

Research on Supply Chain Evaluation of Guangzhou Airport Economic Zone based on AHP

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Abstract. Efficient supply chain management can promote the sharing of information resources among enterprises in airport economic zones and enhance the linking of various economic activities, hence strengthening the comprehensive competitiveness of airport economic zones. This paper aims to evaluating supply chain performance of Guangzhou Airport Economic Zone based on AHP. After analyzing the current development of regional supply chain and the trends of airport economic zones, and reviewing the research of supply chain performance evaluation at home and abroad, this paper attempts to establish a supply chain performance evaluation model and selects several indicators for decomposition, judgment, comparison and calculation. The paper is targeted to optimize and upgrade supply chain management in Guangzhou Airport Economic zone after identifying its shortcomings of supply chain management.

Keywords: AHP; Airport Economic Zone; Supply Chain; Performance Evaluation.

1. Introduction

Air transportation, with the advantage of swiftness, super-high efficiency, safety and punctuality, provide guarantee for the transportation and preservation of fine goods, valuable products and fresh food. With the improvement of people's living standards and the increasingly strict requirements on freight transportation, air transportation has become the preferred choice for many people. The strong air transportation demand has led to the booming of airport economic zones. At present, air cargo volume accounts for about 0.5% of the global trade volume, and the value of air borne goods accounts for about 36% of the global value. The world's major airport economic zones have witnessed a constant and rapid flow of information, passengers, goods and capital from all over the world. Guangzhou Airport Economic Zone, with its unique geographical location, traffic advantages and national policy support, has become one of the fastest growing airport economic zones in the world. In 2015, Guangzhou Municipal Government introduced the Baiyun Airport Development Plan, proposing to construct the Guangzhou Airport Economic Zone into a leading zone of international airport industry convergence, an important window for the development of the Belt and Road Initiative, and a national aviation economic demonstration zone.

The International Airport City Research Center of Fudan University conducted a quantitative evaluation of 27 cities whose passenger throughput reached more than 10 million in 2016. The evaluation is carried out by selecting 19 quantifiable indicators from the perspectives of hub airports, airport industry, hinterland economy, and comprehensive transportation system for comprehensive competitiveness ranking. According to statistics released, the comprehensive competitiveness of the Guangzhou Airport Economic Zone ranks third among the 27 airports in the country. This shows that the strength of the Guangzhou Airport Economic Zone cannot be underestimated. The development of the Guangzhou Airport Economic Zone has become an indispensable factor in the economic growth of Guangzhou.

China's top ten airport economic zones in 2016 are listed as follows:

Table 1. The Rankings of China's Airport Economic Zones (Airport City)

Rank	Airport Economic Zone	Hub Airports	Comprehensive Transportation	Hinterland Economies	Airport Industry	Total score
1	Shanghai Airport	30	10	27.53	23.88	91.41
2	Beijing Airport	22.18	7	25.38	20.5	75.36
3	Guangzhou Airport	16.9	7	16.3	24.5	64.7
4	Chongqing Airport	9.16	7	17.11	18.62	51.89
5	Chengdu Airport	11.78	7	10.52	20.38	49.68
6	Zhengzhou Airport	7.73	8	7.31	25.25	48.32
7	Tianjin Airport	6.47	8	14.26	17	45.73
8	Shenzhen Airport	12.77	8	13.5	11.03	45.73
9	Wuhan Airport	6.95	7	10.69	17.65	42.29
10	Hangzhou Airport	9.47	5	9.41	18.4	42.28

Source: Statistical Communique on the 2016 national economic and social development of China's airport economic zones.

The airport economy, based on large-scale airports and air transportation, refers to the formation and development of airport-oriented industrial clusters, which have an impact on the economies around the airport and lead to the accumulation of production factors such as capital, technology and manpower around the airport. [1] Efficient air transportation and highly centralized economic activities of the airport and its surrounding areas promote the integration of air transportation and regional economy, thus forming an airport economy [2]. As a new type of economy, the airport economy plays an important role in promoting regional economic development and has a major impact on China during economic transition, as China is the largest aviation market in Asia, and the development of aviation business has promoted fierce airport economic competition among cities.

