Research Article

Construction of Internal and External Environmental Management System of Human Resources in Civil Aviation Institutions Based on System Dynamics

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The basic investment needed for the development of civil aviation transportation has a long period, large investment, and strong exclusivity. The quantity of fixed investment should match the scale of the stage of civil aviation development. Scientific demand forecasting is the basis of reasonable planning of civil aviation infrastructure and fleet construction. Based on the principle of system dynamics, this paper analyzes the internal and external influencing factors of air passenger transport demand, and establishes a system dynamics model between civil aviation passenger transport market demand forecast and human resource management system. Using the model, based on the level of economic and social development, it is predicted that the demand for air passenger transport will reach 1 billion passengers around 2024. The demand system dynamics model of civil aviation passenger transport market has universal applicability and long-term effectiveness for the derived long-term demand forecast and analysis of civil aviation transportation. The results show that based on the derivative characteristics of air transport demand, the demand influencing factors of air passenger transport market can be divided into external and internal factors, which are mainly affected by population, economy, residents’ consumption level, air-rail competition, and other factors. Internal factors mainly include ticket price and service level.

1. Introduction

Air transport demand is a derivative demand, which is closely related to social and economic development. The stronger the economic strength of countries and regions, the greater the role of stimulating and promoting civil aviation transport demand [1, 2]. The regional gross domestic product (GDP) is the macroperformance of the regional comprehensive economic strength and an important macroeconomic indicator of the derived demand of civil aviation transportation. The industrial structure and the basis of transportation development that directly affect the demand of civil aviation transportation are closely related to the secondary and tertiary industries of the national economy [3]. Through the correlation analysis of the historical data in the past 10 years, it is found that the correlation coefficient between air passenger volume and GDP is 0.9791, and the correlation coefficient with the output value of secondary and tertiary industries is 0.9838.

The driving force of development determines the speed, efficiency, and sustainability of development. In the process of promoting and realizing the high-quality development of civil aviation, they should not only strengthen the transformation and upgrading of traditional kinetic energy but also vigorously cultivate and strengthen new kinetic energy and also stimulate strong spiritual motivation [4, 5], transform and enhance the traditional kinetic energy. At present, there is a strong demand for civil aviation, but due to the contradiction of insufficient key resources and weak guarantee capacity in the development of the industry, they have to take a series of regulation and control measures [6–8]. We try our best to maintain the balance between the speed of development and security capacity, as shown in Figure 1. Long-term cutting feet to fit shoes, so that the speed
of development will be based on the existing security capacity, is bound to restrain the full release of market demand [9, 10]. They must spare no effort to promote the reform of the airspace management system, increase investment in infrastructure, speed up the application of advanced technology, do everything possible to enhance the capacity of air traffic control, airport, and human resources, and optimize the supply of civil aviation public goods, to ensure that the exuberant market demand can be fully transformed into the sustainable momentum of civil aviation development [11–14].

The new momentum of civil aviation development lies in the improvement of total factor productivity brought about by technological progress, management innovation, and structural optimization. They must strengthen the supply-side structural reform of civil aviation to make the new kinetic energy more powerful and lasting. The new momentum comes from the change in the structure of passengers [15, 16]. Only by adapting to the changes in consumer psychology, consumption habits, and consumption behavior brought about by the changes in passenger structure, and providing aviation products closer to the needs of passengers, external demand can be truly transformed into their own development momentum. The new momentum comes from the improvement of integrated transportation [17, 18]. Only by actively integrating into the integrated transportation network and improving the collection and distribution efficiency of the integrated transport hub with the airport as the core can the passenger transit demand be effectively transformed into a new growth point of civil aviation. The new momentum comes from the progress in the application of technology [19]. Technological progress is an important driving force for economic and social innovation and development, and the civil aviation industry cannot stand still. They should firmly seize the opportunity of technological change, improve operational efficiency, innovate business models, and promote the development, transformation, and upgrading of the industry. The new momentum comes from the improvement of the quality of the staff. Talents are the first resource for development [20]. They must vigorously improve the ability and quality of civil aviation staff to make them more sensitive, more understanding, and more adaptable to the ever-changing changes. The new momentum of civil aviation development is gestated in the improvement of staff quality and ability and the change of human resource structure. The new momentum comes from the agglomeration of factors of production [21]. The agglomeration of high-end production factors has brought a stronger flow of people, logistics, capital and information, which will also give birth to more civil aviation development new business type. As long as they fully mobilize the enthusiasm of all parties in the civil aviation industry chain and form a joint force for development, the advantages brought by the agglomeration of factors can be transformed into an endogenous driving force for the development of civil aviation [22].

