Improving Overseas Aftermarket Aircraft Spare Parts Supply Logistics Using Simulation Modeling

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Abstract:

Computer simulation technology not only enhances the understanding of complex systems but also provides crucial support for decision-making and design, offering an effective method for studying the supply of aftermarket aircraft spare parts (ASPs). The demand for ASPs is different from that for aftermarket general-equipment spare parts in terms of supplier quantity, supply process, and supply conditions. These differences in demand characteristics lead to changes in supply logistics. This study investigates the factors affecting the aftermarket ASP supply and proposes an overseas supply logistics model for aftermarket ASPs. A simulation model was used to reproduce the aftermarket ASP supply and compare different scenarios. The ordinary mode and full-lift-cycle coverage mode are modeled to compare their efficiency. The full-lift-cycle coverage mode was also tested to evaluate the feasibility of its supply process. The results confirm that the full-lift-cycle coverage mode improves supply logistics performance, offering benefits for the overseas supply of aftermarket ASPs for Chinese-made civil aircraft.

Keywords: aftermarket aircraft spare parts, supply logistics modeling, performance improvement, chinese-made civil aircraft, computer simulation.

INTRODUCTION

Solving supply logistics problems in specific industries and markets requires using mathematical statistics, modeling, and computer simulation. The supply logistics process can be simulated using combined methods. By adjusting the variables and parameters, the whole supply logistics system can be changed and improved.

In spare parts supply logistics, aftermarket aircraft spare part (ASP) supply logistics is unique. Aftermarket ASP suppliers are not centralized, the value of aftermarket ASPs is different, and the supply cycle is sometimes limited to the loss of aircraft on ground (AOG). Especially for repairable aftermarket ASPs, suppliers' maintenance quality and time should be considered. Simulating and improving the supply logistics of ASPs for overseas aftermarkets is a complex process.

Compared with aircraft manufactured by Boeing and Airbus, Chinese-made civil aircraft (CCA) have a short history. The decision models are not fully developed, the supply system is incomplete, and the operation data are not comprehensive. However, CCAs have been sold overseas, including the "Xinzhou" series, ARJ21, and C919. Also, the wide-body aircraft C929 has entered the development stage. According to the 2022 Shanghai Science and Technology Progress Report, by the end of 2022, 690 orders for the ARJ21 had been received from 25 customers, and 1,035 orders for the C919 had been received from 32 customers. On December 18, 2022, an ARJ21 was delivered to its first overseas customer, Indonesian Air Asia, marking the first time CCA was purchased in the overseas market. After selling CCA abroad, operational support services become key to market competitiveness.

Aftermarket service is the source of competitiveness in overseas sales. After the aircraft is delivered to the airline, the airline operates and maintains it. Aircraft operation mainly includes maintenance [1], flight operation, cabin service [2], and safety management [3]. In the entire life cycle of an aircraft, the cost of aftermarket ASP maintenance accounts for 10%–20% of the airline's direct operating costs [4]. Line-replaceable units (LRUs), especially high-priced repairable ones (HR-LRUs), are the key object of airline cost management. Therefore, research on aftermarket ASPs for CCA should be based on aftermarket maintenance costs. To our knowledge, no study has systematically investigated the issues related to overseas aftermarket ASPs for CCA.

The aftermarket ASP supply for CCA is a part of supply logistics and the supply chain. It aims to promptly complete the procurement of aftermarket ASPs at an appropriate price, optimize inventory management, and reduce the occupation of working capital, thus reducing total enterprise costs and generating profits. Mainstream supply modes such as just-in-time, vendor-owned-inventory, vendor-managed-inventory, and joint-managed-inventory modes are used to avoid or reduce the "bullwhip effect" of the supply chain. These modes are all based on product procurement and are not fully applicable to the supply management of aftermarket ASPs for CCA.

Research on aftermarket spare parts supply logistics has focused on the following six areas: (1) aftermarket spare parts supply chain management[5], including order processing, transportation, and distribution; (2) aftermarket spare parts demand forecasting[6], exploring how to accurately predict demand for spare parts to promptly replenish and allocate inventory, thus avoiding inventory surplus or shortage problems; (3) supplier management and cooperation[7], studying how to select and manage suitable spare parts suppliers, establish stable cooperative relationships, and ensure the quality and timely delivery of spare parts; (4) spare parts inventory management[8], analysing how to manage spare parts inventory, including determining appropriate inventory levels, optimizing warehouse layout, and implementing regular inventory and maintenance measures to ensure part availability and reduce costs; (5) aftermarket logistics network design[9], focusing on how to design an efficient aftermarket logistics network, including selecting suitable warehouse and logistics centre locations and optimizing transportation routes and modes to meet the demand for fast delivery; and (6) technical support and maintenance services[10], exploring how to provide high-quality technical support and maintenance services, including using remote fault diagnosis, training support, and maintenance manual management to improve equipment utilization.

