ECONOMIC IMPACT ANALYSIS OF DEREGULATION AND AIRPORT CAPACITY EXPANSION IN JAPANESE DOMESTIC AVIATION MARKET

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Abstract: As the market expands, regulation to foster orderly growth of the industry begins to become fetters for further growth. In the 1980's, mission was initiated in Japan to deregulate economic regulations of the domestic aviation market. In line with deregulation policy, airport capacity expansion was accelerated to facilitated growth of the market. In this paper, social welfare of deregulation and airport capacity expansion of Tokyo International Airport (Haneda) is analyzed using both partial and general equilibrium approach. An important implication from this analysis is that deregulation and airport capacity expansion both play significant roles in realizing full benefit of aviation market growth. Large potential of the spill over effect of aviation policy should also be noted.

Key Words: Deregulation, Airport Capacity Expansion, Partial Equilibrium, Computable General Equilibrium Model,

1. INTRODUCTION

Today, domestic aviation in Japan has established its role as a major mode in inter-city transportation. The market, however, has gone through history of growth and maturity over half a century to become what it currently looks.

The market lifted off in the 1960's by the three major airlines operating orderly in their respective markets. Since 1985, Japanese aviation market entered into the period of promoting competition starting from liberalizing route entry and frequency regulations. As the market competition increased and begun to mature, reform of the fare regulation was initiated. In 1995, zone airfare system was introduced with an aim to accelerate decrease in airfares and to foster increase in variety of discount fares. Following this structural reform, variety of new discount fares were introduced, while the normal fare was increased in a number of trunk routes by the incumbent carriers. Price hikes in these routes triggered a movement to seek new entry of airlines into the market. In 1998 two new airlines took off which had not been experienced for more than thirty years. The supply/demand regulation and prior approval of airfare were finally deregulated in 2000 to allow full competition in the market.

Paralleled by regulatory reform, airport capacity expansion to accommodate increasing demand of aviation market had been undergone. By the end of the 20th century, construction of the airports in local regions in Japan was basically completed. Emphasis is now placed on further expansion of megalopolis airports such as Tokyo International Airport (Haneda)[1].
The aim of this study is, adopting both partial equilibrium and general equilibrium approaches, to evaluate the effect of deregulation and airport capacity expansion. Specifically, we estimated demand curve with two-stage least squared (2SLS) method, and carried out quantitative analysis on how these policies contributed to the decrease of generalized cost in domestic aviation market. Further, inputting the effect of decreasing generalized cost derived from 2SLS into a SAM based Computable General Equilibrium (CGE) model, we evaluated social welfare of deregulation and airport capacity expansion including spillover effect on domestic aviation market.

This writing is composed in the following manner; in the 1st part, we review the development of domestic aviation market and historic background of aviation policies. In the 2nd part, we evaluate users' benefit generated by deregulation and airport capacity expansion with partial equilibrium model. In the 3rd part, using a SAM based CGE model, we assess the effect of deregulation and airport capacity expansion from the perspective of social welfare including the spillover effect. Finally, we summarize the findings and the their implication on future aviation policies.

2. DEVELOPMENT OF AVIATION POLICIES AND EVOLUTION OF DOMESTIC AVIATION MARKET

2.1 Fostering growth and maturity of domestic aviation industry

(1) Establishment of operating framework for aviation industry

Japan's aviation industry was allowed to resume its service in 1951, and in 1953, government funded Japan Air Lines (JAL) was set up based on Japan Air Lines Company Limited Law. JAL was assigned to run international and domestic trunk routes, and a number of other airlines were to operate on domestic local routes. As the demand for aviation increased, airline competition became severe and a framework to secure fair competition became increasingly required. Based on the recommendation of 1970 by the Transport Policy Council under the Ministry of Transport[2] and the Ministerial Order of 1972, excessive competition was warded off and service domain of each airline was designated from the perspective of co-existence and co-prosperity; i.e., JAL on international and domestic trunk routes, All Nippon Airways (ANA) on domestic trunk and local routes, Japan Air Systems (JAS, ex-Toa Domestic Airlines (TDA)) on domestic local routes. Industrial activities was conducted for more than ten years under this 45/47[3] framework.

