# A Study on Logistics Mode Selection for Vehicle Parts Supply using Fuzzy Analytic Hierarchy Process

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***Abstract* — In this paper we analyze the advanced concepts and strategies of domestic and international work on supply logistics, and the development environment of China's logistics situation. Viewing the entire automobile supply chain as the core of automobile manufacturing enterprise, we propose parts supply process by putting quality inspection in advance, which is conducive to the supply chain to reduce transportation costs and improve the quality of products. It can provide the necessary material conditions for the implementation of "synchronous delivery", it also has important academic value and significance to improve China's auto supply logistics.**

***Keywords - Vehicle parts; Supply logistics mode; Synchronous supply***

## I. INTRODUCTION

Hlioui [1] dealt with the coordination of production, replenishment and inspection decisions for a manufacturing-oriented supply chain with a failure-prone transformation stage, random lead time and imperfect delivered lots. Zhang Tong [2] thought that the entire car producer should be allied with the 3PL service provider and coordinated with them based on the same target. Zhang Yan [3] found that practicality is not high, lacking of specialized information systems' support and other defects after analyzing auto parks logistics mode. Gonzalez [4] studied the relationship between supply logistics and transportation management system, and analyzed two representative modes of supply logistics transportation. Wang Xuhui and Xu Jian [5] thought that China's high technology enterprises accounted for about 50% in listed logistics company, compared with the port logistics companies, technical efficiency, listed transport logistics company's technical efficiency, pure technical efficiency and scale efficiency is higher. Yao Guanxin [6] analyzed the integrated logistics organization model of industrial cluster from the asset specificity, uncertainty and transaction frequency based on the theory of transaction cost. Li JimaM [7] researched on the innovation management of parts supply logistics operation. Jiao Zhilun and Yu Zhihan [8] pointed out that e-commerce business has the characteristics of diversity, frequent use of new technology, which determines the electronic commerce logistics service needs to adapt to the development of electronic commerce, strengthen its ability to innovate. Bo Ying [9] put forward the basic countermeasures of how to develop modern logistics by analyzing the current situation of logistics enterprises in our country. Zhao Jian [10] made countermeasures for the reform of railway freight transportation and the integration of the third party logistics by analyzing the development status of the third party logistics enterprises in our country.

## II. PROBLEM DESCRIPTION

The supply of parts and components of BOSCH is often delayed, the arrival of the plan is often inaccurate. It can increase the trouble of the people in the logistics center, make them busy without the support of system. It will be an inertia in a long term. If there is a shortage of risk, it will bring loss to customers. After the analysis, the logistics operation has appeared the following three kinds of abnormal situation:

(1) There are differences in basic data

Due to the asymmetry of the information of the parts, the original data will be different, each will have own data, in most cases everyone will not share data, which can make difference in stocking. This will affect the purchase plan, and lead to the increase of inventory costs, less likely to be out of stock. If the factory can not communicate effectively, it will have different materials used in the production process, and make the difference between the amount of the purchase and the materials. This kind of problem is the distortion problem that appears mainly in the transportation, the revision, and the facsimile process.

(2) The coordination between production and logistics

The goods that the factory needs will be some abnormal conditions in the process of logistics transportation, such as the car broke down, or the car illegally detained, and the quality problem that the products need to return the supplier to process. There is no system in this process that can feed back the situation of the production line. This series of differences will lead to differences in production. It lack of a

platform for information feedback, so it may give customers a bad service experience.

(3) The coordination problem between suppliers and manufacturers

The auto parts have the complex products characteristics, the supply and demand sides of spontaneous communication will have a lot of problems, resulting in the supplier unable to complete the commodity in the delivery period, traffic logistics uncertainty, material supply will also affect the production. In order to solve the problem, we can only consider to delivery the goods from the outside, But we must consider the cost, because it is a temporary measure, and it is difficult to control the situation, if there is no other solution, manufacturers can only wait for the material.

(4) It is difficult to promote the information technology comprehensively

The persons in logistics enterprises have different levels, the hardware facilities are backward, information construction is restricted, carrier's information technology is backward, making it unable to use the electronic system facilities, such as various types of electronic form, supply and demand planning, scheduling, information compilation and so on. A lot of things that in logistics companies still need to be done manually, but it bring enormous pressure to them, so efficient operation has encountered a bottleneck.

