Simulation Model for Policy Analysis on Multi-Airport System in Metropolitan Region

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Abstract

Tokyo Metropolitan Area (TMA) has two airports for air service, are Haneda and Narita airport. So far, Haneda airport delivers the service for domestic air flights, while Narita airport for international flights. This has mainly done by the strong regulation of the government.

This has, however, made users pay additional travel time and cost, because Narita airport located in outlying area of TMA.

In this paper, the simulation model for multi-airports system is developed so as to know the answer for the question whether both airports can survive or one lose a demand after competition or cooperation. This model mainly consists of three bodies, namely air passengers, airlines and airports. Under the competition between two airports to get both domestic and international flights, share of air demand between two airports is calculated. Finally, key factors on the service, demand and management of a multi-airports system which are decided depending on the behavior of users, airlines and airport authorities, is defined by using this model.

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1. INTRODUCTION

Recently, most of metropolises in the world used to have several airports for the air service. When each airport is operated independently, the problems on the market share of air service will be occurred. Market share models, generally, are explained by an interaction between two bodies, the demand side and the supply side.
However, the airport operation problem has several features which differ from a basic market share problem. Firstly, three different kinds of bodies exist regarding to an airport problem, namely airport authority, airline and traveler. Indeed, on the model for the multi-airport system, we have to deal with more than three, at least two airport authorities, several domestic and foreign airlines and individual travelers. Another feature is the time interval on the decision making for the measures will differ between bodies extremity. For example, airport authorities would develop their strategies for a long term because they must improve the airport facilities by reconstructing a terminal building, expanding runway, so on in order to provide good service for travelers and more capacity for airlines. On the other hand, airlines won't need a long time to change their operation, such as the schedule of their fright. Thus, the future condition on the multi-airport system including the market shear is quite uncertain and the systematic analysis is required for this problem.
This is a reason of why we tackle these problems. The aim of this paper is that political factors on a multi-airports system in metropolitan region are cleared. These factors will cause behavior of travelers. And in order to evaluate the multi-airports system, the forecasting model is introduced in artificial situation of this system, but this model is just a prototypical model.

2. STATEMENT OF PROBLEMS

Tokyo Metropolitan Area (TMA) has two airports for air service, namely Tokyo International Airport (Haneda airport) and New Tokyo International Airport (Narita airport). So far, Haneda airport delivers the service for domestic air flights, while Narita airport for international flights. This has mainly done by the strong policy of the government.
The separate air service causes users have to prepare additional travel time and cost, because Narita airport located in outlying area of TMA (around 60 km away). A lot of international passengers pass through Narita airport, which are over 60 percent share of international terminal passengers in Japan. Almost all of the users of Narita airport have to gather to central Tokyo by rail or airplane from all over the country in Japan and come to Narita airport by land transports. In order to coping with this problem, it is proposed in this study that both airports operate international and domestic flights.
A research dealing with this problem in TMA was studied by Saito, H. et al. (1993). In this research an optimal frequency of domestic and international flights to Narita airport or Haneda airport estimated by minimizing an index of accessibility for travelers. Mori, H. et al. (1988) studied airport choice problem of travelers for international flights using the logit type model in Kyusyu district, and Furuichi, M. et al. (1993) also studied this problem using the discrete choice model in Japan.

3. THE MULTI-AIRPORT SYSTEM MODEL

3.1 Framework of the system

The multi-airport system in metropolitan region model is based on the system dynamics. Because the system dynamics has many advantages that decisions of each body as strategy affect in some factors in the system with delay and that several strategies which enforce on different terms can be evaluated. On this modeling, we assumed the artificial metropolis in which two airports named A and B which serves both international and domestic flights. Also we assumed three bodies mentioned before, airport authorities, airlines and users for our multi-airport system. Figure 1 shows the relation among bodies on the system. Airport authorities serve slots which are limited on open hour to airlines and airlines pay landing fee for slots. Airports' locations affect airport choice for users accessibility, and airlines serve air flights service to users.

