Early Warning Index System and Method of Production and Operation Monitoring in Airlines

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ABSTRACT

In order to ensure the sustainable and stable development of the airline, according to the characteristics of the production and operation of the airline, an early warning index system for the production and operation monitoring of the airline is established. On this basis, a comprehensive evaluation and early warning model for the production and operation of the airline is constructed by using the weighted average method, in order to fully and accurately understand the production and operation situation of the airline and diagnose various problems in the production process in time so as to make a scientific response decision.

Keywords: *airlines, production and operation, monitoring and early warning, index system*

I. INTRODUCTION

In recent years, the civil aviation industry adheres to the supply side structural reform, comprehensively implements the overall working idea of "one, two, three, four and five" civil aviation, and actively promotes the strategic process of "one acceleration, two realization". The civil aviation industry continues to develop rapidly, with the passenger throughput increasing year by year, and a number of large airports emerge. According to the data, in 2019, there will be 39 domestic 10 million level airports, occupying 10 seats in the top 50 of the world's busiest airports in 2019. Although the construction of China's aviation hub has made its debut in the international market, it still faces many problems and challenges, including operational risks. The operational risk of airlines can be divided into internal risk and external risk. The internal risk mainly includes: capacity risk, market development risk, management risk, decision risk, financial risk, financing risk, etc.; the external risk mainly includes: international political and economic change risk, international oil price change risk, aviation industry policy risk, etc. Therefore, in order to ensure the sustainable and stable development of airlines, it is necessary to strengthen the monitoring and early warning of the production and operation system of airlines, comprehensively and accurately understand the production and operation situation of airlines, diagnose and discover all kinds of problems and influence degree in the production and operation process in real time, so as to make scientific production and operation decisions Monitoring and early warning index system and early warning methods are studied.

II. CONSTRUCTION OF EARLY WARNING INDEX SYSTEM FOR PRODUCTION AND OPERATION MONITORING OF AIRLINES

The airline is a service enterprise mainly engaged in air transportation. In the establishment of the index system, this paper follows the principles of scientificity, representativeness, guidance, operability and comparability, establishes the overall monitoring and early warning system of the production and operation of the airline, and the monitoring and early warning subsystem of each process, and finally establishes the external environment index system, transportation capacity index system and transportation volume The overall production and operation early warning index system of airlines with the transportation rate index system and flight resource index system as the core (see "Table I").

TABLE I. PRODUCTION AND OPERATION MONITORING AND EARLY WARNING INDEX SYSTEM OF AIRLINES

First level indicator	Second level indicator	Third level indicator	Unit
Production and operation monitoring and early warning index	External environment	GDP growth	%
		Economic prosperity index	%
	Capacity capacity	Day number of registered aircraft	Aircraft
		Flight hours	Hours
		Take off and landing sorties	Sortie
		Available seat kilometers	Person kilometers
		Available mail turnover	Ton kilometer
		Ton kilometers available	Ton kilometer
	Traffic volume and rate	Passenger transport volume	Person kilometers
		Passenger turnover	Ton kilometer
		Freight and mail turnover	Ton kilometer
		Total transportation turnover	Ton kilometer
		Aircraft utilization	Hours
		Passenger load factor	%
		Overall load factor	%
		Freight rate	%
		Aircraft utilization	%
	Flight resources	Model matching rate	
		Captain availability	%
		Pilot to pilot ratio	

[a.] Note: In the external environment data, the GDP growth rate can be obtained from the official website of the National Bureau of statistics, and converted into comparable GDP through the deflator index, and the economic prosperity index can be obtained from the prospective database; the index data of capacity, capacity, and flight resources can be obtained from the production database of airlines, where the model matching rate = (number of Boeing pilots * number of Airbus) / (number of Airbus * number of Boeing pilots).

III. EARLY WARNING METHODS OF PRODUCTION AND OPERATION MONITORING FOR AIRLINES

After the establishment of the production and operation monitoring and early warning index system of airlines, it is necessary to monitor and early warn the production and operation system. The steps mainly include:

- determining the standard value of the early warning index;
- determining the index attribute and weight value of each early warning index;
- converting the attribute value of each early warning index into the evaluation score value;
- integrating the production and operation system according to the early warning model Joint evaluation and early warning.