ASP management research has mainly focused on spare parts maintenance strategies [11], demand variability [12], and inventory control [13] ASP demand is a type of intermittent demand [14], and research should select methods based on the specific operational scenario [15]. Studies have shown that ASP maintenance quality has a significant effect on its demand [12]. For an aircraft maintenance service provider, improving maintenance quality control can enhance the reliability of ASPs [16]. Existing studies highlight the need for further research on ASP supply. At the same time, there are relatively few studies conducted from the perspective of suppliers regarding ASPs.

Furthermore, with the increasing “servitization” of the global manufacturing industry, aircraft manufacturers have begun to transform into aftermarket service providers [17,18], as in the cases of Airbus, Boeing, and Pratt & Whitney. A customer service system was built for the Commercial Aircraft Corporation of China (COMAC) based on system dynamics and analyses of the factors affecting customer service system operations using simulations, which included the airline’s aftermarket ASP ownership and use [19]. Although such work provides support for the aftermarket development of CCA overseas, it is still unable to support the scientific development it.

Thus, to coordinate the manufacturing and maintenance of CCA, it is necessary to design an overseas supply mode for aftermarket ASPs. The next section of this paper presents the problem, while section 3 describes the methods. Section 4 presents the simulation results, and section 5 concludes.

PROBLEM PRESENTATION

Aftermarket ASP Demand Concerns

After the 1990s, with the emphasis on the construction of assessment index systems for aviation manufacturing enterprises, research started to focus on ways to better evaluate the quality and reliability of aftermarket ASPs. This topic tends to receive more attention when major emergencies occur, aiming to find more effective evaluation index systems. Current methods for designing evaluation index systems for aviation manufacturing suppliers are mainly based on statistics in the literature and a small amount of field investigation. Based on the abundance of recent literature, the representative evaluation indicators for aircraft manufacturing suppliers were summarized and the construction of indicator systems was briefly analysed [20-22].

The quality–cost–delivery–service (QCDS) mode is an interrelated “four-dimensional” mode adopted by Toyota in its just-in-time manufacturing. This mode is popular and applies to both organizations and manufacturing activities. QCDS can be used to explore the demand features of airlines in the aftermarket for aircraft, especially aftermarket ASPs (Figure 1).

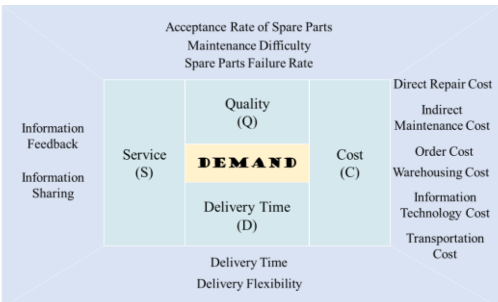

Figure 1. Quality–cost–delivery–service mode for airlines’ aftermarket ASP demand

Based on the characteristics of aviation manufacturing, the advantages of existing supplier evaluation indicators, and the demand for overseas aftermarket ASPs, the demand for aftermarket ASPs was deduced and a QCDS-based index system was established. Then, based on the actual aftermarket ASP operation and maintenance, the first-level indicators are divided into 10 second-level indicators (Table 1).

Table 1. Indicators related to the demand for aftermarket ASPs for operation and maintenance

Indicator level		Description
First	Second	
Quality	Aftermarket ASP compliance (AC)	Whether it receives design, production, maintenance, airworthiness, and installation approval from the related authorities, the manufacturing country, and so on
	Failure impact (FI)	Aftermarket ASPs returned to the factory for repair; whether the number of failures is high and the degree of impact is high
Delivery	On-time delivery (DT)	Whether it can be delivered on time and whether the on-time delivery rate is high
	Delivery flexibility (DF)	When the delivery time and quantity are changed, whether it can be adjusted in time
Price	Price economy (PE)	Are aftermarket ASPs sold at an economical price?
	Transportation economics (TE)	Whether aftermarket ASP transportation prices, labor costs, road transportation management fees, customs taxes, etc., are low
	Payment flexibility (PF)	Are the payment methods and terms flexible?
Service	Aftermarket guarantee (AG)	Includes aftermarket problem-solving, training, communication, etc.
	AOG guarantee (AOG)	Whether high-quality AOG aftermarket ASPs support services are provided