This paper adopts the idea of system dynamics. First of all, it analyzes the main influencing factors of civil aviation passenger transport market demand from the external and internal, and determines the influencing factors of
constructing the system dynamics model. Then, the causal relationship in the air passenger transport market system is analyzed, and the causal feedback loop diagram is constructed. Then, by establishing the system flow diagram and DYNAMO dynamic equation, the system dynamics model of air passenger transport market demand forecasting is constructed, and the validity of the model is verified. Finally, we analyze and estimate the model parameters under the future environment, run the model, and predict the demand and changing trend of air passenger transport market in the future. The results show that, based on the derivative characteristics of air transport demand, the demand influencing factors of air passenger transport market can be divided into external and internal factors, which are mainly affected by population, economy, residents’ consumption level, air-rail competition, and other factors. Internal factors mainly include ticket price and service level.

2. The Influence of External Passenger Transport Demand on Human Resource Management System

2.1. Economic Factors. Air transport demand is a derivative demand, which is closely related to social and economic development. The stronger the economic strength of countries and regions, the greater the role of stimulating and promoting civil aviation transport demand. The regional gross domestic product (GDP) is the macroperformance of the regional comprehensive economic strength and an important macroeconomic indicator of the derived demand of civil aviation transportation. The industrial structure and the basis of transportation development that directly affect the demand of civil aviation transportation are closely related to the secondary and tertiary industries of the national economy. Through the correlation analysis of the historical data in the past 10 years, it is found that the correlation coefficient between air passenger volume and GDP is 0.9791, and the correlation coefficient with the output value of secondary and tertiary industries is 0.9838. It can be seen that the total output value of the secondary and tertiary industries in the region has a greater impact on the demand of the air passenger transport market. Therefore, the economic influencing factors of air transportation select the index of "output value of secondary and tertiary industries" as the representative of the influencing factors of the model.

People are the demand source, service object, and consumer body of civil aviation passenger transport, and the total population is the most direct influence factor of civil aviation passenger transport volume. The larger the base number is, the more the corresponding passenger transport market demand will be. According to the correlation analysis between the historical data of population and air passenger traffic volume in the past 10 years, the correlation coefficient between air passenger volume and total population is 0.9851 and that with urban population is 0.9771 (Figure 2). It can be seen that the total population has a greater impact on the air passenger transport market demand; therefore, the air transport population influence factor selects the “total population” index as the representative of the model influence factor.

With economic development and scientific and technological progress, disposable income has increased, people’s living standards have improved, and travel and consumption have increased. People often choose comfortable, convenient, and fast air transportation, especially long-distance journeys. The marginal propensity to consume can well reflect the change of people’s consumption concept and consumption tendency, and its value is equal to the ratio of the increase and decrease of consumption to the increase or decrease of disposable income. The significance lies in the change of consumption with each increase or decrease of one unit of disposable income. The greater the marginal propensity to consume, the stronger the propensity to consume, and vice versa. Therefore, the influencing factors of residents’ consumption level select the index of “marginal propensity to consume” as the representative of the influencing factors of the model.