(5) The difficulty of building the warehouse system is increased

BOSCH establishes the warehouse in the form of rent, construction and borrowing in the vicinity of the vehicle production enterprises, and builds their own warehouse management system. This can bring a better service experience, but these are based on the sacrifice of their company's interests. Multiple warehouse building system is bad for management, such as the lease of the warehouse, administrators in different levels, management confusion.

## III. ANALYSIS OF INFLUENCING FACTORS OF AUTO PARTS SUPPLY LOGISTICS MODE

After the analysis of production characteristics and operation mode of auto parts enterprises, we will consider four factors: the scale of enterprises, the level of supply chain management, the economic strength and the logistics operation. On the basis of the previous related research data, the influencing factors and evaluation indexes of auto parts supply logistics model were established, referring to table 1.

TABLE I THE SELECTION OF AUTO PARTS SUPPLY LOGISTICS MODE W

| **primary index** | **secondary index** |
|---|---|
| Enterprise scale factor A1 | $B_{11}$ Capital input |
| | $B_{12}$ Infrastructure |
| | $B_{13}$ Information technology |
| Logistics management factors A2 | $B_{21}$ Accuracy in time |
| | $B_{22}$ Fine logistics service |
| | $B_{23}$ Differentiated logistics service |
| economic factor A3 | $B_{31}$ Administration cost |
| | $B_{32}$ Capital risk |
| | $B_{33}$ Operation cost |
| supply chain factors A4 | $B_{41}$ Information management ability |
| | $B_{42}$ Cooperative operation ability |
| | $B_{43}$ Decision-making executive ability |

TABLE II COMPARATIVE ANALYSIS OF AUTO PARTS SUPPLY LOGISTICS MODE UNDER THE INFLUENCE OF FACTORS

| **auto parts supply chain logistics** | | **self-support Logistics** | **outsourcing logistics** | **logistics alliance** |
|---|---|---|---|---|
| A1 | $B_{11}$ | large investment | small investment | greater investment |
| | $B_{12}$ | high requirement | low requirement | lower requirement |
| | $B_{13}$ | lower requirement | higher requirement | high requirement |
| A2 | $B_{21}$ | high | higher | medium |
| | $B_{22}$ | weaker | strong | stronger |
| | $B_{23}$ | weaker | strong | stronger |
| A3 | $B_{31}$ | high | Low | lower |
| | $B_{32}$ | high | Low | lower |
| | $B_{33}$ | high | lower | medium |
| A4 | $B_{41}$ | low requirement | high requirement | higher requirement |
| | $B_{42}$ | Lower requirement | high requirement | higher requirement |
| | $B_{43}$ | high | low | medium |

## IV. LOGISTICS MODE OF AUTO PARTS SUPPLY ANALYSIS BY FUZZY ANALYTIC HIERARCHY PROCESS

### *-A. Construct hierarchical structure model*

In the middle of last century, the United States control experts put forward the mathematical evaluation model. For the degree of membership in the model, the function is used to deal with the index. According to the score of membership function to quantify the value of indicators and make fuzzy on the key factors and the evaluation of experts. The mathematical tool is often used in the assessment of project audit, because human factors can be reduced to the maximum extent. The specific process of fuzzy evaluation include determining factor set, the evaluation index of the dimensionless, giving evaluation index weight, establishing evaluation grade set, determining the membership, establishing the fuzzy evaluation matrix, calculating fuzzy matrix and fuzzy comprehensive evaluation results. The comparison analysis table of supply logistics mode as is shown in table 2.

(1) Building hierarchical structure mode according to the analysis of the specific circumstances of BOSCH.

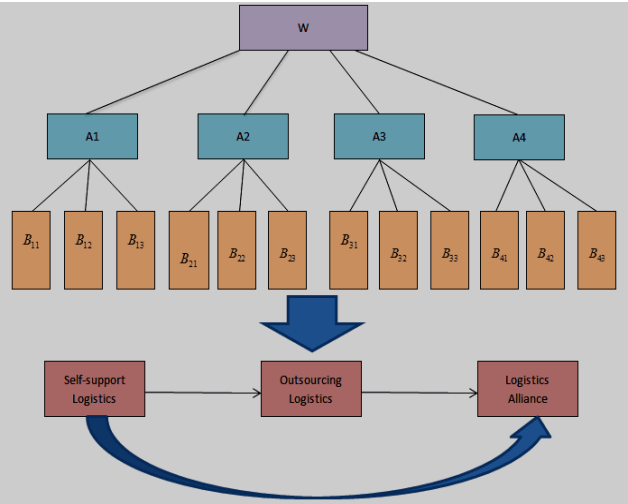


Figure 1 the hierarchical structure model of logistics model selection.