Guangzhou Baiyun International Airport is a significant aviation hub. As far as location and transportation are concerned, Guangzhou Baiyun International Airport eyes 113 international and regional air routes and it is connected to five continents. It achieved a passenger throughput of 59.73 million person-times in 2017, ranking third in China. In terms of policy, Guangzhou Airport Economic Zone is an important part of the Belt and Road Initiative. It is a nationally positioned airport economic center, aviation economic demonstration zone, an important development engine and growth pole in South China, one of the logistics distribution centers in Asia, and a worldwide comprehensive aviation hub. In terms of logistics, more than 200 aviation logistics companies have already established logistics bases in the zone. Not only the FedEx Asia-Pacific Express Transshipment Center has been built and put into use, but also the modern logistics system based on airport economic zone has been established. Therefore, it is safe to conclude that Guangzhou Airport Economic Zone is showing momentum and has a promising future.

British supply chain management scholar Martin Christopher pointed out that the market competition in the 21st century is no longer competition between enterprises, but competition among supply chains. The very existence of the supply chain is to enable various commodities to reach the masses of consumers in a better and faster manner, and ultimately realize the value of commodities [3].

The regional supply chain refers to the supply chain in a certain geographical area, which is more specific and detailed than the broader sense of supply chain. The regional supply chain is a network chain structure, with many enterprises involved as nodes [4]. Each node enterprise in the regional supply chain should observe the principle of mutual trust and cooperation to be organically coordinated with each other and, at the same time, by optimizing the configuration of the node enterprises, realize the economic benefits of the enterprises, promoting the overall development of the regional supply chain. Airport economic zone supply chain, as a type of regional supply chain, shares the characteristics and functions of regional supply chain. The performance evaluation and management optimization of the airport economic zone can promote the effective connection of business and the sharing of information resources among node enterprises. Therefore, the performance evaluation of airport economic zone supply chain is of significance to the development of Guangzhou Airport Economic Zone.

Domestic and foreign research has found that airport economic zones make it possible for high-tech industries, processing and manufacturing industries, and retail industries cluster around the airport and promotes regional economic development. Charles de Gaulle Airport and Schiphol Airport are two typical examples. With the continuous improvement of China's internationalization level and comprehensive national strength, the development of Guangzhou Airport Economic Zone will substantially improve Guangdong's economy and help optimize and upgrade the industrial system. It is not that the development of the airport economic zone is the result of a combination of factors, but supply chain is one of the most vital factors.

Researchers at home and abroad have shown that the supply chain is not only a chain of information, logistics and capital, connecting suppliers, manufacturers, distributors, retailers and end users, but also a value-added chain of value. International scholars focus their attention on various areas of the supply chain, yet little attention is directed to the performance evaluation and evaluation methods of supply chain. This paper, based on the analytic hierarchy process, to evaluate the performance of the supply chain in Guangzhou Airport Economic Zone, is a new exploration.

2. Method of Supply Chain Performance Evaluation

2.1 Main Methods of Supply Chain Performance Evaluation

There are several methods for supply chain performance evaluation:

(1) Fuzzy analysis method: It is an evaluation method derived from fuzzy mathematics. Based on fuzzy mathematics, it calculates the factors that are difficult to quantify, and calculates the membership degree of the evaluation object, and then conducts a comprehensive evaluation.

(2) Grey correlation analysis method: It is usually a measure of the degree of association between two systems in terms of things or time by changing various degree of correlation. If the consistency of the trend is higher, the degree of correlation between the two is higher.

