

Mode Selection of Urban Distribution Systems in the Low Carbon Environment

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Abstract—This paper investigates the mode selection problem of urban distribution based on the environment of low carbon in Guangdong Province. The AHP model is employed to represent the points of view of 20 related personnel, including policy makers, logistics experts, enterprise senior managers and truck drivers. A hierarchical network is developed at three levels for selection. The results show that the logistics environment, transaction cost, carbon trading cost and low carbon determination are the most important variables for the decision of urban distribution modes. Then we find that the most suitable mode of urban distribution is the joint distribution, second is self-distribution and the last is third party distribution. Finally, we outline two suggestions for developing a better joint distribution pattern. First, logistics industry and associations promote the development of joint distribution actively. Second, strengthen the market management and create a good market environment.

Keywords—low carbon; urban distribution; mode; selection; AHP analysis

I. INTRODUCTION

A. Background and Significance of the Research

In order to accelerate the construction of ecological civilization and ensure the completion of “The Twelfth Five” planning objectives, the Guangdong government develops the following plan: during the 2014 and 2015, energy consumption should fall down 3.4% and 2.32%, and carbon dioxide emissions declines more than 3.5% per unit GDP in the next two years [1]. As the country's first GDP province, Guangdong government emphasizes low carbon technology to achieve sustainable development goals.

Urban distribution is an important activity to promote economic development, and it plays a significant role in the development of low carbon. On one hand, the logistics industry is an energy and carbon emitter, when it reduces energy consumption, it can effectively promote the development of low carbon economy. On the other hand, advanced logistics can benefit the production of low carbon economy and lifestyle, so low carbon economy requires modern logistics support. Therefore, the study of logistics mode in low carbon environment has great significance.

B. Related Study

Most of the domestic paper study urban distribution based on low carbon from three levels including government, industry and business. For examples, Li et al. [2], Sun et al. [3] and other scholars used the analysis method of ANP, STIRPAT and principal component analysis to study the low carbon logistics regulations and policies from the government level, then studied the service consulting and personnel training from the logistics level. With quantitative research, foreign scholars studied logistics location, transportation and distribution to reduce carbon emission. With qualitative research of logistics reduction and recycling, Zhu et al. [4] found a kind of operation pattern that coordinates people, environment and resources effectively.

During the last few years, the literature on low carbon is gradually increasing, but there is a lack of research binding qualitative and quantitative method to decide urban distribution model in Guangdong province, it is the focus of this paper. Therefore, we interviewed policy-makers, logistics experts, enterprise senior managers and truck drivers, then used the analytic hierarchy process to identify the most suitable distribution mode based on low carbon.

II. THEORETICAL BACKGROUND

Urban distribution refers to distribution activities of goods and services within the city limits. According to the user's requirements, within a reasonable range of economic region, goods are picked, processed, packaged, segmented and distributed to the designated place or specified client logistics activities on time. There're three main kinds of urban distribution patterns.

1) Self-distribution (SD) is that enterprises complete all of the distribution business independently by themselves, from distribution center construction to distribution management.

2) Joint distribution (JD) is "jointly implemented by a number of business and distribution activities". The mode of operation is shown in Fig.1.

3) Third party distribution (TPD) is a mode that another independent logistics company completes the partial or total distribution business formed by the two transactions sides.

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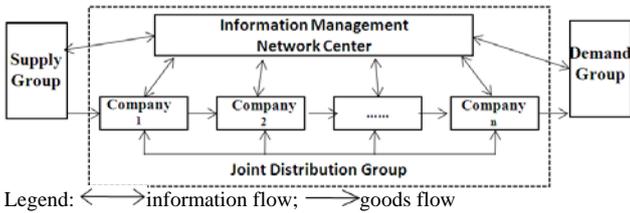


Fig. 1. The mode of operation of joint distribution



Fig. 2. The mode of operation of third party distribution

III. AHP PROCESS

AHP is a systematic and multi-attribute approach that has been applied for formulating and analyzing unstructured problems in a variety of decision making situations.

Firstly, structure the decision into a hierarchical model. The topmost level is the focus of the problem. The intermediate levels correspond to criteria, while the lowest level contains the “decision alternatives”.

Secondly, make pair-wise comparisons and obtain the judgmental matrix. In this step, the elements in the medium level are compared pair-wise with respect to a specific element. This measurement methodology provides the framework for data collection and analysis, and constitutes the heart of the AHP. According to Saaty [5], the 9-point scale is used to transform verbal judgments into numerical quantities ranging from 1 (indifference or equal importance) to 9 (extreme preference or absolute importance).