TABLE III COMPARISON MATRIX

| W | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $W_i$ |
|---|---|---|---|---|---|
| $A_1$ | 1 | 3 | 1/3 | 3 | 0.2859 |
| $A_2$ | 1/3 | 1 | 1/2 | 2 | 0.164 |
| $A_3$ | 3 | 2 | 1 | 3 | 0.445 |
| $A_4$ | 1/3 | 1/2 | 1/3 | 1 | 0.105 |

We can calculate: $\lambda_{max}$=4.258

Conformity Test ： CI= ($\lambda_{max}$ –n)/(n-1)=0.087

CR=CI/RI=0.087/0.9=0.096<0.1

So the matrix fits in with the test.

(2) Compute comparison matrix $A_1$-B

TABLE IV COMPARISON MATRIX A1-B

| $A_1$ | $B_{11}$ | $B_{12}$ | $B_{13}$ | $W_i$ |
|---|---|---|---|---|
| $B_{11}$ | 1 | 1/3 | 2 | 0.249 |
| $B_{12}$ | 3 | 1 | 3 | 0.594 |
| $B_{13}$ | 1/2 | 1/3 | 1 | 0.157 |

Conformity Test：CI= (λ max –n)/(n-1)=3.054… (1)

CR=CI/RI=0.028/0.58=0.046<0.1…… (2)

So the matrix fits in with the test.

(2) Compute comparison matrix A2-B:

TABLE V COMPARISON MATRIX A2-B

| A2 | B21 | B22 | B23 | Wi |
|---|---|---|---|---|
| B21 | 1 | 3 | 4 | 0.614 |
| B22 | 3 | 1 | 3 | 0.268 |
| B23 | 4 | 1/3 | 1 | 0.117 |

We can calculate: λ max=3.074

Conformity Test： CI=(λ max –n)/(n-1)=0.036…(3)

CR=CI/RI=0.036/0.58=0.065<0.1…… (4)

So the matrix fits in with the test.

(3) Compute comparison matrix A3-B:

TABLE VI COMPARISON MATRIX A3-B

| A3 | B31 | B32 | B33 | Wi |
|---|---|---|---|---|
| $B_{31}$ | 1 | 5 | 4 | 0.974 |
| $B_{32}$ | 5 | 1 | 1/2 | 0.162 |
| $B_{33}$ | 1/4 | 2 | 1 | 0.227 |

We can calculate: λ max=3.025

Conformity Test：CI=(λ max –n)/(n-1)=0.017……（5）

CR=CI/RI=0.017/0.58=0.024<0.1……（6）

So the matrix fits in with the test.

(5) Compute comparison matrix A4-B：

TABLE VII COMPARISON MATRIX A4-B

| A4 | B41 | B42 | B43 | Wi |
|---|---|---|---|---|
| $B_{41}$ | 1 | 3 | 5 | 0.619 |
| $B_{42}$ | 1/3 | 1 | 4 | 0.284 |
| $B_{43}$ | 1/5 | 1/4 | 1 | 0.097 |

We can calculate: λ max=3.087

Conformity Test：CI=(λ max–n)/(n-1)=0.055…（7）

CR=CI/RI=0.055/0.58=0.086<0.1…… （8）

So the matrix fits in with the test.

Based on the above data, we can get the evaluation model weight table 8.