Key Factors

Interpretative structural modelling (ISM) is a kind of structural modeling technology. The main function of ISM is to analyze the factors of certain complex systems with many factors, but it cannot express the main degree between factors. The decision-making trial and evaluation laboratory (DEMATEL) is a method for analyzing and solving difficult, complex, multilevel problems. DEMATEL mainly evaluates the strength of the relationships between factors in the system and screens out the main complex factors. DEMATEL-ISM can not only identify a clear hierarchical structure in the system affected by many complex factors but also deduce several key factors in the structure. Thus, DEMATEL-ISM is used to find the top three key factors (Table 2).

To determine the relationships among various factors, an expert scoring table for the factors was designed and five researchers and experts in the field of aftermarket ASPs was invited, as well as some staff related to aftermarket ASPs, to participate in scoring. These experts and staff came from airlines, aircraft manufacturers (COMAC), aftermarket ASPs suppliers, and so on. The five-level (0, 1, 2, 3, 4) scoring rule was used, where influence gradually increases from small to large.

First, DEMATEL was used to calculate the direct influence matrix, the comprehensive influence matrix T, and the weight of the factors. Then, the influence-influenced degree diagram and central-cause degree diagram was obtained, as shown in Figures 2 and 3, respectively.

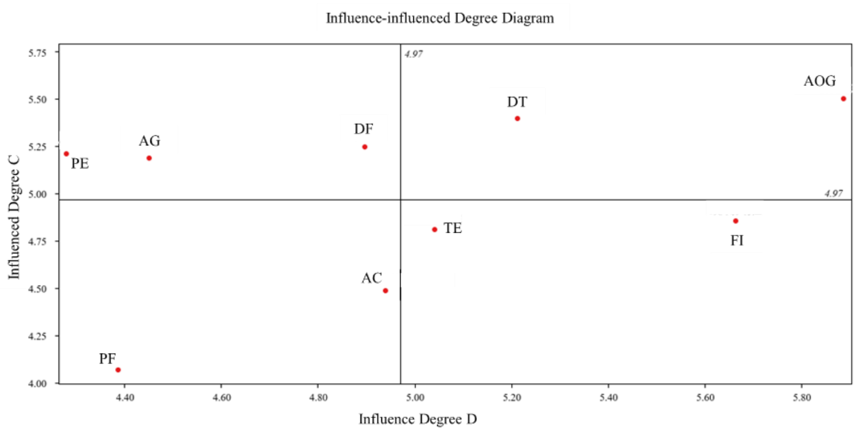

Figure 2. Influence-influenced degree diagram

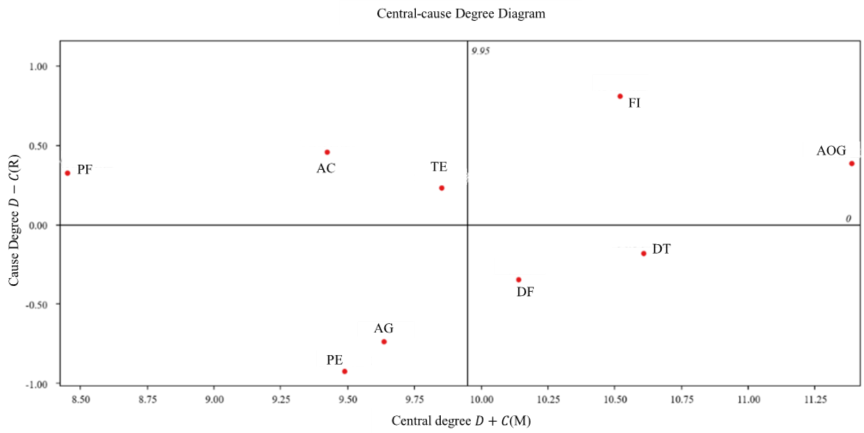

Figure 3. Central-cause degree diagram

Second, set a threshold value λ for comprehensive influence matrix T to eliminate redundant information in the system. If $t_{ij} > \lambda$, then $A_{ij} = 1$, while if $t_{ij} < \lambda$, then $A_{ij} = 0$. The related statistical data of the comprehensive influence matrix T to set λ was used. So, if the mean of T is x, and the standard deviation of T is σ, then $\lambda = x + \sigma$. The $\lambda = 0.635$ was calculated by using MATLAB. Thus, the reachability matrix was finally obtained, with the hierarchical decomposition table as shown in Table 2.

