Research on the Path of Supply Chain Collaboration of Airport Economic Zones based on Structural Equation Modeling

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Abstract. With the further development of the Belt and Road Initiative, Airport Economic zones in China is expected to see an increase of government support soon and thus is of great potential for development. This paper attempts to establish a path of supply chain collaboration of airport economic zone based on Structural Equation Modeling. After the analysis of the synergistic factors of supply chain collaboration of airport economic zone, some path hypotheses are formulated. Structural Equation Modeling is then adopted for path analyses, using data from Guangzhou Airport Economic Zone.

Keywords: Structural Equation Model; Airport Economic Zone; Regional Supply Chain; Supply Chain Collaboration.

1. Introduction

Globalization has accelerated the expansion of the world market, making trade activities between countries more active than ever before and competition of the world market increasingly fierce. Different from the previous supply chain management systems, the competition between countries is now based on time and efficiency. The advancement of science and technology has greatly increased the cargo volume and the speed of jets and leads to the booming of air transportation industry. Global air passenger traffic and freight traffic have increased year by year. Many companies that rely heavily on-air transportation choose to develop, manufacture and process their products near the airport in order to save time and transportation cost. These highly concentrated economic activities of companies and airports promote the integration of air transport and regional economy and eventually developed into an airport economic zone.

The market competition in the 21st century is no longer competition between enterprises, but competition among supply chain. With increasingly fierce competition of world market and diversified and individualized demand of customers, an effective supply chain is the key to the domination of world market. David Anderson, a supply chain management expert, puts forward the theory of Supply Chain Collaboration. He holds the view that in order to improve the response speed and the ability against various risks, enterprises should collaborate with each other in the level of organization, information and business, and make an alliance to integrate their resources so as to realize supply chain collaboration.

Relevant domestic and foreign research shows that airport economy has become the growth pole of regional economic development. China’s airport economy is still in the early stage, so it has great potential for development. Moreover, the passenger and freight volume of China’s airports are increasing year by year. As China further promotes the Belt and Road Initiative, the demand for air transportation will become increasingly stronger. Airport Economic Zone, with its location and policy advantages, can realize supply chain collaboration and improve the overall response speed and risk resistance ability of supply chain. Therefore, it is necessary to make the most of airport resources and it is of great practical significance to conduct research on the airport economic zone.

Compared with developed countries, such as United States and the Netherlands, China’s airport economic zones start relatively late. China’s theoretical research is rather weak and is confined to airport economic zone’s industrial composition, development strategy and interaction with the regional economy. Little attention is directed to the research on the path of supply chain collaboration. Therefore, this paper will explore the path of supply chain collaboration of airport economic zone based on Structural Equation modeling.

2. Construction of Structural Equation Model

2.1 Introduction to Structural Equation Modeling

Structural Equation Modeling (SEM) is a statistical method that refers to the analysis of the relationship between variables through the variable covariance matrix. It can analyze multiple dependent variables simultaneously and explore factor structure and factor relationship. In conventional path analyses, there is no clear way to directly compare competing models of the same system. Therefore, in this paper, SEM is adopted for path analyses of the supply chain collaboration of airport economic zone.

2.2 Components of Structural Equation Modeling

Two main components of structural equation model are the measurement model and the structural model.

measurement equation:

$$\mathbf{X} = \Lambda_X \boldsymbol{\xi} + \boldsymbol{\delta}$$

$$\mathbf{Y} = \Lambda_Y \boldsymbol{\eta} + \boldsymbol{\varepsilon}$$

structural equation:

$$\eta = B\eta + \Gamma\xi + \zeta$$

Here, X is the exogenous observed index; Λ_X refers to the relationship between the index X and the latent variable $\boldsymbol{\xi}$; $\boldsymbol{\delta}$ is the measurement error of X; Y is the endogenous observed index; Λ_Y refers to the relationship between the index Y and the latent variable; $\boldsymbol{\varepsilon}$ is the measurement error of Y; B refers to the relationship between the endogenous latent variable; η is the exogenous latent variable; Γ indicates the influence of exogenous latent variables on endogenous latent variables; ζ refers to the unexplained relationship between the variables.

2.3 Modeling Steps for Structural Equations

The first step is to summarize the synergistic factors of supply chain collaboration in the airport economic zone and establish an index system based on the characteristics of Guangzhou airport economic zone. A structural equation model is then established to formulate path hypotheses.