TABLE VIII EVALUATION MODEL WEIGHT

| primary index | weight | secondary index | Comprehensive weight |
|---|---|---|---|
| Enterprise scale factor$A_1$ | 0.285 | Capital input level $B_{11}$ | 0.071 |
| | | Infrastructure level $B_{12}$ | 0.169 |
| | | Information technology level $B_{13}$ | 0.045 |
| Logistics Management factors$A_2$ | 0.164 | Timely accuracy $B_{21}$ | 0.101 |
| | | Fine logistics service $B_{22}$ | 0.044 |

According to the questionnaire survey of BOSCH employees, the results of single factor evaluation are shown in table 9

TABLE IX SINGLE FACTOR EVALUATION RESULTS

| Primary Index | Secondary Index | Self-Support Logistics | | | | Outsourcing Logistics | | | | Logistics Alliance | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Good | Better | Ordinary | Bad | Good | Better | Ordinary | Bad | Good | Better | Ordinary | Bad |
| $A_1$ | $B_{11}$ | 0 | 0.1 | 0.4 | 0.5 | 0.6 | 0.2 | 0.1 | 0.1 | 0.4 | 0.3 | 0.2 | 0.1 |
| | $B_{12}$ | 0.1 | 0.1 | 0.3 | 0.5 | 0.5 | 0.3 | 0.1 | 0.1 | 0.3 | 0.4 | 0.2 | 0.1 |
| | $B_{13}$ | 0.3 | 0.4 | 0.2 | 0.1 | 0 | 0.1 | 0.3 | 0.6 | 0.1 | 0.2 | 0.4 | 0.3 |
| $A_2$ | $B_{21}$ | 0.5 | 0.3 | 0.2 | 0 | 0.2 | 0.5 | 0.1 | 0.3 | 0.2 | 0.3 | 0.5 | 0 |
| $A_3$ | $B_{31}$ | 0 | 0.1 | 0.2 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0 | 0.1 | 0.2 | 0.7 |
| | $B_{32}$ | 0.7 | 0.2 | 0.1 | 0 | 0.2 | 0.2 | 0.3 | 0.3 | 0.7 | 0.2 | 0.1 | 0 |
| | $B_{33}$ | 0 | 0.1 | 0.4 | 0.5 | 0.4 | 0.4 | 0.1 | 0.1 | 0 | 0.1 | 0.4 | 0.5 |
| $A_4$ | $B_{41}$ | 0.2 | 0.2 | 0.3 | 0.3 | 0.6 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 |
| | $B_{42}$ | 0.1 | 0.1 | 0.2 | 0.6 | 0.5 | 0.4 | 0.1 | 0 | 0.3 | 0.4 | 0.2 | 0.1 |
| | $B_{43}$ | 0.7 | 0.2 | 0.1 | 0 | 0.1 | 0.1 | 0.4 | 0.4 | 0.5 | 0.3 | 0.2 | 0 |

*A. A fuzzy evaluation matrix model is established by three kinds of supply modes*

(1) Self-support logistics mode

$$R_1=\begin{bmatrix}0.2 & 0.5 & 0.2 & 0.1\\ 0.4 & 0.3 & 0.1 & 0.2\\ 0.4 & 0.4 & 0.2 & 0.1\end{bmatrix}$$

$$R_2=\begin{bmatrix}0.5 & 0.3 & 0.1 & 0.1\\ 0.1 & 0.2 & 0.3 & 0.4\\ 0.1 & 0.1 & 0.4 & 0.4\end{bmatrix}$$

$$R_3=\begin{bmatrix}0 & 0.1 & 0.2 & 0.7\\ 0.7 & 0.2 & 0.1 & 0\\ 0 & 0.1 & 0.4 & 0.5\end{bmatrix}$$

$$R_4=\begin{bmatrix}0.2 & 0.2 & 0.3 & 0.3\\ 0.1 & 0.1 & 0.2 & 0.5\\ 0.7 & 0.2 & 0.1 & 0\end{bmatrix}$$

(2) outsourcing logistics model

$$R_1=\begin{bmatrix}0.6 & 0.2 & 0.1 & 0.1\\ 0.5 & 0.3 & 0.1 & 0.1\\ 0 & 0.1 & 0.4 & 0.3\end{bmatrix}$$

$$R_2=\begin{bmatrix}0.2 & 0.5 & 0.2 & 0.1\\ 0.4 & 0.3 & 0.1 & 0.1\\ 0.5 & 0.4 & 0.1 & 0.1\end{bmatrix}$$

$$R_3=\begin{bmatrix}0.6 & 0.2 & 0.1 & 0.1\\ 0.4 & 0.4 & 0.1 & 0.1\\ 0 & 0.1 & 0.5 & 0.3\end{bmatrix}$$

$$R_4=\begin{bmatrix}0.6 & 0.2 & 0.1 & 0.1\\ 0.5 & 0.3 & 0.2 & 0.1\\ 0 & 0.1 & 0.6 & 0.3\end{bmatrix}$$