Table 2. Hierarchical decomposition table

Hierarchy	Factors
Upper	AC, DF, PE, PF, AG
Bottom	FI, DT, TE, AOG

Finally, using DEMATEL-ISM, AOG, DT, and FI are identified as the deep causes and also the cause factors, and centrality ranks high, ranking in the top three. Although delivery punctuality is the underlying cause, it ranks fifth in the centrality ranking and is not as important as AOG guarantee, delivery punctuality, and failure impact. Thus, the three factors of AOG guarantee, delivery punctuality, and failure impact are selected for the main research.

Features based on the AOG factor

Owing to a lack of aftermarket ASPs, AOG can always be said to be the weakness in the aftermarket ASP management of various airlines; it is also the “short-board effect” in the management level. It is generally believed that the lack of aircraft AOG parts will increase the cost of delivery of revised goods or leasing. In fact, the main costs are the cost of aircraft parking, logistics costs of parts, and AOG equipment handling fees. The sharing of aftermarket ASPs can effectively solve the AOG problem.

In aftermarket ASP sharing service (pooling), the airline only needs to pay a certain service fee according to the flight hours and use the aircraft manufacturer to share equipment and aftermarket ASP maintenance. Aftermarket ASP pooling provides airlines with excellent solutions in terms of aftermarket ASPs, minimizes their initial investment in high-cost repairable accessories inventory and resources, and makes full use of professional technology and its vast supply of aftermarket ASP maintenance services. The network of dealers greatly saves on maintenance and inventory transportation costs, reduces the required storage space, conserves the resources required for maintenance management, and guarantees the level of operation. In the operation process of pooling, the exchange inventory is the core hub for ensuring the timely supply of accessories. Aftermarket ASPs in the on-site warehouse are owned by the customer or CCA manufacturer and stored in the user’s warehouse. These aftermarket ASPs are all accessories selected in advance, mainly to avoid the occurrence of AOG. These accessories mainly contain “NOGO” accessories to meet the needs of emergency situations. At the same time, the accessories stored in it will be customized according to the customer’s operating conditions, and on-site inventory management will be performed on the goods received, inspected, processed, and prepared for shipment according to the airline’s requirements.

The sharing of aftermarket ASPs reduces airlines’ large investment in the early stage related to aftermarket ASPs, maintains a stable cash flow, and does not affect the availability of high-value aftermarket ASPs. After the fleet size grows, airlines can also choose to establish their own aftermarket ASPs library. In actual operations, however, airlines can still choose a mixed aftermarket ASP support mode, meeting part of the demand for aftermarket ASPs through pooling and meeting the other part of demand through self-built inventory.

Features based on the DT factor

Considering the management of special customs control areas, the actual needs of enterprises regarding customs control area policies, and the total amount of general tariffs on high-priced LRU pieces, the establishment of free-trade zones (FTZs) is recommended. This can take advantage of the status of FTZs as commodity distribution centers, cancel the quota control on aftermarket ASPs, and further expand regional export trade and re-export trade. In an FTZ, manufacturers can send unsold high-priced LRU pieces to the FTZ, put them in overseas warehouses, and then sell them. If they are not sold, they cannot leave the trade zone, but there is no need for customs declaration. In terms of logistics and customs clearance, this will save a lot of time.

Features based on the FI factor

Build a maintenance and replacement base, a composite deep repair center (CRC) with full capabilities, and an advanced aircraft accessory business center (CBC). The maintenance and replacement base mainly provides high-quality, on-time maintenance services for high-priced LRU parts, such as the inspection, renovation, replacement, and repair of parts and accessories.

Supply Mode Design

Based on the 80-20 rule, three key factors can be found, and then no more than eight modes are designed using a 3D framework, as shown in Figure 4.