The second step is to construct covariance matrix after analyzing the data obtained from the empirical research and identifying the latent and observed variables.

The last step is to run a model fitting test of the path hypotheses and the covariance matrix constructed. If the model fits the sample data, the model is established; if not, the hypothesis model needs to be modified, and tested again.

2.4 Research on Synergistic Factors

Synergistic factor refers to the common factor that affects supply chain collaboration. This paper assumes that enterprises in the supply chain of airport economic zone are composed of leading enterprises and affiliated enterprises, the relationship of whom is that of the principal and the agent. Leading enterprises, dominant in the supply chain of airport economic zone, are a great magnet for affiliated enterprises and are mainly in charge of supervising the operations of affiliated enterprises while affiliated enterprises, as ordinary enterprises in the supply chain, are mainly responsible for providing products or services to the market. Because the supply chain of airport economic zone features information asymmetry, the degree of informatization of leading enterprises and affiliated enterprises in the supply chain plays an important role in the realization of supply chain collaboration. Moreover, the degree of absolute risk aversion and effort cost coefficient of affiliated enterprises in the airport economic zone share the same impact on leading companies. Therefore, degree of informatization, degree of absolute risk aversion, effort cost coefficient, and minimum revenue level are selected as synergistic factors of this study, whose purpose is to explore the relationship between these synergistic factors by structural equations.

Latent variables are variables that cannot be directly observed but can be inferred from other observable variables. Therefore, it is necessary to select relevant observation indexes to observe the latent variables.

Based on the features of the airport economic zone, this paper selects the following observation indexes.

Table 1. Latent variables and observation indexes

Latent Variables	Observation Indexes
Effort cost coefficient	Management capacity
	Employee competence level
	Facility level
	Technology level
Degree of informatization	Information sharing level
	Accuracy level of information
	Information utilization level
	Information transfer efficiency
Degree of absolute risk aversion	Policy support
	Business size
	Incentive level
Minimum revenue level	Distribution rationality
	Business market position
	Opportunity cost

After the analysis of synergistic factors, the following path hypotheses of supply chain collaboration in the airport economic zone are formulated. A structural equation model is established with the aid of textual description and path diagram. Figure 1 is the theoretical structural equation model of supply chain collaboration of the airport economic zone.

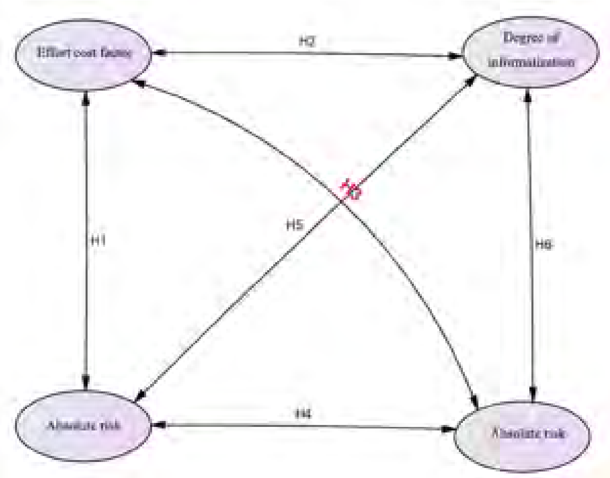

Figure 1. Theoretical Structural Equation Model of Supply Chain Collaboration of Airport Economy Zone

As is shown in the theoretical structural equation model above, the path hypotheses are:

H1: The degree of absolute risk aversion in the airport economic zone is negatively correlated with the effort cost coefficient;

H2: The effort cost coefficient in the airport economic zone is negatively correlated with the degree of informatization;

H3: The effort cost coefficient in the airport economic zone is positively correlated with the minimum revenue level;

H4: The degree of absolute risk aversion in the airport economic zone is positively correlated with the minimum revenue level;

H5: The degree of absolute risk aversion in the airport economic zone is negatively correlated with the degree of informatization;

H6: The minimum revenue level in the airport economic zone is negatively correlated with the degree of informatization.

3. Survey Design and Analysis

3.1 Questionnaire Design

The subjects of the survey are 250 representative companies in Guangzhou airport economic zone, covering dominant industries such as auto and auto parts manufacturing industry, jewelry industry, the convention and exhibition industry, microelectronics manufacturing industry and logistics industry. The questionnaires are sent to subjects via emails and Wenjuanxing, an online survey platform. The data is then collected and put in SPSS25.0 software for analysis.