(3) logistics alliance mode

$$R_1=\begin{bmatrix}0 & 0.1 & 0.2 & 0.7\\ 0.6 & 0.2 & 0.1 & 0\\ 0 & 0.1 & 0.4 & 0.5\end{bmatrix}$$

$$R_2=\begin{bmatrix}0.2 & 0.2 & 0.3 & 0.3\\ 0.1 & 0.1 & 0.2 & 0.6\\ 0.7 & 0.2 & 0.1 & 0\end{bmatrix}$$

$$R_3=\begin{bmatrix}0.4 & 0.3 & 0.2 & 0.1\\ 0.6 & 0.3 & 0.2 & 0.1\\ 0 & 0.2 & 0.7 & 0.3\end{bmatrix}$$

$$R_4=\begin{bmatrix}0.5 & 0.4 & 0.0 & 0.1\\ 0.1 & 0.2 & 0.3 & 0.4\\ 0.1 & 0.3 & 0.3 & 0.3\end{bmatrix}$$

*B. Fuzzy comprehensive evaluation*

(1) Comprehensive evaluation of Self-support logistics mode

$$B_1=A_1*R_1=(0.071\ \ 0.169\ \ 0.045)*\begin{bmatrix}0.6 & 0.2 & 0.1 & 0.1\\ 0.5 & 0.3 & 0.1 & 0.1\\ 0 & 0.1 & 0.6 & 0.3\end{bmatrix}$$

$$=(0.030\ \ 0.045\ \ 0.008\ \ 0.126)$$

$$B_2=A_2*R_2=(0.101\ \ 0.044\ \ 0.019)*\begin{bmatrix}0.5 & 0.3 & 0.1 & 0.1\\ 0.1 & 0.2 & 0.3 & 0.4\\ 0.1 & 0.1 & 0.4 & 0.4\end{bmatrix}$$

$$=(0.057\ \ 0.041\ \ 0.031\ \ 0.035)$$

$$B_3=A_3*R_3=(0.071\ \ 0.169\ \ 0.045)*\begin{bmatrix}0 & 0.1 & 0.2 & 0.7\\ 0.7 & 0.2 & 0.1 & 0\\ 0 & 0.1 & 0.4 & 0.5\end{bmatrix}$$

$$=(0.050\ \ 0.069\ \ 0.141\ \ 0.356)$$

$$B_4=A_4*R_4=(0.071\ \ 0.169\ \ 0.045)*\begin{bmatrix}0.5 & 0.3 & 0.1 & 0.1\\ 0.1 & 0.2 & 0.3 & 0.4\\ 0.1 & 0.1 & 0.4 & 0.4\end{bmatrix}$$

$$=(0.023\ \ 0.018\ \ 0.027\ \ 0.038)$$

So $B=A*R=(0.043\ \ 0.051\ \ 0.096\ \ 0.204)$

(2) Comprehensive evaluation of Outsourcing logistics model

$$B_1=A_1*R_1=(0.071\ \ 0.168\ \ 0.046)*\begin{bmatrix}0.6 & 0.2 & 0.1 & 0.1\\ 0.5 & 0.3 & 0.1 & 0.1\\ 0 & 0.1 & 0.6 & 0.3\end{bmatrix}$$

$$=(0.030\ \ 0.042\ \ 0.008\ \ 0.125)$$

$$B_2=A_2*R_2=(0.101\ \ 0.044\ \ 0.019)*\begin{bmatrix}0.4 & 0.2 & 0.3 & 0.1\\ 0.1 & 0.4 & 0.1 & 0.4\\ 0.1 & 0.1 & 0.4 & 0.4\end{bmatrix}$$

$$=(0.057\ \ 0.041\ \ 0.031\ \ 0.035)$$

$$B_3=A_3*R_3=(0.071\ \ 0.168\ \ 0.046)*\begin{bmatrix}0.6 & 0.2 & 0.1 & 0.1\\ 0.5 & 0.3 & 0.1 & 0.1\\ 0 & 0.1 & 0.6 & 0.3\end{bmatrix}$$

$$=(0.050\ \ 0.069\ \ 0.141\ \ 0.356)$$

$$B_4=A_4*R_4=(0.071\ \ 0.168\ \ 0.046)*\begin{bmatrix}0.4 & 0.2 & 0.3 & 0.1\\ 0.1 & 0.4 & 0.1 & 0.4\\ 0.1 & 0.1 & 0.4 & 0.4\end{bmatrix}$$