(2) Promotion of competitive policies

1) Promotion of double/triple tracking of domestic aviation

[1] Tokyo International Airport (Haneda) has basically served as a domestic airport since New Tokyo International Airport (Narita) opened in 1978.
[2] As of January 2001, Ministry of Transport was integrated with Ministry of Construction etc., into Ministry of Land, Infrastructure and Transport (MLIT).
[3] 45/47 stands for 1970 and 1972 in Japan's Showa era.

In the 1980's, rapid growth both in international and domestic aviation was achieved, due to the improved standard of living and enhanced recognition of time value. In 1985, Transport Policy Council reviewed the operating framework of the aviation industry and based on its recommendation, 45/47 framework was abolished by the Cabinet in December 1985. New policy was introduced to promote plural number of airlines operating in routes with large number of passengers. Ministry of Transport set level of passengers for route in which two airlines (double tracking) or three airlines (triple trucking) could operate. This so called double/triple tracking criteria was initially set at 700 thousand and one million annual number of passengers respectively. This meant that in routes with more annual passengers than 700 thousand, two airlines could enter, and in routes with more annual passengers than one million, three airlines could enter. Based on supply/demand regulation, frequency in each routes were coordinated by the Civil Aviation Bureau to foster balanced development. The level of double/triple tracking criteria was reduced sequentially in 1992 and in 1996 for further improvement of users' benefit. In 1997, the criteria was abolished so that airlines could enter into any route at their discretion regardless of the volume of that route. As a consequence, the ratio of available seats in routes with multiple number of airlines against total available seats in the domestic aviation market rose from 53% in 1985 to 80% in 1999.

In addition to promotion of double/triple tracking in the domestic market, the new aviation policy set out in 1985 included introduction of airlines other than JAL into the international aviation market and complete privatization of JAL.

2) Regulatory reform of domestic airfare

The regulation on domestic airfare was basically aimed to check increase in airfares that could not be justified by cost. When the airlines applied for increase in airfares due to inflation or upspring in fuel price etc., overall cost of airline operation was scrutinized by the Civil Aviation Bureau, and airfare increase was only allowed up to the level which could balance income to aggregate cost under efficient operation. This "aggregate cost formula" was adopted in most of the public utilities.

Japanese economy entered into deflation in the early 1990's and the market in general started to feel the pain of inevitably being forced to reduce prices. Public utilities including transportation services, however, started to apply for price hikes. Since 1994, strong criticism over raise in price of public utilities under the aggregate cost formula emerged. Reform of regulatory framework for public utilities became a keen political agenda. As a result, with regard to the domestic airfare, "zone airfare system" setting upper limit based on standard cost and 25% reduction zone in normal fares was introduced. This zone airfare system allowed each airlines to set the normal fare at their discretion within the margin of 25% under the standard cost of competitive routes; i.e. double/triple tracking routes. Under the zone airfare system, introduction of flexible airfares such as seasonality, flight by flight pricing, etc. was now possible. In 1996, airlines' applications were approved under the new regulation. Prior to the introduction of the zone airfare system, the aviation law had been amended in 1994 so that discount airfares up to 50% below the normal fare could be set at airlines' discretion. Combining the two regulatory reform, existing airlines increased the normal fares in trunk routes such as Tokyo-Fukuoka and Tokyo-Sapporo, while introducing various discount fares such as advance booking discounts and improved frequent flyer programs (FFPs). However, increase in routes with heavy traffic such as Tokyo-Fukuoka and Tokyo-Sapporo, the two largest routes in the world, caused criticism from Fukuoka and Sapporo regions.