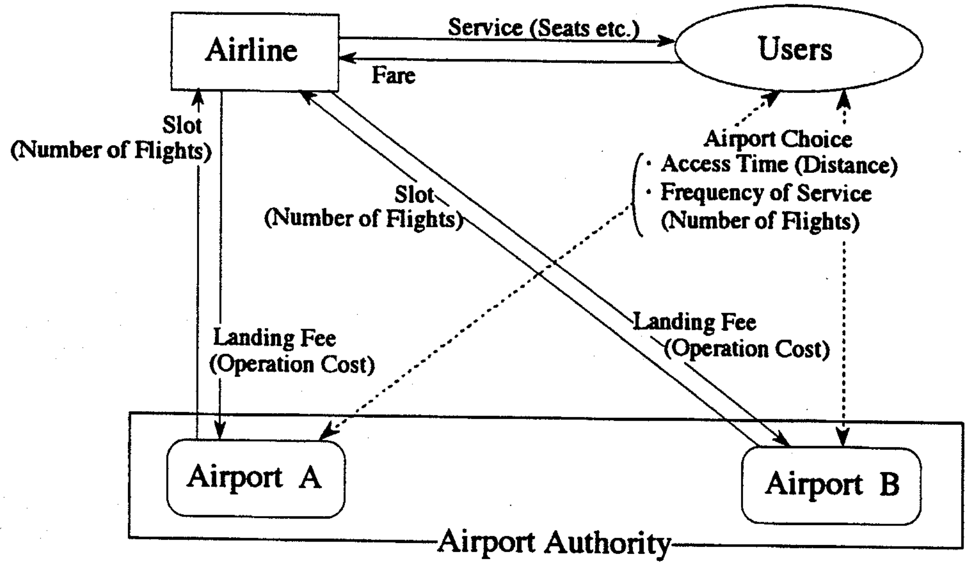

Figure 1. Structure of bodies on the multi-airport system

3.2 Structure of the system

The multi-airport system in metropolitan region can be depicted by the causal loops shown in figure 2. This system consist of the causal loop of passenger share of each airport and income and expenditure of carriers.

Passenger share, airline profit and number of flights form a positive feedback loop, which accounts for the calculated airport choice rate. On the other hand, number of flights, operation cost and airline profit form a negative loop. These loops exist on both domestic and international fields of each airport.