$$=(0.023\ \ 0.018\ \ 0.027\ \ 0.038)$$

So $B=A*R=(0.158\ \ 0.116\ \ 0.072\ \ 0.056)$

(3) Comprehensive evaluation of logistics alliance mode

$$B_1=A_1*R_1=(0.071\ \ 0.168\ \ 0.046)*\begin{bmatrix}0.6 & 0.2 & 0.1 & 0.1\\ 0.5 & 0.3 & 0.1 & 0.1\\ 0 & 0.1 & 0.6 & 0.3\end{bmatrix}$$

$$=(0.030\ \ 0.043\ \ 0.008\ \ 0.126)$$

$$B_2=A_2*R_2=(0.101\ \ 0.044\ \ 0.019)*\begin{bmatrix}0.4 & 0.2 & 0.3 & 0.1\\ 0.3 & 0.2 & 0.1 & 0.4\\ 0.1 & 0.1 & 0.4 & 0.4\end{bmatrix}$$

$$=(0.057\ \ 0.041\ \ 0.031\ \ 0.035)$$

$$B_3=A_3*R_3=(0.071\ \ 0.168\ \ 0.046)*\begin{bmatrix}0 & 0.1 & 0.2 & 0.7\\ 0.7 & 0.2 & 0.1 & 0\\ 0 & 0.1 & 0.4 & 0.5\end{bmatrix}$$

$$=(0.050\ \ 0.069\ \ 0.141\ \ 0.356)$$

$$B_4=A_4*R_4=(0.071\ \ 0.168\ \ 0.046)*\begin{bmatrix}0.4 & 0.2 & 0.3 & 0.1\\ 0.1 & 0.4 & 0.1 & 0.4\\ 0.1 & 0.1 & 0.4 & 0.4\end{bmatrix}$$

$$=(0.023\ \ 0.018\ \ 0.027\ \ 0.038)$$

So $B=A*R=(0.086\ \ 0.103\ \ 0.149\ \ 0.058)$

According to the fuzzy analytic hierarchy process, the result is that the model of self - run logistics is general, the logistics alliance mode is better, the outsourcing logistics mode is good.

## V. PRODUCTION AND TRANSPORTATION OPTIMIZATION

For the implementation of the material on line, the development of new lean production plan focuses the following 3 aspects: data synchronization system, production and logistics pull system, supply chain visualization system SRM.

(1) production and logistics pull system

At present, BOSCH makes the production and logistics system as the company's core of lean production. On the basis of the original system, building workshop production information system platform to promote the production on

production plan.

(2) supply chain visualization system SRM

BOSCH can be seen from the two part of the visual platform, Network is a part. The supplier can query MES system suppliers and manufacturers can also see the inventory. Another part is that manufacturers can browse SRM system suppliers. It can query the inventory of the goods, the delivery status, the receiving and verification information of the suppliers.

(3) data synchronization system

Data synchronization system can realize the automatic update of product data and sales data. It can achieve seamless connection of the information system between the company and the subsidiary. So it can not only improve the management level, but also reduce the cost and save the auditor's time.

## VI. CONCLUSIONS

The automotive supply chain of China is still at the lower end of the stage, which belongs to the decentralized supply chain. Due to the modern software technology has improved, the data analysis by analog integrated customer information can improve the profit and integrate a vehicle logistics supply chain. The integration of supply chain not only has the strategic advantage, but also makes the enterprise more focus on the development of the product, so that the production enterprises have more energy to deal with complex market environment and increase the responsiveness of enterprises to the market. The third party companies' involvement make the capital output and the cost of the output more open and transparent. Simplifying the logistics operations, reducing the cost of logistics operations and delivery can get ahead of schedule. Not only the level of service has been improved, efficiency can be greatly improved.

## ACKNOWLEDGEMENT

The authors thank the editor and reviewers for their insightful comments and suggestions. This work is financially supported by supported by National Social Science Foundation (13CJY014), Supported by Innovation Program of Shanghai Municipal Education Commission (13ZS129), Shanghai University Teacher Training Program (ZZGCD15014) and Ph.D. Programs Foundation of Shanghai University of Engineering Science (2015).

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