Thirdly, compare with individual priorities and consistency. The group of participants provides a measurement theory to establish the priorities of the elements of the hierarchy and the consistency of the judgmental data. Calculated priorities are used to compare the relative contribution of the elements with another element in the adjacent upper level. Synthesis of priorities is used to calculate a composite weight for each alternative based on the preferences derived from the comparison matrix. Consistency is defined as the cardinal transitivity between judgments [6]. A consistency ratio (CR) provides a measure of the probability that the pair-wise comparison matrix is filled in purely at random.

Fourthly, after calculating the individual priorities of elements of different levels in the previous step, they are aggregated equally to obtain the overall priorities of the alternatives. For aggregation, the AHP model manipulates the values entered in the second step to determine the best alternative for a particular goal.

IV. METHOD

This paper is formed by the research in Guangdong Province, China, which can be divided into two phases. In the first stage, we went through lots of literature, including

1,640,000 billion dollars in logistics industry and 4.72 billion tons of carbon emissions from National Bureau learned in 2012. To reduce the carbon dioxide emission, the Guangdong government put many efforts to promote low carbon economy and logistics development, and in 2017 carbon trading will be applied to transportation, which will increase 1.3% logistics cost [7]. Moreover, the Guangdong government has been implementing joint distribution, but the extent of joint distribution has been very low, with little success, the public vehicles sometimes are private. We are wondering if we should use the joint distribution in consideration of low carbon environment. So we specifically chose the nine variables affecting urban distribution, measured on a seven-point scale using the following bands: strongly disagree; disagree, tend to disagree; average; tend to agree; agree, strongly agree. The maximum weight was given for ‘strongly agree’ in the case of a favorable attitude and for ‘strongly disagree’ in the case of an unfavorable attitude. Finally we chose four groups, a total of 20 people, with their score data as a basis for subsequent decisions.

In the second phase, before we obtained the scores of four groups, we carefully explained to them in detail the meaning and impact of the nine related variables to ensure that all respondents could understand. We interviewed government policy-makers, enterprise senior managers, logistics experts and truck drivers each five people, let them fill up a corresponding questionnaire. Questionnaires were developed based on the AHP model, every problem was to compare the two standards, which produced a total of nine standard 42 questions. The survey was based on the overall perception of the situation to confirm the two standard weights. Then we filled up the scores in AHP model.

Finally, sensitive analysis was needed to reduce the influence of subjective factors, and improved the accuracy of risk assessment results. Under the principle that we wouldn’t change the importance of mutual evaluation, but we changed the tone values in AHP judgment matrix, so that each criterion would have 3 different weights, then determine the final result. If the results were consistent, then we could accept it.

V. RESULTS

A. The Development of AHP

This stage is to establish a network AHP to reflect our problem as shown in Fig.3, including the top of the target layer, an intermediate layer of guidelines, and most low-end alternative layers. In this study, our ultimate goal is to select

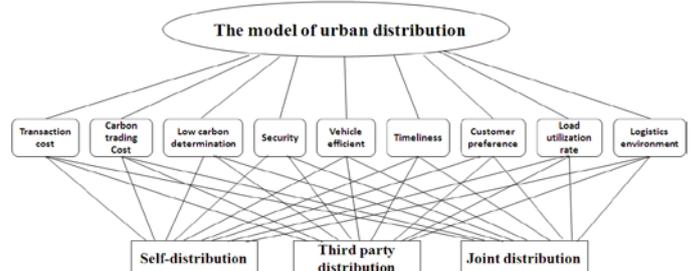


Fig. 3. Hierarchical model for selection of urban distribution model

the most appropriate mode of urban distribution in Guangdong Province. Therefore, there are self-distribution, third party distribution and joint distribution on the bottom.

B. Comparison between Two Avaluation Standards

After this stage the following four groups are involved in pair-wise comparison of the nine criteria.

The use of an AHP model requires determining the relative importance of each element in the hierarchy. Each element in a level is compared pair-wise with other elements in the same level with respect to an element at a higher level. Twenty participants in four groups examined the criteria with respect to the overall goal. Before the performance of pair-wise comparisons, all members of the groups were instructed on how to compare criteria with respect to the overall goal. Their judgment of the importance of one criterion over another was made subjectively and converted to a numerical value using a scale of 1–9. Table I shows the normalized weights and ranks for the nine criteria with the overall goal in each four groups and as a whole. The results of pair-wise comparisons of criteria by the four groups and the overall comparison are presented below.