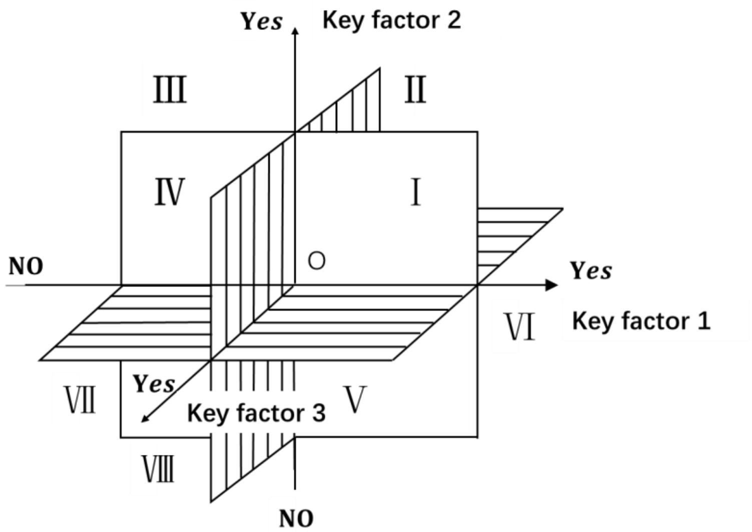

Figure 4. Schematic diagram of supply mode library

Each mode contains at least one KF, as shown in Table 3. In the table, √ indicates the matching of the mode and the KFs, while × means not applicable.

Table 3. CCA aftermarket ASP supply mode

Matching	Modes							
Key factors	Ordinary	AP	TW	RM	QR	MA	TM	FC
AOG	×	√	×	×	√	√	×	√
DT	×	×	√	×	√	×	√	√
FI	×	×	×	√	×	√	√	√

The aftermarket ASP pooling (AP) mode only meets the AOG factor. Applying data sharing and AI technology, manufacturers provide aftermarket ASP pooling to airlines. Aftermarket ASP pooling means using the professional technology and aftermarket ASP suppliers' network of COMAC to minimize airlines' high initial investment in HR-LRU. This can significantly reduce the costs of maintenance and inventory, the requirements of warehouse space, and the need for maintenance management resources, but it still can guarantee operational levels.

The trade warehousing (TW) mode only meets the DT factor. Setting an FTZ can meet aftermarket ASPs' storage needs for overseas customer airlines and reduce the long overseas delivery procedures and frequency. It can improve the timeliness and economy of maintenance for CCA. Furthermore, by taking advantage of the location, the delivery and installation of aftermarket ASPs to the overseas market can be performed in time.

The replacement maintenance (RM) mode only meets the FI factor. The RM mode refers to building a replacement and maintenance base right in the market of these customer airlines. The RM mode can provide high-quality, on-time maintenance services for HR-LRU parts, such as inspection, renovation, replacement, and deep repair.

The quick response (QR) mode meets both the AOG factor and the DT factor. QR is the combination of AP and TW. The maintenance assistance (MA) mode meets both the AOG factor and the FI factor. MA is the combination of AP and RM. The trade maintenance (TM) mode meets both the DT factor and the FI factor. TM is the combination of TW and RM. The full-lift-cycle coverage (FC) mode meets all the three key factors. With the development of FTZs and maintenance bases, aftermarket ASP pooling can be processed on time. The export and import, support, maintenance upgrades, and other services of aftermarket ASPs also can be offered. This can help to obtain good aftermarket services and maximize the economic value of the whole life cycle of CCAs.

SIMULATION

Method Selection

An experiment for the overseas aftermarket ASP supply of CCA is established using a software platform called ANYLOGIC. ANYLOGIC is commercial software that supports agent-based modeling and multiagent modeling, which is more suitable for the fine-grained modeling of aftermarket ASP supply behavior than traditional agent modeling software. ANYLOGIC has rich data functions; it can read and write text, use Excel and other file types, and import 3D images and CAD drawings.

A modeling method based on a combination of agent and discrete events in the simulation was used. Process modeling libraries are applied, which can help us understand the processes and services and predict the dependencies between logistics and manufacturing. This can help us gain better insight into the details of the decision-making process.

The database is provided in the ANYLOGIC software. Users only need to drag and drop the objects to the appropriate position when creating the mode and complete the modeling by attributing relationships between objects; the modeling process is simple and intuitive. Moreover, users can use the Java port in the secondary development software, which provides the flexibility to model complex passenger flow lines, various pedestrian attributes, station configurations, and facility locations; the prediction will then present more realistic and reliable results.

Simulation Process Design

The ordinary mode is compared with the FC mode, and the specific process is shown in Figure 5. In the ordinary mode, after the suppliers accept the orders, aftermarket ASPs are transported to the overseas airline after customs clearance. When aftermarket ASPs need to be repaired, they must be sent to the suppliers' maintenance base for repair and then back to the airline. In the FC mode, aftermarket CCA ASPs are first delivered to the FTZ, and after hearing the requirements, aftermarket ASPs will be directly transported to the overseas airlines. When aftermarket CCA ASPs need repairing, they will be returned to the maintenance base within the FTZ for repair.