The questionnaire is formulated as 5-item Likert type scale (1= strongly disagreed; 5=strongly agree) and is designed to evaluate the subjects' basic situations, the nature of the enterprises and measurement items of supply chain collaboration. Table 2 is the questionnaire items used in this study.

3.2 The Analysis of Survey Results

In this survey, 350 questionnaires were distributed, and a total of 232 questionnaires were collected with a response rate of 66%. After manually eliminating the invalid questionnaires, 204 valid questionnaires were finally obtained. The valid response rate of the questionnaire was 87.93%.

After analyzing the data of the samples, it is found that most of the samples are in the modern tour agriculture industry, airport logistics industry and biomedical manufacturing industry, which accounted for 21.71%, 18.57% and 14.29% of the samples. In terms of the nature of the enterprises, they are mostly private enterprises and foreign-funded enterprises.

A descriptive analysis is then conducted, with SPSS 25.0. software, to obtain the numerical summaries of the data, which includes the mean, standard deviation, skewness and kurtosis. The mean refers to the central tendency of the data; the standard deviation reflects the degree of dispersion of the data; skewness is a measure of the asymmetry and kurtosis is a measure of "peakedness" of a distribution.

Table 3 is the numerical summary of the data. As is shown in the table, the standard deviations are between 0.70-1.20, indicating that there is little difference between the respondents. The means are in the range of 2-4, among which the average turnover rate of inventory materials and the average purchasing cycle of materials are the lowest; the data sharing ratio, timeliness of information transfer and communication are the highest. The skewness and kurtosis show that the data are in a normal distribution. Therefore, this set of data is ready for structural equation analysis.

Table 2. Questionnaire items

Test items	Contents	Question items
Effort cost coefficient	Management capacity X1	Strong management capacity
	Employee competence X2	High level of employee competence
	Facility X3	Advanced facilities
	Technology X4	Advanced technology
The degree of Informatization	Information sharing level X5	Enterprises can share the data they need very well
	Accuracy level of Information X6	The information provided by the alliance enterprises is accurate
	Information transfer efficiency X7	Enterprises can make full use of the data provided by alliance enterprises.
	Information transfer efficiency X8	Enterprises can deliver necessary information in a timely manner
The degree of absolute risk aversion	Policy support X9	Strong policy support
	Business size X10	Clear development path
	Incentive level X11	Incentive plans are fully implemented
Minimum revenue level	Distribution rationality X12	Reasonable distribution of minimum revenue
	Business market position X13	Enterprises are in a favorable position in market competition
	Opportunity cost X14	High opportunity cost

Table 3. Descriptive Statistics for Variables

	N	Mean	Standard Deviation	Skewness	Kurtosis
X1	204	3.55	1.088	-0.35	-0.313
X2	204	3.47	0.997	-0.472	-0.115
X3	204	3.58	1.087	-0.532	0.222
X4	204	3.62	1.066	-0.72	0.216
X5	204	3.35	1.008	-0.317	-0.451
X6	204	3.43	1.011	-0.342	-0.249
X7	204	3.51	0.769	-0.549	0.024
X8	204	3.34	0.879	-0.599	-0.044
X9	204	2.56	1.052	0.53	-0.873
X10	204	2.74	1.065	0.367	-0.4
X11	204	2.99	1.071	0.498	-0.763
X12	204	2.64	1.166	0.512	-0.589
X13	204	2.78	1.057	0.381	-0.513
X14	204	2.82	1.178	0.375	-0.457
Effective N	204				

3.3 Reliability Analysis

Reliability refers to the overall consistency of a measure. Cronbach's coefficient alpha is adopted to analyze the reliability of the questionnaire. Cronbach's coefficient alpha is commonly used for analyzing the measurement results of attitudes and opinions. In general, the fact that the Cronbach's coefficient alpha obtained is greater than 0.62 means good reliability. The Cronbach's alpha of the measurement variables of the questionnaire used are all above 0.62, which indicate that the questionnaire has good reliability and we could proceed to further analysis.

3.4 Validity Analysis

Validity test can be divided into two parts: content validity and construct validity. Content validity involves the examination of the test content to determine if it covers a representative sample of ideas in question. Most of the question items in this paper are modified from the previous research on factors affecting supply chain collaboration, which have been proved to be valid. Therefore, as far as content validity is concerned, the questionnaire is valid.