In order to simplify the charts, we have to express some shorthand. Such as: LTC(logistics transaction cost); CTC(carbon trading cost); SCT(security); TLN(timeliness); CP(customer preference); LUR(load utilization rate); VE(vehicle efficiency); LCD(low carbon determination) and LE(logistics environment).

1) Policy-makers. Fig.4 (a) shows that what policy-makers consider most are to develop low carbon logistics and logistics environment, which are accounted for 0.1582. The next level customer preferences and carbon trading costs are accounted for 0.1352 and 0.1227 respectively. That is to say, the determination of logistics and logistics environment are important. The least important is the security, only accounted for 0.0448. Because when the government makes decision, they don't take much attention on the independence and confidentiality between enterprises.

2) Enterprise senior managers. Fig.4 (b) shows that enterprise senior managers believe the logistics environment and transaction costs are the most important, respectively

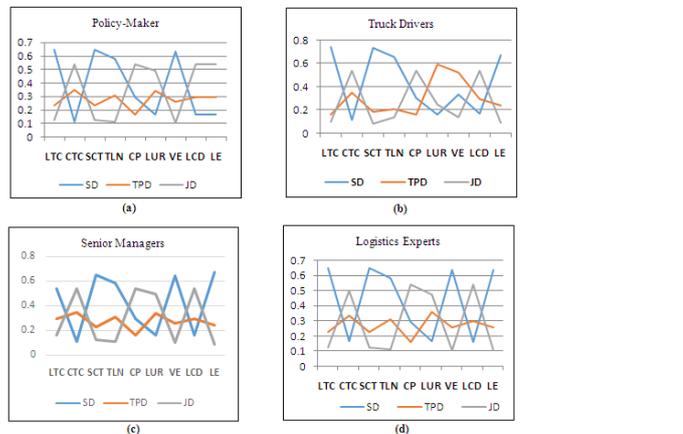


Fig. 4. Priority of SD,TPD and JD by different kinds of people

accounted for 0.2963 and 0.255. The profitability is weak, but the logistics enterprises compete intensively, the market environment and cost decides the enterprise mode of operation. The weakest factor for the decision is customer preference, only 0.0066, for most of the enterprises, in order to achieve the purpose of existence and requirements of government, they can only ignore consumer preference.

3) Logistics experts. Fig.4 (c) shows the logistics experts think the most important factor are the determination of low carbon and customer preference, accounted for 0.2025 and 0.1952, respectively. What influences the decision least are the logistics environment and transaction costs, accounted for 0.0675 and 0.0647 respectively. To develop the urban distribution in low carbon environment, we should put a long-term perspective on the problem. It is necessary to make good use of policy advantages, but also pay special attention to the customer preference.

4) Truck drivers. Fig.4 (d) shows that truck drivers think the most important factors are carbon trading costs and transaction costs, which are both accounted for 0.2566, following by the logistics environment and the load utilization rate are accounted for 0.1872 and 0.1602. The least important factor are the timeliness and customer preference, accounted for 0.0106 and 0.0094. In other words, truck drivers think the most important factor is the cost, whatever internal carbon trading or cost increases, it will greatly influence the choice of mode. But they pay least attention to customers.

5) Overall groups. To choose the urban distribution pattern is a complex proposition in the low carbon environment, which must go through lots of researches and make the statistical analysis of data. In this study, we integrated the evaluation score of policy-makers, enterprise senior managers, logistics experts and truck drivers, then find that joint distribution, self-distribution and third-party distribution are accounted 0.360, 0.358 and 0.282 respectively. And we know that self-distribution in Guangdong accounts for more than 70%. That is to say after the practice of carbon trading, joint distribution will be more welcomed because it reduces the cost and improves the profits. Fig.5 shows that important factors affected urban distribution pattern mainly are logistics environment, the determination of low carbon, the transaction costs and logistics environment, accounted for 0.176, 0.151, 0.136 and 0.136 respectively. Unimportant factor are security and vehicle efficiency, accounted for 0.06 and 0.064 respectively.

The prioritizing and ranking of the criteria for urban distribution model is shown as Table I. The summary effects of four groups for AHP analysis is shown as Table II. Both of them show the final decision and the priority of each factor.

C. Synthetic Judgment

Sensitivity analysis allows the results of a decision to be verified. A sensitivity analysis is formed to see how sensitive the alternatives are to change with the importance of the criteria. Here, performance sensitivity analysis is employed. Table III shows how well each alternative selection of city distribution models performed on each criterion by increasing

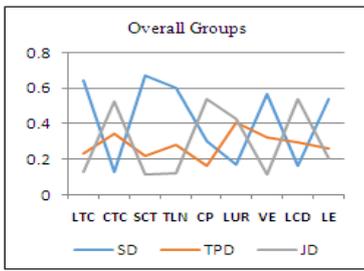


Fig. 5. Priority of SD,TPD by overall respondents

TABLE I. PRIORITIZING AND RANKING OF THE CRITERIA FOR URBAN DISTRIBUTION MODEL.