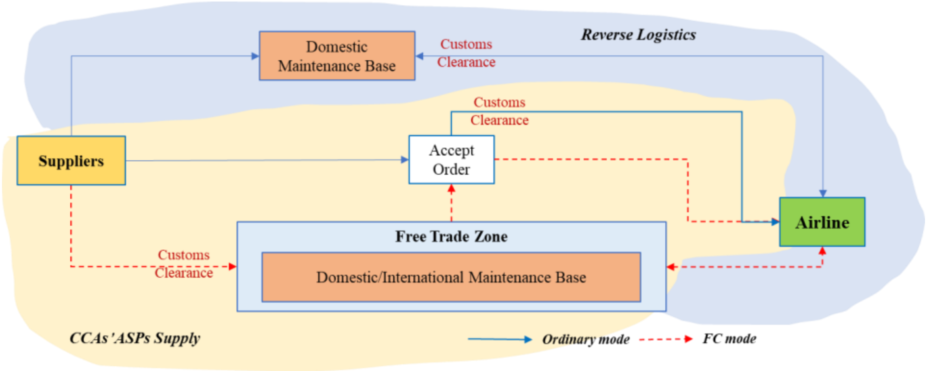

Figure 5. Flowchart of the supply mode simulation

The process modeling library template in ANYLOGIC was mainly used to build a simulation model of the above process, including the customs clearance, transportation, maintenance, and aftermarket ASP supply process, according to different modes. Finally, the simulation results was obtained by comparing the time-spending data of two modes to support the corresponding recommendations based on the simulation results.

To obtain reliable output and accurately represent the supply status, the simulation mode of aftermarket CCA ASPs must meet the following requirements:

(1) CCAs' aftermarket ASP supply process must be accurately simulated, including the order, customs clearance, selection of different transportation modes, acceptance, and maintenance.

(2) Reliable and effective statistical system indicators must be obtained. The simulation mode can record arrival, waiting, and maintenance. At the end of the simulation, performance metrics are displayed per unit of time, such as the time and volume of the last ASP arrival, and these data are compared with the best solution.

Figure 6 shows the simulation process based on the ANYLOGIC process modeling library.

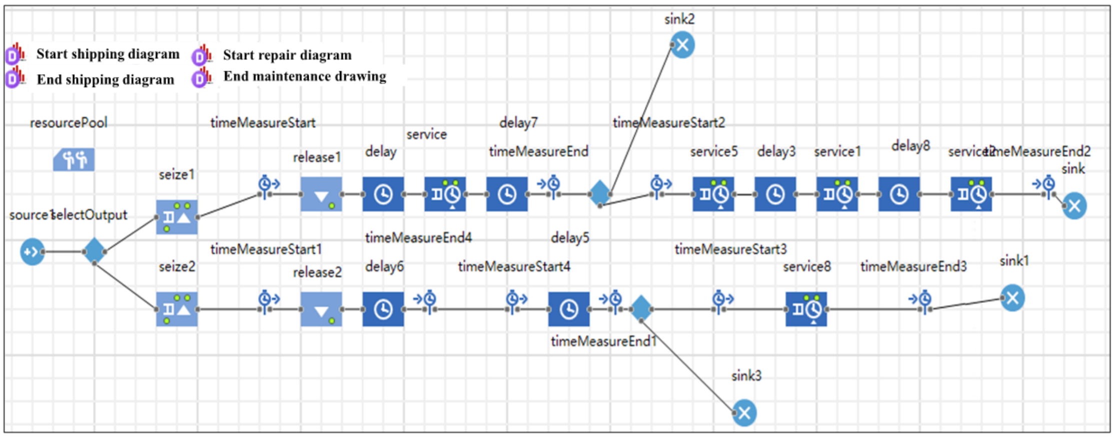

Figure 6. ANYLOGIC simulation flowchart

Simulation Parameter Setting

In addition to external factors, the length of the supply lead time directly depends on the design of the supply mode. Thus, CCAs' aftermarket ASP transportation time was used as the simulation parameter. The simulation parameters are set as follows:

Source: Conditions for generating aftermarket CCA ASPs; indicates the production rate of aftermarket CCA ASPs. Based on Airbus's announcement about setting a new average production rate, the rate is set to three pieces/day.

Select output: diversion. The supply mode may choose the ordinary mode or the FC mode. Using the specified probability, 50% of aftermarket CCA ASPs will choose the ordinary mode, and 50% will choose FC. In addition, the failure rate is set to 2%, which means 2% of aftermarket CCA ASPs will be sent for repair.

Delay: Delay is the time required for transportation or maintenance. The shipping setting time of the trunk line is triangular (3, 5, 7), which conforms to triangular distribution with an average value of five, and it can be completed in up to seven days. Domestic and international transportation time are triangular (5, 8, 11 and 5, 10, 15, respectively).