To test the construct validity, KMO and Bartlett test are adopted after varimax orthogonal rotation and factor analysis. In general, the data is suitable for factor analysis when the KMO value is above 0.7, the p value of Bartlett's test is significant at the 0.05 level, and the correlation matrix of the sample has a common factor.

Information about the results of the KMO and Bartlett test is shown in Table 4. As it is seen on Table 4, the KMO value is 0.839; the Bartlett test value is 171.963; the p value is 0.002. These values show that the data is excellently suitable for factor analysis.

Table 4. KMO and Bartlett's test

Kaiser-Meyer-Olkin Measures of Sampling Adequacy		0.843
Approx. Chi-Square		171.963
Bartlett's Test of Sphericity	df	84
	Sig.	0.002

In order to test the relative importance of the measurement factors, the common factor variance test is conducted. Generally speaking, the larger the value of the common factor variance, the higher the dependence on the common factor. In general, the common factor variance of the measurement factors should be above 0.5. The common factor variances of measurement factors are between 0.6 and 0.8, which indicates that the variables have a significant synergistic effect on the supply chain of the airport economic zone.

4. Path test of Structural Equation Model

4.1 Confirmatory Analysis of Synergistic Factors

In order to test whether the relationships between the latent variables and its corresponding observed variables are consistent with the path hypotheses of the structural equation model established in this paper, a confirmatory analysis of the synergistic factors will be carried out. Generally speaking, in a structural equation model, factor loading should be minimum of 0.5 for better results. Table 5 shows the factor loadings of the measurement variables calculated by AMOS 20.0 software. It can be seen that the factor loadings of the model are all greater than 0.5,which indicates a high correlation between the latent variables and observed variables.

4.2 Model Fitting Analysis

After the confirmatory analysis of synergistic factors, we need to proceed to assess model fit. Model fit refers to the degree of fit between the empirical model and the ideal model, which can be categorized into absolute, relative and parsimony fit index. In this paper, CMIN/DF, GFI, RMSEA and FMIN are selected as the absolute fit index; AGFI, CFI, TLI and IFI are used as the relative fit index; PNFI, PGFI and PCFI are used as the parsimony fit index. The results obtained by AMOS20.0 software is shown in Table 6 below, which reveals that all indexes meet the standards.

Table 5. Confirmatory analysis of synergistic factors

Latent variables	Measurement variables	Factor loading
Effort cost coefficient	X1	0.866
	X2	0.787
	X3	0.943
	X4	0.984
Degree of Informatization	X5	0.871
	X6	0.853
	X7	0.829
	X8	0.948
Degree of absolute risk aversion	X9	0.895
	X10	0.79
	X11	0.72
Minimum revenue level	X12	0.876
	X13	0.887
	X14	0.785

Table 6. Model fitting analysis

	Absolute fit index				Relative fit index				Parsimony fit index		
Index	CMIN/DF	GFI	RMSEA	FMIN	AGFI	CFI	TLI	TLI	PNFI	PGFI	PCFI
Optimal standard	<3	>0.9	<0.05	<0.5	>0.9	>0.9	>0.9	>0.9	>0.5	>0.5	>0.5
Actual results	2.51	0.937	0.01	0.359	0.904	0.966	0.922	0.912	0.688	0.602	0.708

4.3 Hypotheses Tests

In order to better test the influence relationship between the latent variables and examine the similarities and differences between the empirical model and the theoretical model, the data obtained from the questionnaire is put into the structural equation. If the path coefficient turns out to be positive, it indicates a positive correlation; if the path coefficient is negative, it indicates a negative correlation. A t value greater than 1.96 and a p-value less than 0.05 is considered statistically significant. If the path coefficient is at a significant level, it means the larger the value of the path coefficient, the stronger the influence relationship between them. Table 7 shows the results of the path test obtained with AMOS 20.0 software. As is shown in the table, three hypotheses paths are supported and three have are rejected.

4.4 Result Analysis

According to the output of the above structural equations, the results of hypotheses tests are as follows:

H1: The effort cost coefficient in the airport economic zone is negatively correlated with the degree of absolute risk aversion.