Indicators	Policy-Makers	Logistics Experts	Senior Managers	Truck Drivers	Overall Groups
Carbon Trading Cost	0.316 (1)	0.135 (8)	0.593 (1)	0.257 (1)	0.186 (1)
Low Carbon Determination	0.315 (2)	0.405 (1)	0.296 (3)	0.037 (6)	0.151 (2)
Transaction Costs	0.245 (4)	0.193 (4)	0.255 (4)	0.257 (2)	0.136 (3)
Logistics Environment	0.123 (8)	0.129 (9)	0.510 (2)	0.187 (3)	0.136 (4)
Load Utilization Rate	0.229 (6)	0.144 (7)	0.166 (1)	0.160 (4)	0.100 (5)
Customer Preference	0.270 (3)	0.390 (2)	0.013 (9)	0.009 (9)	0.098 (6)
Timeliness	0.180 (7)	0.271 (3)	0.032 (8)	0.011 (8)	0.071 (7)
Vehicle Efficiency	0.229 (5)	0.144 (6)	0.055 (7)	0.023 (7)	0.064 (8)
Security	0.090 (9)	0.188 (5)	0.080 (6)	0.059 (5)	0.060 (9)

TABLE II. SUMMARY OF EFFECTS FOR AHP ANALYSIS.

Distribution Model	Policy Makers	Senior Managers	Truck Drivers	Logistics Experts	Overall Groups
JD	0.46	0.29	0.26	0.38	0.35
TPD	0.28	0.29	0.31	0.26	0.29
SD	0.26	0.43	0.43	0.35	0.37

TABLE III. SENSITIVITY ANALYSIS RESULTS FOR AHP MODEL.

Sensitivity Analysis	SD(5)	JD(3)	TPD(1)	Weight
Transaction Costs	0.47	0.31	0.32	0.13
Carbon trading Cost	0.14	0.53	0.33	0.17
Security	0.44	0.34	0.22	0.14
Timeliness	0.49	0.23	0.18	0.04
Customer Preference	0.30	0.54	0.13	0.04
Load Utilization Rate	0.18	0.43	0.39	0.22
Vehicle Efficiency	0.36	0.33	0.31	0.04
Low Carbon Determination	0.30	0.54	0.16	0.11
Logistics Environment	0.33	0.41	0.26	0.10

or decreasing its tone value. After we got the score of 3.06, we thought joint distribution pattern could be accepted.

VI. CONCLUSION AND RECOMMENDATION

A. Conclusion

Urban distribution is an important indicator to promote the urban economic development, but it causes lots of carbon pollution. To study the effects of different variables on urban distribution model, it will help us choose a more suitable urban distribution pattern, then find the most influential variable, which needs special attention and control.

We develop the AHP model and consider the related variables, then four types of groups are selected to participate in evaluation, their scores are incorporated into the decision-making model. For the three urban distribution models, there will be differences in scoring among the four groups, but after

weight distribution and sensitivity analysis we finalize the pattern of joint distribution. Firstly, start together with self-distribution and joint distribution, then gradually transform to a high degree of joint distribution. To accept joint distribution model, we should pay great attention to the cost and the government's determination to develop low carbon economics.

B. Recommendation

In 2017, the Guangdong government is to promote carbon trading, which will have a huge impact on the transportation. To promote transformation and upgrading of urban distribution, we believe that this result will have a huge impact. By the curve of overall objective of the decision, we can find the four of most important factors are carbon trading costs, determination of low carbon, transaction costs and logistics environment. However carbon trading prices and credits are issued by the government decision, and logistics transaction costs are determined by the enterprise. As the research shows what we can do is to strengthen the determination of low carbon logistics, providing more guidance for enterprises and improve logistics environment.

On one hand, industry associations promote the joint distribution development actively. First, the associations should be responsible for organization, coordination, service and supervision. Then strengthen the strategic importance of its joint distribution, give some technical guidance and support to those companies who are willing to accept the mode of joint distribution. Second, during the joint distribution operation, industry associations should grasp industry news and coordinate multi conflicts of interest.

On the other hand, we should strengthen market management and create a good market environment. We should be clear about the content of cargo transportation management, rules and standards. After that, we make the business practices norms and legal responsibility in case of confidential disclosure and unfair competition. Finally, guide those company lead to standardization development.

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