(3) Analytic Hierarchy Process: Compared with the two methods mentioned, AHP is more concise and practical. It is a multi-level, multi-standard, multi-objective supply chain performance evaluation method. Based on comprehensive analysis of quantitative and qualitative factors, it is an organized and hierarchical research method. It is generally necessary to assign weights to relevant values. Determining the weight is of significance for AHP. Different factors have different influences on the evaluation object, so there are also differences in the weight of the evaluation object. Using sorting method, historical data reference method and analytic hierarchy process, it is possible to properly determine the weight of different evaluation indicators. The determination of the weight of indicators can make the evaluation indicators fully play their roles.

Only scientific evaluation methods can achieve effective supply chain performance evaluation, and the effectiveness of supply chain performance evaluation has two criteria. One is whether it builds a comprehensive, complete and scientific supply chain performance indicator system; the other is whether it is an appropriate assessment method. In the supply chain management system, only by using scientific, efficient and comprehensive method to evaluate the various links and overall

performance of the Guangzhou Airport Economic Zone supply chain can we promote the healthy and sustainable development of the Guangzhou Airport Economic Zone.

2.2 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP), proposed by Thomas L. Saaty, a researcher from the University of Pittsburgh in the United States in 1977, is a quantitative decision-making analysis method for qualitative problems. This method will optimize a complex multi-objective decision. Here is how it works: the problem, as a system, is decomposed into the target layer (X), the criterion layer (Y), and the indicator layer (Z). The weights of the indicators or factors at each level are accordingly calculated for multi-objective decision optimization [5].

The advantages of AHP are as follows:

- (1) Systematicness;
- (2) Simplicity and practicability;
- (3) No need for a large amount of quantitative data.

The factors of the analytic hierarchy process are as follows:

Table 2. Scales of Relative Importance

Scale a_{ij}	definition
1	The factor i is equally as important as the factor j
3	The factor i is moderately more important than the factor j
5	The factor i is essentially important than the factor j
7	The factor i is very important to the factor j
9	The factor i is absolutely important than the factor j
2,4,6,8	Intermediate value between the two adjacent judgement
reciprocals	If the factor i is compared with the factor j, the obtained judgment value is $a_{ij}=1/a_{ji}$

Source: Ma Shihua, Lin Yong. Supply Chain Management [M].4th edition. Beijing Higher Education Press, 2015. 4

The first step is to compare the research factors and build a matrix. The two factors i and j in the above table respectively represent the two criteria for comparison, or two schemes for comparison within one evaluation criterion. The matrix constructed by the a_{ij} scale element is called a pairwise comparison matrix.

The following formula is needed during the operation:

$$CI=\lambda_{max}-n/(n-1); CR=CI/RI$$

Here n is the number of comparison factor, CI is a one-time indicator, and CR is the consistency rate. Consistency stipulates that when $CR \leq 0.1$, the consistency of the pairwise comparison matrix is acceptable. Otherwise, the matrix consistency of the comparison is considered too weak, and the pairwise comparison judgment of the matrix must be performed again.

RI is an indicator of degree of freedom. The more factors are compared, the larger the dimension of the pairwise comparison matrix is and the worse the consistency is. Therefore, the consistency requirement is relaxed, and the correction value RI is introduced.

The RI reference values used in the calculation process are shown in Table 3:

Table 3. RI Reference Value

Dimension(n)	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.96	1.12	1.24	1.32	1.41	1.45

Source: Ma Shihua, Lin Yong. Supply Chain Management [M].4th edition. Beijing Higher Education Press, 2015. 4.

2.3 Selection Principles of Supply Chain Performance Evaluation Indicators

(1) The principle of measurability and comparability. The measurability means that the measurement and calculation can be carried out when setting up the indicator system, so that the obtained result is more accurate. Secondly, the obtained evaluation conclusion can accurately reflect the actual situation of the measurement object.

(2) The principle of systematicness and comprehensiveness. The establishment of the evaluation system should ensure that each selected indicator reflect the management status of the supply chain from a certain angle. The indicators should complement each other and form a system. They are neither contradictory nor overlapped, and can be organically coordinated.