The increasing improvement of the high-speed rail network and the improvement of the speed per hour have a great impact on the civil aviation medium-and short-range market. The transportation market with a transportation distance of less than 1000 kilometers between the two places is the medium-and short-distance transportation market. There is a negative correlation between the competition of high-speed rail in the medium-and short-distance passenger transport market and the demand of air passenger transport market. The fiercer the air-rail competition is, the lower the share rate of civil aviation transportation is. Generally speaking, the impact of high-speed rail on civil aviation will reach more than 50% within 500 km, the impact of 500–800 km high-speed rail on civil aviation will reach more than 30%, and the impact of 1000 km will be reduced to about 20%. Therefore, the study should take into account the impact of air-rail competition. Based on the principle of acceleration, the marginal growth of high-speed rail passenger transport is set to quantify the impact of high-speed rail passenger transport on the civil aviation passenger transport market. The index describes the growth rate of high-speed rail passenger transport, and the higher the value, the greater the impact on civil aviation competition as the attractiveness of high-speed rail increases.

2.2. Service Factor. When other conditions remain the same, the ticket price is negatively related to the market demand. The higher the ticket price is, the less the demand is, and vice versa. At present, the pricing of air tickets is mainly based on cost pricing. However, with the continuous development of science and technology, new materials, new equipment, and new systems are more and more widely used in aviation manufacturing and operation, and the operating cost of airlines continues to reduce. In order to improve the competitive advantage of the market, airlines have reduced their fares as much as possible. Moreover, with the improvement of people’s living standards and the enhancement of spending power, the impact of ticket price fluctuations on travel choices has gradually weakened. To sum up, the price of air tickets is not taken into accounting. It can be seen in the following formula:
Using the passenger flow data detected by WIFI probe, the passenger flow points are distributed in the divided grid. The passenger flow density near each detection point is calculated. The formula is as follows:

\[ \rho = \frac{S}{S_i} \]  

(1)

"Fast, comfortable, and safe" is the differential feature of civil aviation transport products compared with other modes of transportation. The better the air service, the higher the passenger satisfaction, and the higher the preference for air travel, which will naturally lead to more air passenger demand; therefore, the "service level impact" index is selected as the model impact factor. Analogous to the price elasticity theory of demand, "service level impact" is quantified by the time elasticity of demand, that is, the change in market demand caused by a 1% change in flight hours. The time elasticity coefficient of demand is generally negative, that is, the more delay in flight hours than the planned time, the lower the satisfaction of passengers’ air travel and the decrease of market demand. The time elasticity coefficient of air passenger demand is about −1.6. Then, the satisfaction rate of return of the asset from \( y-1 \) to \( y \) is

\[ S_r = \frac{X_y - X_{y-1}}{X_{y-1}} \]  

(2)

If the dividend payment of the asset from \( y-1 \) time to \( y \) time is \( D_y \), then the net rate of return of the single interest of the asset from \( y-1 \) moment to \( y \) time is

\[ S_r = \frac{X_y - D_y}{X_{y-1}} - 1 \]  

(3)

Demand \( (u, t_k) = P(u, t_0)Pr(u t_k) \).

2.3. Systematic Causality Analysis. The causal cycle diagram of the system is the basis of constructing the system flow diagram, which can show the population, economy, air-rail competition, the impact of service level, aviation supply and air passenger transport demand, and the causal relationship between them. The arrow with polar symbol is called causal chain, which represents the causal relationship between the variables before and after; the "+" symbol leads to the increase of the target variable; and the "−" symbol leads to the decrease of the target variable. A closed loop formed by the combination of several causal chains connected from end to end is called a feedback loop. There are two kinds of feedback loops, one is to strengthen the feedback loop, which means that the feedback flow will grow exponentially, and the other is to balance the feedback loop, which means that the feedback loop will maintain the stability of the system. According to the selected model influence factors, the main causal feedback relationships are analyzed as follows:

(1) The output value of secondary and tertiary industries, the consumption level of residents (disposable income of residents), the demand for air passenger transport, the volume of air passenger transport. The feedback loop describes the positive effects of economic factors on the demand for air passenger transport. With the development of society and the progress of science and technology, the industrial structure of countries and regions is constantly upgraded and optimized, the economic level is improved, people’s living standards are also rising, and tourism and leisure travel is increasing. With the improvement of people’s disposable income and the change of consumption concept, the demand for air passenger transport and the actual passenger volume will continue to increase.