A. Determination of standard value of early warning index

In order to evaluate and forewarn the production and operation of aviation enterprises, according to the purpose and requirements of each index evaluation, the first step is to reasonably determine the standard value and critical value of each index evaluation index. Only when a reasonable standard value is determined, can the actual value be compared with the standard value, and the differences between them be examined, so as to evaluate and forewarn the production and operation status of enterprises. The methods to determine the standard value of each evaluation index for the production and operation of airlines are as follows:

- adopt the standards formulated by the relevant national departments;
- adopt the average value of the actual value of the last three years;
- directly adopt the value of the previous year;
- the annual or quarterly plan value formulated by the company;
- according to the law of economic development, combined with the development of world economy, domestic economy and aviation economy, the standard value and critical value are determined.

B. Determination of attribute and weight value of each early warning index

In order to evaluate and warn each index comprehensively, it is necessary to determine the attribute and weight value of each index. The determination of indicator attributes is mainly based on the relevant regulations of airlines. The indicator attributes are divided into three categories: positive indicators, negative indicators and moderate indicators. The positive indicator has a positive value, which is a positive indicator of the greater the better; the reverse index has a negative value, which is a negative index of the smaller the better; the moderate index requires that

its index value should be moderate, that is to say, the index should be good within a certain range.

In the above index system, the importance of each index is very different. Sometimes, when one index exceeds the boundary, the situation of production and operation will be seriously worsened. Sometimes, when several indexes exceed the boundary at the same time, the situation of production and operation will be worsened. Therefore, different weight values should be given to make objective and scientific evaluation and early warning of the production and operation of enterprises. Three methods can be used to determine the weight value of each index: subjective method, objective method and subjective and objective method. The subjective evaluation method is a method that experts judge the relative importance of each evaluation index relative to the evaluation purpose based on experience, and then get the index weight through comprehensive processing, such as Delphi method, Gulin method, pair by pair comparison method, etc. Objective evaluation method is to determine the weight of each index directly according to the discrete degree of the attribute numerical sequence of each evaluation index, such as: the method of maximizing the deviation, the method of mean square deviation, etc. In this paper, the subjective evaluation method is used to determine the weight of each index. Through the actual investigation, understanding and soliciting the opinions of relevant managers, the weight value of each index is determined by their production management experience and the importance and role of each index for their management work.

C. Attribute value of each early warning indicator is converted into evaluation score

Because the measurement units of each indicator are mostly different, after the weight value and attribute of each indicator system are determined, comprehensive evaluation and early warning should be carried out, and attribute value of each indicator system should be dimensionless, converted into evaluation score value, then the comprehensive score value of each indicator system should be calculated according to the evaluation model of the indicator system, and then the production and operation status should be determined according to the score value Conduct evaluation and early warning.

For the conversion of index evaluation score, combining with the actual situation of airline production data, the following calculation formula is used for conversion:

Positive indicator:

$$P_{ij}^{P} = 1 + C\left\{\frac{Y_{ij}}{B_j} - \frac{B_{ij}}{Y_{ij}}\right\}^2, C = \begin{cases} 1, Y_{ij} \geq B_j \\ -1, Y_{ij} \leq B_j \end{cases}$$

Negative indicator:

$$P_{ij}^{N} = 1\text{-}C\left\{\frac{Y_{ij}}{B_j} - \frac{B_{ij}}{Y_{ij}}\right\}^2, C = \begin{cases} 1, Y_{ij} \geq B_j \\ -1, Y_{ij} \leq B_j \end{cases}$$

Moderate indicator:

$$P_{ij}^{M} = 1\text{-}C\begin{cases} P_{ij}^{\mathrm{P}}, Y_{ij} < B_j \\ P_{ij}^{\mathrm{N}}, Y_{ij} \geq B_j \end{cases}$$

P_{ij}^{P} 、 $P_{ij}^{N}$and P_{ij}^{M} are the evaluation scores of positive indicator, negative indicator and moderate indicator respectively, of which B_{j} is the standard value. Y_{ij} is the actual value of the j-th evaluation index of the i-th early warning system. Therefore, according to the above formula derivation, in the actual work, the above formula can be directly used for score conversion.