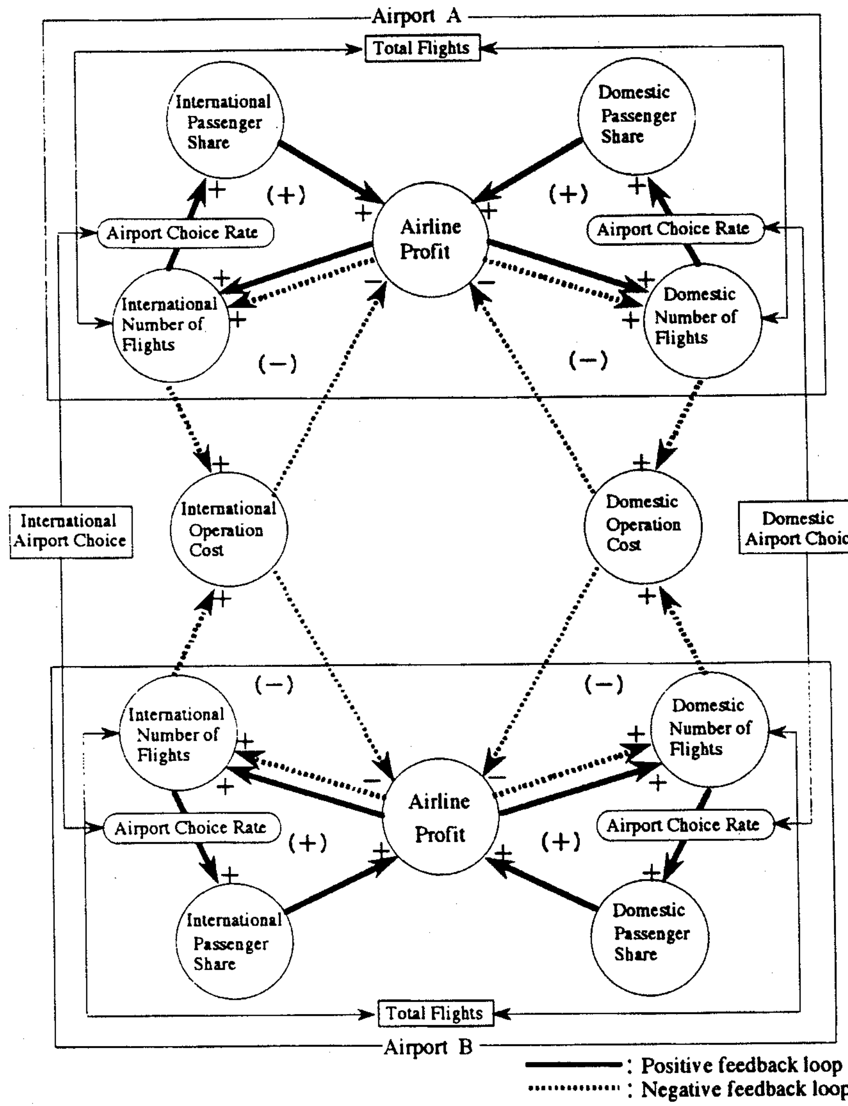

Figure 2. Feedback loops for the multi-airport system

3.3 Modeling

This system consists of two main parts, airport A and B. And each part has two categories, domestic service and international service. A flow diagram of the subsystems of airport A is shown in figure 3. Under an assumption of coexistence domestic and international flights at each airport, share of air demand between two airports is calculated. The share model as the logit type is formulated by access time and cost to each airports and frequencies of flights. The income of an airline is calculated by multiplying the number of passengers in fare of air routes, and the balance between this income and operating cost is able to be calculated. The frequency of flights at each airports are adjusted according to profits of air routes operation. This Frequency is one of variables of the share model.