(2) The shortage of air passenger transport; the supply of air passenger transport; the output value of secondary and tertiary industries; the consumption level...
of residents; the demand of air passenger transport. The feedback loop shows the stimulating effect caused by shortage. When the air passenger transport market is in short supply, resulting in a transport shortage, the supply side of the market will make a replenishment response to increase the air transport supply, thus transforming part of the previously unmet potential demand into actual effective demand, that is, an increase in passenger volume. The increase in passenger volume will not only bring more direct benefits to aviation enterprises but also drive the development of other related industries and create more national output value for the country. While improving the national economy, the personal lives of the people have improved, and since then, back to point (1), economic development will lead to more demand for aviation.

(3) High-speed rail passenger investment high-speed rail passenger supply high-speed rail passenger transport competition affects air passenger demand air passenger volume secondary and tertiary industrial output value transportation passenger transport investment in high-speed rail passenger transport investment. The feedback loop describes the competitive impact of high-speed rail passenger diversion on air passenger transport. The increase of investment in any other mode of transportation, whether it is to increase supply or improve service quality, will inevitably cause competitive pressure on air passenger transport and weaken the demand for air passenger transport. The demand of statistics is

$$\text{Demand}(u_i, t_k) = P(u_i, t_0) \Pr(u_i t_k).$$

(5)
The parameters to be estimated in the matrix H, S, and K are

$$P(u_i, t_0) = N(N + 1)/2.$$  

(6)

(4) Civil aviation passenger transport investment, air passenger transport supply, air passenger transport shortage, air passenger transport demand, air passenger volume, secondary and tertiary industrial output value, transportation passenger transport investment, and civil aviation passenger transport investment. The feedback loop reflects the role of increasing supply in promoting the demand of air passenger transport. Like other modes of transportation, civil aviation itself increases its investment, which is bound to enhance its own competitiveness and increase aviation demand and passenger volume. In addition to the above feedback loop relationship, there are some other common causalities in the system. According to the causality of the above analysis, draw the casual feedback loop diagram of the air passenger transport market system, as shown in Figure 3. The casual feedback loop can be settled as

$$\text{Feedbacktime} = N(N + 1)/2\sqrt{E_1^2 + E_2^2 + \ldots + E_n^2}.$$  

(7)

3. Strategic Plan for the Construction of Management System in Civil Aviation Colleges and Universities

3.1. Popularization Strategy. Popularization is the expansion of civil aviation from providing high-end consumption to meeting economic consumption, as shown in Figure 4. To implement the popularization strategy is to fully grasp the growing trend of aviation demand, continuously strengthen the building of supply capacity, and expand the scope of services, so that high-end consumers can fully enjoy the high-quality services of air transportation. And the general public can also fully enjoy safe, convenient, and economic air transport services. The strategic idea is to encrypt the airport layout, improve network accessibility, improve ground traffic connectivity, and improve travel efficiency:

(1) They will spare no effort to promote the airport layout oriented to meet the demand and improve the layout, and establish an airport system with reasonable layout, structural optimization, and convergence. First, classify and sort out the airports with the top 20 throughput, and their overall planning should, in principle, be guided by the scale of more than 20 million people. The second is to continue to cultivate an international hub, expand its international functions, improve its functional positioning, and promote its development into an international hub airport with a central position in the Asia-Pacific region. Third, they should further open up and develop the international functions of hub airports in coastal, border, and central regions, and cultivate gateway airports. Fourth, strengthen the planning and construction of regional airports and build new regional airports in areas with low airport density and great market potential.

(2) Give priority to point-to-point routes, vigorously develop air passenger express lines, actively develop regional and commuter airlines, establish a sound
national public route network, and enhance aviation service and competitiveness in an all-round way. First, route network is mainly to build a hub-and-spoke structure in the near future, and it should gradually transitioned to a point-to-point model in the long term. The second is to support the operation of medium-and long-range routes through the establishment of a good airport ground connection system. The third is to establish an air passenger express line system between the main airports. Fourth, support the development of regional aviation in the western region, improve the accessibility of small and medium-sized cities, and enhance the depth of air transport access. Fifth, integrate the construction of commuter airports and the operation of commuter flights into the national public air transport system, and make overall planning and management.

