive Impact**
$0.25 < X \le 0.5$	**General Positive Impact**
$0 < X \le 0.25$	**No Positive Impact**
$X \le 0$	**Negative Impact**

From $B_i = A_i \times R_i$, we can calculate the first level of fuzzy comprehensive evaluation sets B_1, B_2, B_3, B_4, then we multiplied the weight of second level index by it and got the second level fuzzy comprehensive evaluation results.

$$B = A \times \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{bmatrix} = [0.21, 027, 0.31, 0.21] \times \begin{bmatrix} 0.397 & 0.178 & 0.130 & 0.251 & 0.043 \\ 0.243 & 0.227 & 0.305 & 0.160 & 0.065 \\ 0.290 & 0.210 & 0.265 & 0.121 & 0.115 \\ 0.064 & 0.149 & 0.190 & 0.177 & 0.419 \end{bmatrix}$$

$$= [0.252, 0.195, 0.232, 0.171, 0.150]$$

4.5. Result Analysis

Multiply the evaluation result matrix $B = (0.252, 0.195, 0.232, 0.171, 0.150)$ with corresponding scores of evaluation sets (87.5, 62.5, 37.5, 12.5, 0). The calculated results is: U = 87.5 × 0.252 + 62.5 × 0195 + 37.5 × 0232 + 12.5 × 0.171 + 0 × 0.150 = 45.075. According to the criteria of evaluation sets = {A = 75 − 100, B = 50 − 75, C = 25 − 50, D = 0 − 25, E < 0| Strongly great positive impact, great positive impact, general positive impact, no positive impact, negative impact}, the impact of "motorcycle ban" policy toward Donguan's green transportation development is general. Further, calculate each dimension scores:

$$U_1 = (87.5 \times 0.397 + 62.5 \times 0.178 + 37.5 \times 0.130 + 12.5 \times 0.251 + 0 \times 0.043) \times 0.21 = 11.325$$

$$U_2 = (87.5 \times 0.243 + 62.5 \times 0.227 + 37.5 \times 0.305 + 12.5 \times 0.160 + 0 \times 0.065) \times 0.27 = 13.205$$

$$U_3 = (87.5 \times 0.290 + 62.5 \times 0.210 + 37.5 \times 0.265 + 12.5 \times 0.121 + 0 \times 0.115) \times 0.31 = 15.467$$

$$U_4 = (87.5 \times 0.064 + 62.5 \times 0.149 + 37.5 \times 0.190 + 12.5 \times 0.177 + 0 \times 0.419) \times 0.21 = 5.087$$

The above scores suggested that the most significant influence of Dongguan "motorcycle ban" policy was on the dimension of transportation and society harmony next is transportation and future and transportation and environment, but the impact on transportation and resources was not significant. It is no doubt that 'motorcycle ban' policy is an effective way to deter robbing and stealing crime and reduce traffic accidents.

5. Conclusion and Policy Suggestion

Carrying out the evaluation of green transportation policy can perfect the development of city transportation system and improve accuracy of public policies enactment. This paper chose Dongguan "motorcycle ban" policy as the case study of green transportation policies, constructed the second grade evaluation index and used fuzzy comprehensive evaluation model to do the analysis. The results suggest that the impact of "motorcycle ban" policy toward Donguan's green transportation development is general. Further, the most significant influence of this policy was on the dimension of transportation and society harmony, next was transportation and future and transportation and environment, but the impact on transportation and resources was not significant. Thus, "motorcycle ban" policy can reduce city pollution effectively, deter social crime, reduce social congestion and promote public transportation system development.

This research also found that the "motorcycle ban" policy in Dongguan came out when the public transportation system was far behind than other cities. Only after this policy appeared, would the public transportation system improve gradually. Therefore, the implementation of "motorcycle ban" policy in Dongguan was far more difficult and tough than other cities, resulting that the impact on green transportation system was not outstanding. Thus, it can be concluded that "motorcycle ban" policy will perform the maximum effectiveness. Finally, this paper proposes following suggestions to promote positive impact of green transportation of "motorcycle ban" policy in Dongguan.

5.1. Develop Government Functions Fully

Firstly, governments should stick to enforcing "motorcycle ban" policy all the time. After "motorcycle ban" policy was enforced, the positive impact of this policy was greater than the negative impact, especially on the

transportation environment and transportation safety. Besides, motorcycles that were regarded as a transition travel means in cities would disappear eventually with the improvement of public transportation system, thus, it is still necessary for Dongguan's government to implement this policy steadily. Another function of government is to be responsible for the participation and management of public transportation. Currently, public buses in Dongguan are supposed to continue to adopt bus route operation model, but it needs to strengthen the participation of government that requires both private companies and government to manage public buses operation. We can draw on the experience in Shenzhen, promoting moderate marketlization of public buses by adopting the integration of limited competition and open competition model and withdrawing part of operation rights to enhance government participation. What's more, government should strive to develop bus lane to boost the efficiency of buses travel and plan and optimize the bus path by utilizing lands and buses hubs to do transit-oriented development (TOD). Finally, the government also needs to make effort to propagate the idea of green travel, to be specific, it is vital for the citizens to realize the emergence and importance of developing green transportation in Dongguan and for locals to remove the old concepts of public transportation, resulting that everyone can take part in the development of green transportation actively. In terms of promotion of walk and bicycles, the government can organize some activities such as "Healthy Walking Day" and "Green Bicycle Travel Day" to propagate the benefits and meaningfulness of walking and cycling and encourage citizens to choose more walking and cycling to commute.

5.2. Limit the Use of Private Cars

The amount of private cars in Dongguan saw a dramatically increase after the implementation of "motorcycle ban" policy, so it is urgent for governments to enact some actions to regulate the use of private cars. Studies have proved that limiting the car population is of low efficiency, while limiting the use of private cars is the root to solve this problem. Dongguan may imitate the initiatives in Hongkong. For one thing, it is possible to enhance purchase fee and license annual fee of private cars and parking fee as well as that reducing the supply of parking spaces. For another, it is likely to enforce the odd and even number rule to encourage cars sharing, thereby relieving traffic congestion pressure.

5.3. Accelerate the Construction of Metro Traffic

Metro Traffic as a public transportation means has the advantages of big passenger transport volume, high speed and safety, low consumption and pollution. In view of the experience from foreign countries, metro traffic has accounted for more than 50% of the whole city passenger transport volume. As Dongguan's traffic development was limited by city-town-village administrative management system, there was "buses break" between the city center and towns. To tackle this problem needs the construction of metro traffic, because comfortable, convenient and punctual metro traffic is popular among middle class and top class groups. Once the metro traffic paths have built up, it can shorten the commuting time between towns and towns, and strengthen trade partnership as well, even can connect the metro traffic between Shenzhen and Guangzhou, which will bring much convenience for the citizens in Pearl River Delta.

There are three building metro traffic lines in Dongguan, but it is far not enough. Our suggestions are: 1) Investing more in the metro traffic building. Based on reasonable planning, government can offer more daily life need lines to meet citizen's demand, but it should pay attention to the coordination with other cities in Pearl River Delta when programming paths; 2) Integrating land development with metro traffic construction. We can draw on experience and ideas of TOD on Hongkong and Taiwan, then move the central function areas to suburbs when building the metro traffic, but we need to give importance to the effective connection among airports, bus stations and railway stations; 3) Choosing the metro traffic sites away from sensitive environment areas. For example, water resources protection areas and city scenery areas cannot be built with metro traffic. In the meanwhile, it is necessary to take some measures to reduce noise pollution for its adverse effect on environment [12].

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