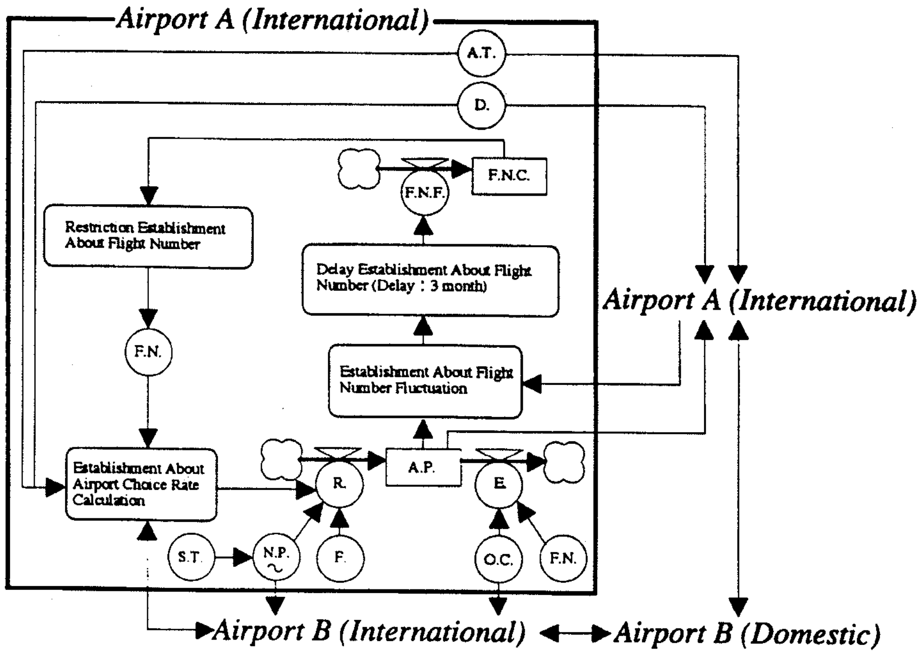

Figure 3. Flow diagram of multi-airport system

4. SIMULATION OF THE MULTI-AIRPORT SYSTEM

4.1 Set of basic situations

Using this constructed prototype model, the multi-airport system is simulated in simple hypothetical area and situation.
The following assumptions are incorporated into this model for the base run :
1) Each airport A and B serve several flights on an international route and a domestic route by an airline.
2) Number of total flights for domestic and international of each airport is fixed. Increment of fright frequency is adjusted three months later since airline profit increases or decreases.
3) This model runs to seventy two months by one month.

4.2 A search for multi-airport system policies

The multi-airport system policies are searched out and judged if policies are good or bad, by viewing the problem through the system dynamic computer simulation model.
The following three aspects is examined by searching multi-airport system policies.
1) Accessibility from central city to airport
In the case of plural airports in the city, generally they are divided in near from central city or not, because new airports are constructed in suburban in order to cope with environmental problems. This will be improve of accessibility, for example construction of new access rail way, and choice of new airport location are evaluated. In this simulation, it is value of initial conditions that one airport locates in twenty km from central city and another airport locates in forty km from there.
2) Number of slot for air flights
This policy analysis is able to clear that it is good how many allotment of shares of domestic and international flights are. In this simulation, value of initial condition of slot allotment is assumed that

airport A serves three international flights and two domestic flights a day and airport B serves one international flight and two domestic flights a day.

3) Balance of fare between domestic and international flight

Fare of a route could be reduced if operational costs for flight can be low. Terminal costs such as landing fee is mainly one of the cost for airlines. So, it is a main reason why analyzing in impact of fare means examining of impact of terminal costs which are related to the terminal fee. In this simulation, an international route is assumed in short distance. And it is assumed that value of initial condition of fare of international flight is 100,000 yen, while fare of domestic flight is 30,000 yen.

Situation of two basic cases and value of initial conditions for model runnings are shown in Table 1. Airport A is located 40 km far from central city and mainly serves international flights, while airport B is located near central city and mainly serves domestic flights. Sixteen patterns which are based on their cases are investigated in this study.

The results of basic runs that are typical pattern are shown in Figure 4 and 5. In the former pattern, the airport A has almost international passengers share and the airport B has domestic share. While in the latter case, the airport A has high shares of both domestic and international passengers. Because of an impact from passenger shares of airports choice, which are estimated by balance of air fares of domestic and international flights, is one of the most important factors.

In comparing of several simulations, volume order of policy factors which impact to airport share is cleared. The first important factor is air fare, the second is frequency of air flights, and the third is passenger share. From this result, the airport strategies of fare control, like as landing fee, is useful policies to compete or coordinate with other airports on the multi-airport system in a metropolitan area. Because this is one of the most important elements of air flight fare, when airlines set their fare of flights.

Table 1. Value of initial coefficients

Airport	Airway	Number of Flights (per month)	Fare (Yen)	Distance From City	
				Distance (km)	Time (hour)
A	International	90	100.000	40	1
	Domestic	60	30,000		
B	International	30	100,000	20	0.5
	Domestic	60	30,000		