(3) Moderate development of low-cost aviation to meet the needs of different consumer groups. The first is to support low-cost airlines in route resources and flight time. The second is to support low-cost airlines to take various measures to reduce costs. The third is to relax price control and expand the pricing power of low-cost airlines. Fourth, under the premise of ensuring that safety standards are not lowered, low-cost airlines are allowed to formulate service standards commensurate with low-cost fares.

3.2. Globalization Strategy. The basic idea of implementing the globalization strategy is to adapt to the new situation of economic globalization and the new trend of “sky opening up,” to focus on “going out,” to make more flights fly out, to build a global route network, and to expand international influence, to serve the country’s foreign economic and trade policy and the overall strategy of international political exchanges. At the same time, they should expand and deepen opening up, "bring in" more good things, and realize digestion, absorption, and innovation:

(1) To serve the national opening-up strategy and improve the capacity of international air transport services, they will implement the policy of opening up to promote development, and in accordance with the principles of orderly order, differences between regions, internal and external differences, and proximity, they will actively, gradually, orderly, and guarantee the opening up of traffic rights, and effectively deal with the opening up of the sky. Airlines are encouraged to make full use of the "two markets" and "two resources" to set up overseas branches and overseas aviation hub nodes by means of mergers and acquisitions so as to support an accessible and unobstructed international air transport network. Encourage large carriers to play a key role in the global aviation alliance and establish a network of civil aviation international routes covering five continents, with access to important cities in major
countries in each region. Enhance the strength of aviation enterprises to compete with foreign airlines on international routes, and establish the dominant position of aviation enterprises in international routes.

(2) Adapt to the development trend of civil aviation and improve the international competitiveness of air transport. Give full play to the leading role of the market and the guiding role of the government, encourage airlines to carry out joint reorganization, cultivate large-scale network airlines with international competitiveness as soon as possible, and form more than one super passenger carrier. Company size, network, quality, and other comprehensive brand strength into the top five in the world. The formation of an internationally competitive air cargo company, comprehensive strength into the world’s top 5. Change the situation of decentralized operation of traffic rights on international routes, concentrate efforts on the allocation of flight time resources, and support the operation and operation of large network airlines, with emphasis on competing for the hub position of Northeast Asia Aviation Center and Southeast Asia Aviation Center. They will speed up the construction of the three major international portal composite hubs and develop a number of regional international hubs in the central and western regions. Improve airport transit facilities and processes to facilitate international and domestic transit. They will implement custom clearance policies for passengers and goods conducive to the operation of hub airports, and simplify the joint entry and exit inspection procedures of customs, border inspection, inspection, and quarantine departments. At least two hub airports have entered the top 5 in the international ranking of comprehensive strength.

3.3. System Modeling. From the simulation results of the total air passenger demand, the error between the total air passenger demand and the actual value is very small, the two broken lines almost coincide, and the annual relative error is less than 1%, which is a good fit; from the simulation results of the increment of air passenger demand, the relative error with the actual value is less than ±8%, which meets the model accuracy requirements determined by system dynamics. The distribution of air passenger human resource structure can be shown in Figure 5.