D. Monitoring, evaluation and early warning process

1) Evaluation, monitoring and early warning process of single index: The single evaluation index is an index reflecting the specific situation of the production and operation of airlines. The evaluation value of the index only reflects the quality of the work of this specific index, and only plays the role of evaluation and early warning for the aspects involved in the index. In the process of specific early warning, evaluation and early warning should be carried out according to the different attributes of indicators.

For the indicator with positive attribute, when the actual occurrence value of an indicator is lower than the normal range determined according to the determined standard value, an early warning signal shall be sent out. At this time, the production and operation status in this aspect shall be analyzed and investigated in order to find out the causes of abnormal conditions and the solutions;

For the indicator with reverse attribute, when the actual value of an index is higher than the normal range determined according to the determined standard value, an early warning signal shall be sent for this aspect of work, so as to discover problems in time and adjust its production and operation work in time;

For an indicator with moderate attribute, when the actual occurrence value of an indicator is lower than the normal range determined according to the determined standard value or higher than the normal range determined according to the determined standard value, it is considered that the production and operation status of this indicator is abnormal, and an early warning signal shall be sent for this aspect of work.

2) Comprehensive evaluation and early warning of index system by weighted average method: Each early

warning index system reflects the comprehensive situation of an airline's production and operation, According to the difference of early warning index system, the comprehensive evaluation and early warning of early warning index system can be divided into four categories: the evaluation and early warning of external environment index system, the evaluation and early warning of capacity index system, the evaluation and early warning of traffic rate index system, and the evaluation and early warning of flight resource index system. Therefore, an evaluation early warning model is established, which uses the index scoring method based on the weighted average, that is, the evaluation scores of multiple indexes are integrated into one (or several) comprehensive evaluation scores by the weighted average method. The basic model of this method is as follows:

$$ZP_i = \sum_{j=1}^{n} W_j \times P_{ij}$$

$$\sum_{j=1}^{n} W_j = 100$$

$$W_j \geq 0$$

$$i = 1, 2, 3, ..., m$$

Among them, ZP_i is the comprehensive evaluation score of the i-th evaluated index system; P_{ij} is the evaluation score of the j-th index of the i-th evaluated index system; W_j is the weight value of the j-th evaluated index of the evaluated system; m is the number of evaluated indexes; n is the number of evaluated indexes.

After the evaluation value of each index is determined, the weight value and the evaluation value of each index are substituted into the evaluation model of the index system, the comprehensive evaluation score of each index system is calculated, and then the comprehensive evaluation and early warning of the production and operation situation are carried out according to the comprehensive evaluation score of each index system. The judgment criteria for the comprehensive evaluation results of the index system are listed as follows ("Table II"):

TABLE II. EARLY WARNING CRITERIA FOR PRODUCTION AND OPERATION MONITORING OF AIRLINES

Comprehensive evaluation score	Operation status	Status indicator	Alert or not
ZPi>105	Good	Purple	No
105>*ZPi*>101	Preferably	Blue	No
101>*ZPi*>99	Normal	Green	No
99>*ZPi*>95	Poor	Yellow	Yes
ZPi<95	Abnormal	Red	Yes

IV. CONCLUSION

In this paper, the monitoring and early warning index system and methods of airline production and operation system are discussed preliminarily. The index system may not be complete. How to establish a complete and comprehensive index system reflecting the crisis situation of airline needs further study. The data used in this paper is only used to show that the early warning method may not be completely consistent with the reality. Through the research of early-warning index system and early-warning method, its main purpose is:

- to correctly evaluate and diagnose the current operation status of airline production and operation activities;
- to make a scientific and quantitative evaluation of the economic boundary value of its production and operation in various states (overheated, stable, stable, descending and supercooled);
- to accurately predict the possible development trend of its future business situation, compare the trend value with the boundary value of various states and its early warning signal interval, send out purple, blue, green, yellow, red and other signals in time after calculation and analysis, indicate various problems that are about to occur, and study its early warning countermeasures according to the actual situation, so as to provide basis for leaders to make decisions.

It has important practical significance and application value to ensure the sustained, stable and healthy development of airline production and operation.

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