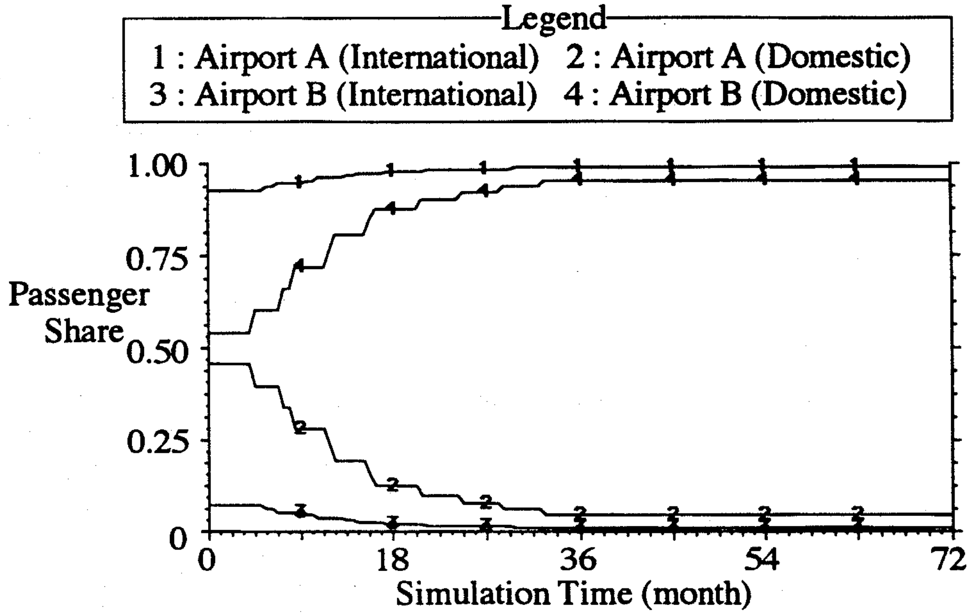

Figure 4. Passenger shares (Pattern 1)

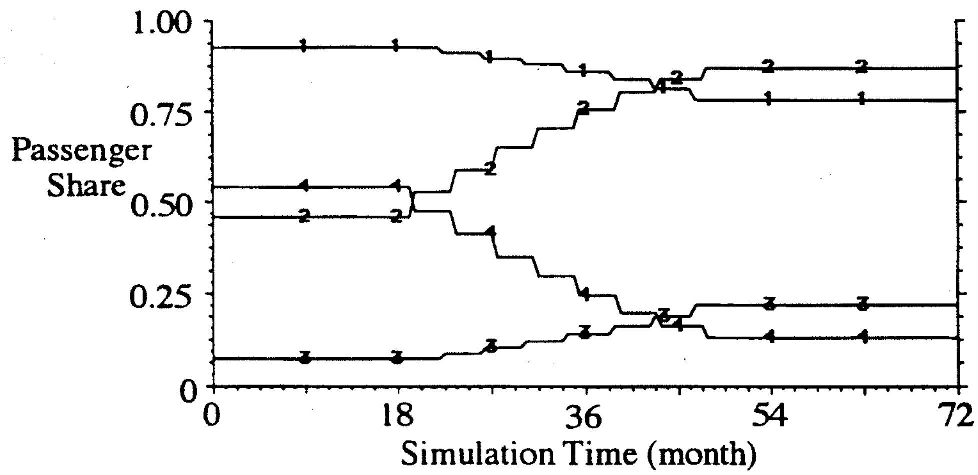

Figure 5. Passenger shares (Pattern 2)

5. CONCLUSIONS

In this paper, in order to analyze a structure of the multi-airport system in metropolitan region, the basic model developed by using the system dynamic was introduced. And the impact of several policies on the market shear were evaluated by using this model. As a result, it was delighted that most of policies would affect mainly on the behavior of travelers on this multi-airports system. However the introduced mode was just applied in the artificial world. Thus, we have to make an attempt to apply our proposed model in the existing situation. Also, we have to test other policies, especially regarding to airport authorities.

APPENDIX

Table a.1. Description of parameters

Abbreviation	Term
A.P.	Airline Profit
A.T.	Access Time
D.	Distance
E.	Expenditure
F.	Fare
F.N.C.	Flight Number Calcultion
F.N.F.	Flight Number Fluctuation
N.P.	Number of Passenger
O.C.	Operation Cost
R.	Revenue
S.T.	Simulation Time

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