Table 7. Path Hypotheses Test Result

Hypotheses	Standardized Path Coefficient Estimation	SE	T	P	Test Results
H1	0.577	0.277	-2.983	0.058	invalid
H2	0.230	0.223	2.503	***	valid
H3	0.416	0.179	2.685	**	valid
H4	0.418	0.169	0.078	0.369	invalid
H5	0.283	0.081	3.876	***	valid
H6	0.156	0.21	0.293	0.927	invalid

Note: ** stands for P<0.01, *** stands for P<0.001

Path hypothesis 1 assumes that the reduction of the investment in training of employees and managers or in the research and development of new technologies can lead to the increase of a enterprise's effort cost coefficient, hence achieving the goal of improving the degree of absolute risk aversion. The output shows that the T value is -2.083 (smaller than the critical value of 1.96), and the P value is 0.058 (greater than the significance level of 0.05). Therefore, path hypothesis1 is invalid, that is, the change in the effort cost coefficient does not have a significant impact on the degree of absolute risk aversion.

H2: The effort cost coefficient in the airport economic zone is negatively correlated with the degree of informatization.

Path hypothesis 2 assumes that the improvement of the degree of informatization helps to reduce enterprises' effort cost. The output shows that the T value is 2.503, which is greater than the critical value of 1.96, and the P value is smaller than 0.001. Therefore, path hypothesis 2 is valid.

H3: The effort cost coefficient in the airport economic zone is positively correlated with the minimum revenue level.

Path hypothesis 3 assumes that enterprises can reduce their effort cost coefficient by enhancing management capacity, employee competence, facilities and technology, thereby increasing the minimum revenue level of enterprises. The output shows that the T value of H3 is 2.685, which is also greater than the critical value of 1.96, and the P value is smaller than 0.01. Therefore, path hypothesis 3 is valid.

H4: The degree of absolute risk aversion in the airport economic zone is positively correlated with the minimum revenue level.

Path hypothesis 4 assumes that companies can lower the degree of absolute risk aversion by improving incentive level, expanding business, and increasing policy support, thereby improving the minimum revenue level. The output shows that the T value is 0.078, which is smaller than the critical value of 1.96, and the P value is 0.369, which is much larger than 0.05. Therefore, path hypothesis 4 is not valid. In other words, the degree of absolute risk aversion has no significant relationship with the minimum revenue level.

H5: The degree of absolute risk aversion in the airport economic zone is negatively correlated with the degree of informatization.

Path hypothesis 5 assumes that enterprises can improve the degree of absolute risk aversion by the increase of the degree of informatization and the response speed. The output shows that the T value is 3.876, which is greater than the critical value, and the P value is smaller than 0.001. Therefore, path hypothesis 5 is valid.

H6: The minimum revenue level in the airport economic zone is negatively correlated with the degree of informatization.

Path hypothesis 6 assumes that companies can reduce the maximum revenue level by increasing the level of informatization and making full use of the information provided by affiliated companies. The output shows that the T value is 0.293, which is less than the critical value of 1.96, and the P value is 0.927, which is much larger than 0.05. Therefore, path hypothesis 6 is not valid, namely, the degree of informatization of an enterprise does not have a significant impact on the minimum level of return.

5. Conclusion

Through the tests of the above structural equations, it is concluded that there are three main paths of supply chain collaboration in the airport economic zone.

Firstly, leading enterprises and affiliated enterprises in the airport economic zone should reduce the cost of information acquisition by improving the degree of informationization. By timely and accurately sharing the information they need, companies can reduce the information asymmetry and improve the competitiveness of the supply chain. Moreover, by improving the degree of informationization, enterprises can reduce the effort cost coefficient, which will help them maintain a competitive advantage in market competition.

The second path is to reduce the minimum revenue level by the reduction of the enterprises' effort cost coefficient. The effort cost, directly reflected in the management capacity, employee competence, facility level and technology, is closely related to a company's revenue. A low effort cost, which indicates a strong ability to offer products and a better chance to gain competition advantage in the market, can lead to the increase of revenue. Therefore, to realize supply chain collaboration in the airport economic zone, it is important for enterprises to make the most of their unique advantages to improve the capacity and competence of their staff and introduce new technology.

Third, enterprises in the airport economic zone can decrease the degree of absolute risk aversion by increasing the degree of informatization. In realizing supply chain collaboration in the airport economic zone, it is impossible for enterprises to rely solely on their own efforts to avoid absolute risks. Successful aversion of systemic risks results not only from relevant policy support, but also from the collaboration of alliance companies in the supply chain. To work together efficiently, companies must improve their own degree of informatization. Only by mutual trust, high information transfer efficiency and high information accuracy level can leading enterprises and affiliated enterprises resist systemic risks in a more effective manner. As for the aversion of unique risks, it is a must to see to it that enterprises' incentive measures are in place and that enterprises must have a clear development plan.

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