(3) The principle of operability. The data collected, which reflects the performance of a supply chain should be able to be calculated and verified.

(4) The principle of science and impartiality. The design of the evaluation system should be based on scientific theories, follow the scientific research direction, and be scientific and impartial in the selection, calculation and evaluation of indicators.

3. Constructing a Supply Chain Performance Evaluation System based on Analytic Hierarchy Process

3.1 Selection of Supply Chain Performance Evaluation Indicators for Guangzhou Airport Economic Zone

For a long time, many foreign experts and scholars have focused their studies on the selection of supply chain performance evaluation indicators from different perspectives, and have put forward their own opinions. For example, Lin Yong and Ma Shihua proposed to evaluate the performance of supply chain from four aspects: customer service, production and quality, asset management and cost [6]. Zhang Hualun, Feng Tianjun and Dong Hongguo established green supply chain performance evaluation indicators from three aspects of supply chain management level, supply chain green level and core enterprise performance level.

From the definition of supply chain and regional supply chain, supply chain performance evaluation indicators should involve four important parts: procurement, production, sales and delivery. Therefore, the present study employs the procurement performance, production performance, sales performance, and delivery performance as the main evaluation indicators of the Guangzhou Airport Economic Zone supply chain performance evaluation system, and select some evaluation contents as the secondary indicators.

3.2 Construction of Supply Chain Performance Evaluation System based on Analytic Hierarchy Process

The analytic hierarchy process (AHP) is a hierarchical structure theory. According to the theory, in order to come up with solutions to decision-making problems, the evaluation target is decomposed into multiple levels, such as the target layer (X), the criterion layer (Y), and the indicator layer (Z), and the weight of each level indicator or factor is calculated by qualitative and quantitative methods [7]. Factors are grouped into clusters, according to their interrelated influences and membership degrees, to form a multi-level analytical structure model, which is quantitatively described and finally sorted to synthesize the results to obtain the final priorities of the alternatives [8].

The general hierarchical structure model can be divided into three layers: the highest level is the goal to solve the problem; the middle level is the intermediate link to achieve the highest-level goal; and the lowest level indicator is the specific implementation plan to achieve the highest-level goal. Therefore, we will layer the graphs in Figure 1, and the tiered performance evaluation indicators for the Guangzhou Airport Economic Zone are as follows:

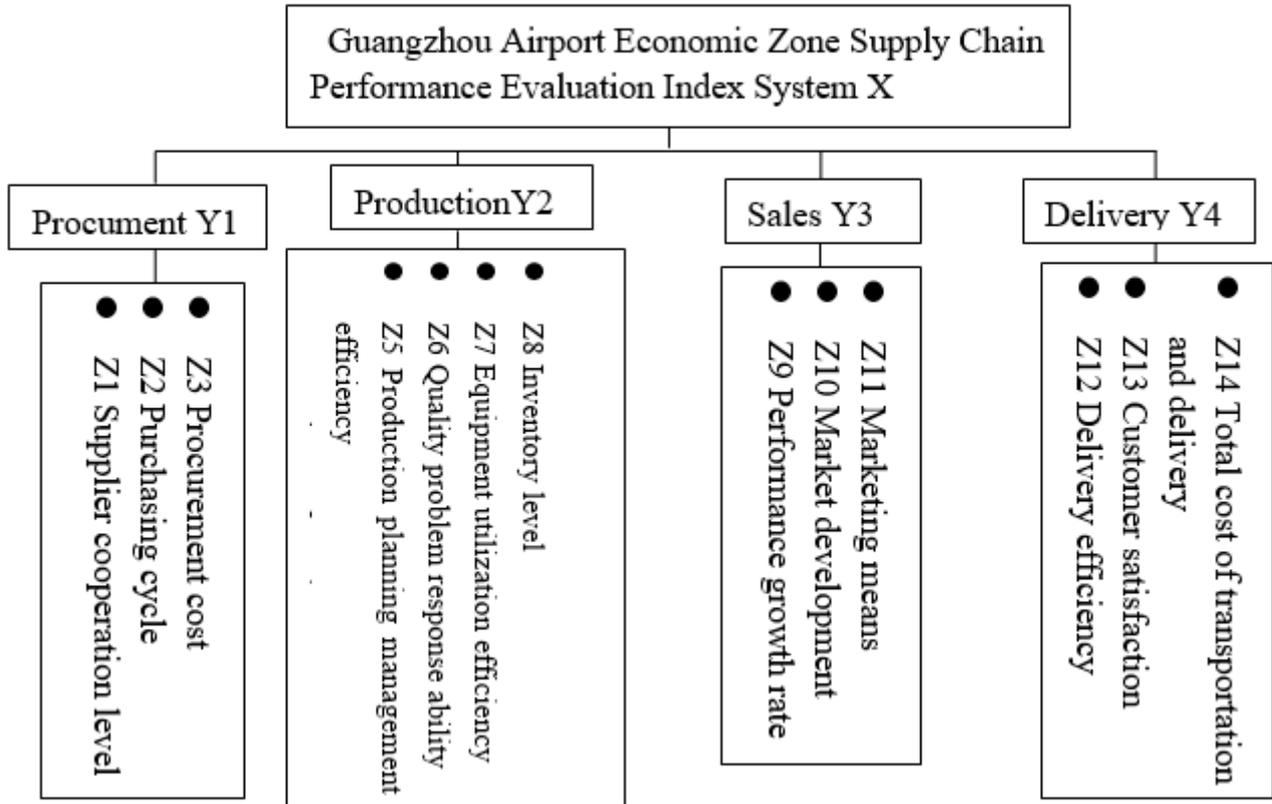


Figure 1. Hierarchy structure of the indicator system of the supply chain performance evaluation system of Guangzhou Airport Economic Zone

Based on analytic hierarchy process, the supply chain performance evaluation system of Guangzhou Airport Economic Zone consists of four basic elements: procurement Y1, production Y2, sales Y3 and delivery Y4, which constitutes the criterion layer. The scheme layer includes supplier cooperation level Z1, purchasing cycle Z2, procurement cost Z3, total manufacturing cost Z4, production planning management efficiency Z5, quality problem response ability Z6, equipment utilization efficiency Z7, inventory level Z8, performance growth rate Z9, market development Z10, marketing means Z11, delivery efficiency Z12, customer satisfaction Z13, and total cost of transportation and delivery Z14.

In order to be able to compare the various criteria, or the various schemes under a certain criterion, and to obtain relative weights, the scales of relative importance are introduced as follows:

The actual situation of the supply chain of Guangzhou Airport Economic Zone is captured in the following five-level judgment matrices X-Y_i, Y₁-Z_i, Y₂-Z_i, Y₃-Z_i, and Y₄-Z_i after the calculation of the corresponding numerical indicators and consistency test. The results are shown in Table 4 to Table 8.

Table 4. X-Y_i single-level sorting results

X	Y ₁	Y ₂	Y ₃	Y ₄	W
Y ₁	1	5	7	1	0.42
Y ₂	1/5	1	3	1/5	0.11
Y ₃	1/7	1/3	1	1/7	0.05
Y ₄	1	5	7	1	0.42
Consistency test: $\lambda_{max}=4.07, CI=0.04, RI=0.89, CR=0.03 < 0.1$, passed the consistency test					

Table 5. X-Yi single-level sorting results

Y ₁	Z ₁	Z ₂	Z ₃	W
Z ₁	1	3	6	0.33
Z ₂	1/3	1	2	0.33
Z ₃	1/6	1/2	1	0.33
Consistency test: $\lambda_{\max}=3, CI=0, RI=0.58, CR=0<0.1$, passed the consistency test				