3) Entry of new airlines

Criticism against incumbent carriers triggered a movement to seek opportunity to set up new airlines. Amidst such movement, airport capacity expansion of highly congested Haneda Airport, the major domestic hub airport located in Tokyo, was in due course. The Haneda airport was expanded towards the bay area, and in March 1997, a new runway was opened so that simultaneous take-off and landing in two parallel runways would be possible. This made it possible to increase slots for additional 40-flight per day. These slots were allocated to airlines in two stages: July 1997 and April 1998. At that time, there were six projects launched to raise new airlines and the first two to be in the market was Skymark Airlines in September 1998 on Tokyo-Fukuoka, and Hokkaido International Airlines (AIR DO) in December 1998 on Tokyo-Sapporo. Apart from subsidiaries of the major three companies, it was a new entry in 35 years. The above two newly established airlines, at the launch of their services, set extremely lower airfares compared to incumbent carriers. Skymark offered normal fare at half the price and AIR DO at 36% below incumbents' fares. This was accomplished by streamlining onboard service and administrative cost-cuts through outsourcing aircraft maintenance and airport service. As a result, "everyday low fare" strategy won the popularity and the load factor rose as high as 80%. On the contrary, incumbent carriers suffered sudden drop in passengers where new airlines entered. These routes were lucrative trunk routes with many business travel. Faced with such a consequence, the incumbent carriers started to offer discount fares on specific flights just before and after the flights of new entrants, as well as upgrading FFPs. This strategy was quite effective and by March 1999, the incumbent carriers regained their load factor to the same level as that of a year ago. Such competitive force resulted in an annual increase of 16.3% in passengers between Tokyo and Fukuoka, and 9.4% between Tokyo and Sapporo.

Since then, anti-trust policy and slot allocation policy at congested airports such as Haneda Airport, has become a new agenda. Ministry of Transport has set out a new slot allocation policy to review slot allocation in congested airports every five years by preset indexes for appraisal of consumer benefit and efficiency.

(3) Abolishment of demand/supply regulation policy

In Japan, deregulation in the transportation sector has been implemented gradually, an the domestic aviation market was the front runner. With a view to accelerate deregulation in every transportation sector and to promote administrative reform, thus stimulating the sluggish economy, in December 1996, Ministry of Transport, decided to abolish supply/demand test in all the transportation sector by the end of the century. Based on the report from the Transport Policy Council on April 1998, measures for maintaining essential air services and the rule for slot allocation in congested airports were reinforced. Having set out necessary measures for liberalization, Civil Aeronautics Law was amended and put into effect on February 2000, so that supply/demand regulation policy was abolished and license for each route was no longer needed. The airfare regulation was also deregulated from approval regulation to prior notification. With regard to the congested airports, the approval regulation for slot allocation was adopted and subject to review per every five years based on pre-set allocation criteria.

2.2 Airport capacity expansion and growth of domestic aviation market

(1) Construction of the airports

Since 1967, long-term airport construction plan was set every five years[4]. The number of airports more than doubled in twenty years; from 45 in 1975 to 94 in 2002. In addition, the proportion of the runways compatible to jet aircrafts reached 64% by 2000. Also, airports that have the capability to enable take-off and landing of Boeing 747 size aircrafts comprise 34% of the total airports in Japan.

Table 1. Transition of 5 year (7 year) Long-term Airport Construction Plan (billion yen)

Section	1st	2nd	3rd	4th	5th	6th	7th
Period	1967-1971	1971-1975	1976-1980	1981-1985	1986-1990	1991-1995	1996-2002
Planned Investment	115	560	920	1710	1920	3190	3600
Real Investment	63.4	431.2	834.5	1066.6	2097.2	3319.4	2666
Achievement Ratio (%)	55.1	77.0 (82.1)	90.7 (95.9)	62.4 (65.8)	109.2 (116.5)	104.1 (109.9)	74.1 (78.4)

(Annotation)

(1) Figures in brackets show the achievement ratio against planned investment excluding reserve fund, adjustment costs.

(2) With regard to the 1st plan, planned investment cover the specified period, namely 5 years, however, real investment covers only cover 4 years, between fiscal year 1967 and 1970.