Service: Indicates the maintenance or customs clearance process, including queuing, delay, collection, and distribution. The customs clearance time is triangular (2, 3, 4), and the capacity is set to 10; that is, a maximum of 10 aftermarket ASPs can be cleared each time. The maintenance time of the non-maintenance base is triangular (5, 10, 15), and the maintenance time of the maintenance base is triangular (3, 4, 5). The capacity is 10, which means there are at most 10 aftermarket ASPs for maintenance each time.

Time measure: The time at which the measurement starts and ends.

Seize/release: The collection and release of aftermarket ASPs can represent the process of accumulating aftermarket ASPs through processing or transportation.

Sink: In ANYLOGIC, the source of the object must correspond to the evanescent source. Thus, the logical relationship must be satisfied, and when creating the simulation mode, the evanescent source must be defined; that is, aftermarket ASPs are delivered to the airline.

Simulation time: The simulation time is set as one year.

RESULTS

During the simulation running time, 492 aftermarket ASPs are supplied in the ordinary mode, six of which are repaired; the number of aftermarket ASPs in the FC mode is 530, 16 of which are repaired.

Figure 7 shows that the supply time of the ordinary mode is significantly higher than that of the FC mode. The peak and average values of the ordinary mode are higher than those of the FC mode.

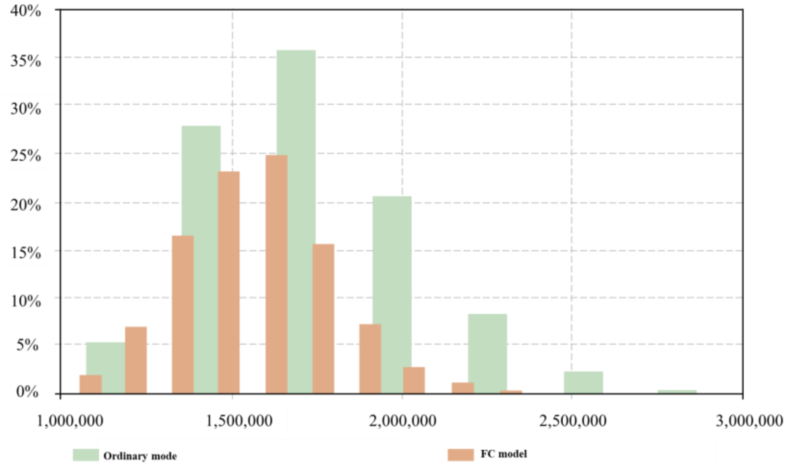

Figure 7. Comparison of supply times

Figure 8 shows that the maintenance time gap of these two modes is more than 3,000,000 s.

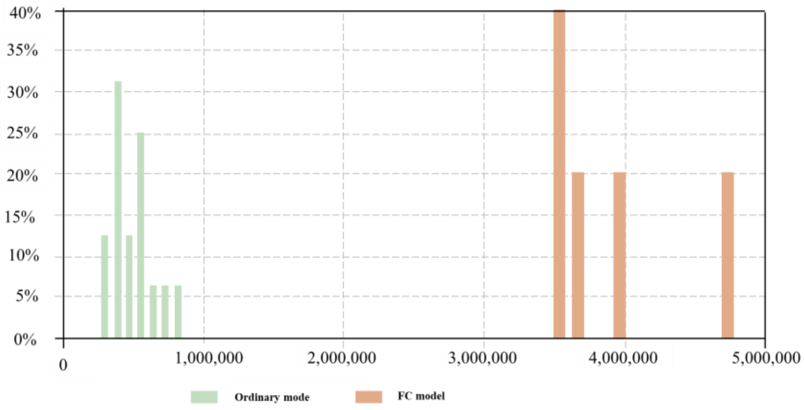

Figure 8. Comparison of maintenance times

When the number of aftermarket ASP failures in an overseas market is about 100, 95 aftermarket ASPs can be sent to airlines, and an additional five are repaired in the FC mode, while only 95 are supplied in the ordinary mode. Figure 9 shows that the average supply time of each aftermarket ASP in the ordinary mode is also higher than in the FC mode. The FC mode can shorten the inventory holding day, speed up the airline's cash turnover, and reduce operating time and cost.