Table 6. X-Yi single-level sorting results

Y ₂	Z ₄	Z ₅	Z ₆	Z ₇	Z ₈	W
Z ₄	1	2	6	9	2	0.43
Z ₅	1/2	1	3	6	1	0.23
Z ₆	1/6	1/3	1	3	1/3	0.08
Z ₇	1/9	1/6	1/3	1	1/6	0.04
Z ₈	1/2	1	3	6	6	0.23
Consistency test: $\lambda_{\max}=5.04, CI=0.01, RI=1.12, CR=0.01<0.1$, passed the consistency test						

Table 7. X-Yi single-level sorting results

Y ₃	Z ₉	Z ₁₀	Z ₁₁	W
Z ₉	1	1/2	3	0.3
Z ₁₀	2	1	6	0.6
Z ₁₁	1/3	1/6	1	0.1
Consistency test: $\lambda_{\max}=3, CI=0, RI=0.58, CR=0<0.1$, passed the consistency test				

Table 8. X-Yi single-level sorting results

Y ₄	Z ₁₂	Z ₁₃	Z ₁₄	W
Z ₁₂	1	1/5	1/5	0.09
Z ₁₃	5	1	2	0.56
Z ₁₄	5	1/2	1	0.35
Consistency test: $\lambda_{\max}=3.05, CI=0.03, RI=0.58, CR=0.05<0.1$, passed the consistency test				

From the above five tables, it can be concluded that all the data have passed the consistency test, that is, the consistency ratio of each single-level order is less than 0.1, so the degree of consistency of each judgment matrix is acceptable. Based on the ranking of the relative importance of the single-level sorting, the ordering of the overall structure level can be performed.

The overall rankings of factors affecting the supply chain performance evaluation of Guangzhou Airport Economic Zone, after calculation, are listed, sorted by weight from large to small, as follows:

Z13 customer satisfaction (0.23), Z14 total cost of transportation and delivery (0.15), Z1 supplier cooperation level (0.14), Z2 purchasing cycle (0.14), Z3 procurement cost (0.14), Z4 total manufacturing cost (0.05), Z10 market development (0.03), Z12 delivery efficiency (0.03), Z5 production planning management efficiency (0.02), Z8 inventory level (0.02), Z9 performance growth rate (0.02), Z6 quality problem response ability (0.01), Z11 marketing means (0.01), Z7 equipment utilization efficiency (0.00).

4. Conclusion

After the establishment of the supply chain performance evaluation system based on analytic hierarchy process and based on the sorting results of relative weights and the overall rankings of various factors, it can be concluded that the factors affecting the supply chain performance of the Guangzhou Airport Economic Zone most are procurement and delivery and there is little difference between the two factors(both are 0.42), followed by production (0.11) and sales (0.05). The overall rankings reveal that as far as the supply chain of the Guangzhou Airport Economic Zone is concerned,

the relative importance of the above fourteen influencing factors is ranked as Z13 customer satisfaction, Z14 total cost of transportation and delivery, and Z1 supplier cooperation level, Z2 purchasing cycle, Z3 procurement cost, Z4 total manufacturing cost, Z10 market development, Z12 delivery efficiency, Z5 production planning management efficiency, Z8 inventory level, Z9 performance growth rate, Z6 quality problem response ability, Z11 marketing means, Z7 equipment utilization efficiency. In other words, the customer satisfaction, the total cost of transportation and delivery, and the level of supplier cooperation are the factors that should be taken into consideration in the performance evaluation of Guangzhou Airport Economic Zone's supply chain. And factors like Utilization efficiency are secondary factors that least affect the performance level of the supply chain. The ranking results generally reflect the performance of supply chain. It is of significance to evaluate the supply chain performance of Guangzhou Airport Economic Zone as it can not only enable Guangzhou Airport Economic Zone to have a better understanding of its own characteristics and maintain its competitive advantages, but also realize its shortcomings and drawbacks, thereby bettering the supply chain and enhancing the comprehensive competitiveness of the Guangzhou Airport Economic Zone.

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