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4 The current 7th Long-term Airport Construction Plan, set out in 1996, was turned into a seven-year plan without increasing the total expenditure by a fiscal reform package set out in 1997. Thus the current plan terminates in fiscal year of 2002. The government is planning to integrate a number of long-term infrastructure construction plans such as roads, harbors, river management, etc. and have a comprehensive plan.

(3) As for the 7th plan, the real investment and achievement ratio were calculated based on figures from real investment between fiscal year 1996 and 2000 and adjusted budget of fiscal year 2000.

Source: Japan civil aviation promotion foundation, 2000, Air Transport Statistics.

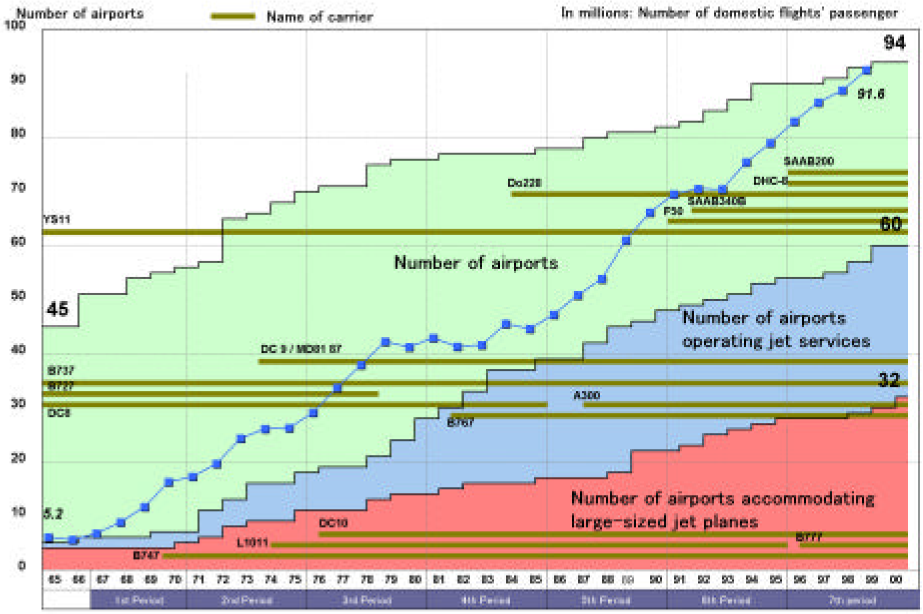


Figure1. The number of airports in Japan

Source: Civil Aviation Bureau, MLIT

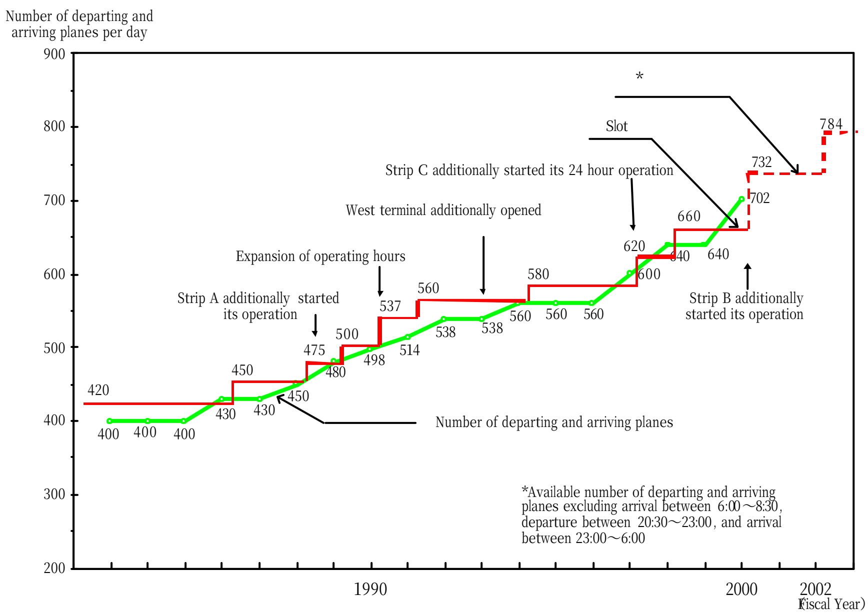


Figure2. Capacity expansion of Tokyo International Airport (Haneda)