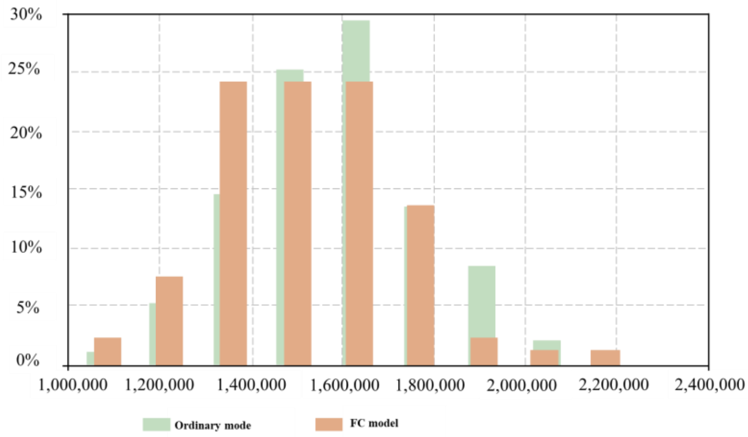

Figure 9. Comparison of supply time forecasting

The simulation comparison between the ordinary mode and the FC mode indicates that the FC mode is superior to the ordinary mode in terms of supply, maintenance quantity, and time. Therefore, when aftermarket CCA ASPs are supplied to overseas customers, they can choose according to the seven supply modes in section 3.2.

CONCLUSION AND SUGGESTIONS

This study uses computer simulation technology to reproduce the proposed ASP overseas supply logistics model and compare different scenarios with ANYLOGIC software. Based on the simulations, the following conclusions can be drawn:

(1) Based on the QCDS mode, the factors affecting the demand for aftermarket ASPs cover four categories: aftermarket ASP quality, price level, service level, and delivery level. Among them, the three factors of AOG guarantee, delivery punctuality, and failure impact are the key factors.

(2) There are seven supply modes for overseas aftermarket CCA ASPs: supply full-cycle coverage mode, quick response mode, maintenance assistance mode, trade maintenance mode, aftermarket ASP sharing mode, trade warehousing mode, and replacement maintenance mode.

(3) Based on the ANYLOGIC simulation of the common aftermarket ASP supply mode and the supply full-cycle coverage mode, the supply full-cycle coverage mode is superior to the common aftermarket ASP supply mode in terms of supply quantity and time. Also, the full supply cycle coverage mode can save user costs and speed up capital flow.

Based on the seven modes, the following management suggestions can be made in terms of demand forecasting, early-warning maintenance, customs clearance supervision, and aircraft parking emergency aftermarket ASP sharing:

(1) Develop a demand forecasting system for the overseas supply assurance of aftermarket CCA ASPs. By tracking the operation of CCA routes, the system collects fault data, maintenance records, and aftermarket ASP supply data, among other data, and establishes an aftermarket ASP demand forecasting system based on deep learning to clarify the safety inventory of CCA aftermarket ASPs under different overseas operation and maintenance scenarios.

(2) Establish an early-warning maintenance mechanism for overseas users of CCA. Carry out monitoring and early warning for aircraft failures among overseas users of CCA, deploy aftermarket ASPs in advance according to the health status and storage quantity of aftermarket ASPs in different regions, and actively respond to support.

(3) Optimize the supervision and management of the export and re-export of aftermarket CCA ASPs. Use the Internet of Things to establish an identification and positioning system for aftermarket CCA ASPs and provide technical support for exports, re-exports, and bonded supervision. Establish a special clearance/transit channel for the export of domestic aftermarket ASPs for CCA and the re-export of purchased aftermarket ASPs. Assist overseas CCA users, provide technical assistance for aftermarket ASP maintenance, and design a personalized special supervision mode, place, or area that is suitable for the location of the base. Build an overseas aftermarket ASP distribution center for domestic aircraft, and develop an inventory management mode for overseas suppliers of aftermarket CCA ASPs.

(4) Establish an emergency aftermarket ASP sharing platform for CCA parking. Based on a CCA operation database, unite overseas CCA users, aftermarket ASP distributors, and original equipment manufacturers to build a shared platform, and

determine the storage center for shared aftermarket ASPs according to the spatial distribution of users to support emergency situations.

(5) For all links involved in the export of aftermarket CCA ASPs, formulate support measures in various aspects such as cost, logistics, customs clearance, and taxation, and promptly establish a complete set of policy plans. Implementation and improvement are carried out at the same time, and through the accumulation of practice, an overseas aftermarket ASP policy system for CCA is gradually formed.

ACKNOWLEDGEMENT

This work was partially supported by the Tianjin Municipal Education Commission Major Social Science Project (2023JWZD23).

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