As a result, the validity of the model is verified, and compared with the models built by predecessors, the accuracy is improved obviously. According to the current relevant policies of our country, the future social development trend of the country is predicted. Firstly, the relevant parameters of the system dynamics prediction model for determining the future demand of air passenger transport are analyzed, which is mainly the determination of economic and population growth rate. On the economic side, under the guidance of national policies in recent years, the real estate industry has gradually debubbled and returned to rationality, which has had a certain impact on the short-term market economy. The growth rate of GDP and the growth rate of output value of secondary and tertiary industries have declined significantly compared with previous years. However, in the long run, after the throes of reform, economic development will inevitably return to a normal, healthy, and steady development track. Based on the analysis, combined with historical statistics, it is estimated that the output value of the secondary and tertiary industries will grow by 7% to 8% from 2018 to 2020, and 11% to 12% from 2021 to 2030. In terms of population, the National Population Development Plan (2016Mui 2030) issued by the State Council points out that fertility rate has been below the replacement level for a long time, and the number of short-term births has increased after the implementation of the comprehensive two-child policy. Statistics show that in the past two years, the birth rate has increased significantly compared with the past, close to 13 per thousand. However, in the long run, due to the change of reproductive choice behavior, the decrease in the number of women of child-bearing age, as well as the aging of the population and other factors, the birth rate decreases, the mortality rate increases, and the potential energy of population growth weakens. Based on the analysis, combined with historical statistics, from 2018 to 2020, the birth rate was 10.94%, 10.41%, 8.52%, and the mortality rate was 7.13%, 7.14%, 7.07%, and it is expected that the birth rate will decrease to 8% ~ 7% and the death rate will increase to 7.1% ~ 7.3% in 2021 ~ 2030. In terms of the number of passengers per capita, although the per capita number of passengers is not as good as the level of developed countries, it has been greatly improved. “Some opinions of the State Council on promoting the Development of Civil Aviation Industry” puts forward that the number of flights per capita in the country will reach 0.5 by 2020. Based on the current level and growth trend of the number of passengers per capita, combined with the national development goals, it is estimated that the per capita number of passengers in 2018 will be about 0.5 in 2020, 0.7 in 2021, 0.7 in 2025, and 1.2 in 2026~2030. The other parameters such as the proportion coefficient of civil aviation passenger transport investment and the impact of high-speed rail passenger transport competition are taken as the historical average of 3 years.

4. Discussion

It can promote scientific and technological innovation and enhance the internal driving force of sustainable development. Adhere to the principle of combining original innovation, integrated innovation, introduction, digestion, absorption, and reinnovation strive to build a number of key civil aviation scientific research bases and actively cultivate more than five state-level key laboratories. They will also improve the mechanism for coordinating civil aviation basic research, soft science research, and applied technology research, and establish an open scientific and technological innovation system with the government as the lead enterprises as the main body, and industry-university research.
**Figure 5:** Distribution of human resources structure of air passenger transport.

**Figure 6:** Distribution of human resource structure of air passenger transport.

**Figure 7:** Development trend of human resources in the future.
The distribution of air passenger human resource structure can be shown in Figure 6.

It can explore the application of low-emission and renewable alternative energy sources such as bioblended fuels to meet the needs of sustainable human development and the growing demand of the civil aviation market. It can input the parameter values determined by the analysis, take 2017 as the simulation starting point, 2030 as the end point, take one year as the simulation time step, run the system dynamics model, and get the prediction results and changing trend of air passenger transport human resources in the future, as shown in Figure 7. The forecast results show that in terms of the total amount, the total demand of air passenger transport market will maintain a steady upward trend in the next 15 years and will break through the mark of 1 billion passengers around 2024; in terms of increment, although the demand increment of the future air passenger transport market shows an overall upward trend, it is affected by many factors, mainly economic and demographic instability, and the range of growth fluctuates greatly.

5. Conclusion

This paper adopts the idea of system dynamics. First of all, it analyzes the main influencing factors of civil aviation passenger transport market demand from the external and internal, and determines the influencing factors of constructing the system dynamics model. Then, the causal relationship in the air passenger transport market system is analyzed, and the causal feedback loop diagram is constructed. Then, by establishing the system flow diagram and dynamic equation, the system dynamics model of air passenger transport market demand forecasting is constructed, and the validity of the model is verified. Finally, analyze and estimate the model parameters under the future environment, run the model, and predict the demand and changing trend of air passenger transport market in the future. The results show that, based on the derivative characteristics of air transport demand, the demand influencing factors of air passenger transport market can be divided into external and internal factors, which are mainly affected by population, economy, residents’ consumption level, air-rail competition, and other factors. Internal factors mainly include ticket price and service level.

Data Availability

The figures and tables used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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