Source: Civil Aviation Bureau, MLIT

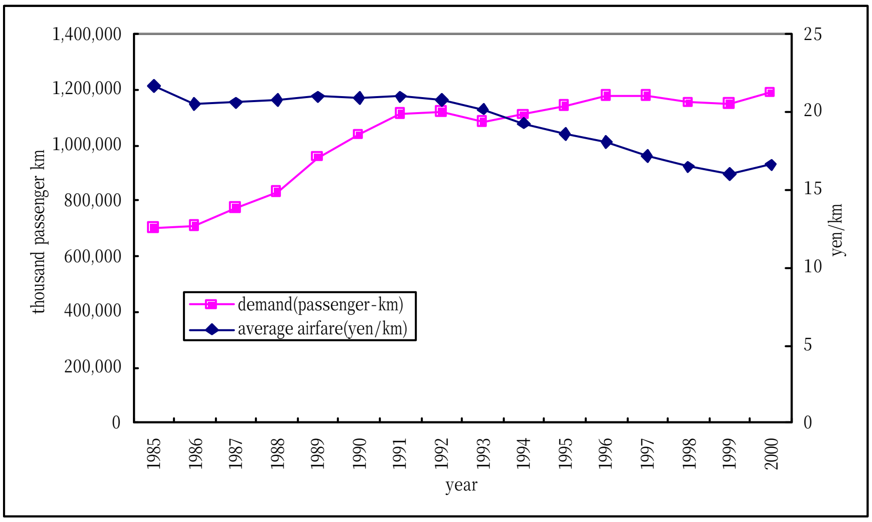
(2) Trends in aviation demand and airfare

Since the start of deregulation, Japanese domestic aviation market has experienced growth of demand and decrease in airfare level. Our presumptions of the market performance in the domestic since the mid '80s are as follows:

I. Improvement of income level per capita and enhancement of time value due to growth of the overall economy.

II. Relative drop in traveling cost as a consequence of deregulation and airport capacity expansion forcing the airline to operate more efficiently.

Figure3. The changes of average fare (yield) and demand in domestic airline(the major 3 firms)



※To calculate average fare[5] (yield), we divided the passenger fare revenue on each firm's financial report by passenger kilometer on Annual Statistics of Air Transport.

Source: Civil Aviation Bureau, MLIT

3. EVALUATION OF THE AVIATION POLICY BY THE PARTIAL EQUILIBRIUM ANALYSIS

In this chapter, we first describe our macro partial equilibrium model of the domestic aviation market. Then we calculate the users' benefit from deregulation and the airport capacity expansion of Haneda Airport in Tokyo.

3.1 Estimation of Demand and Supply Curve

Firstly, we estimate demand and supply curve with two-stage least squared (2SLS) method which can calculate incremental effects of both deregulation and airport capacity expansion.

In order to measure effects of various deregulation and airport capacity expansion, it is necessary to develop a partial equilibrium model, which explicitly includes variables representing both factors. Basically these policies seem to affect productivity of the airline companies. More concretely, we will estimate the supply curve installing these variables and the demand curve simultaneously.

Using time series data from 1985 to 1999, demand and supply curve was estimated setting the dependent variable and independent variable as follows. We sorted out the independent variables considering significance of t-ratios.

＜Demand Curve＞
Dependent variable：Passenger kilometer
Independent variables：Real yield （average fare per passenger kilometer）,
Real GDP （billion yen/year）

＜Supply Curve＞
Dependent variable：Real yield （average fare per passenger kilometer）
Independent variables：Passenger kilometer, Number of Haneda slots per day, Double-triple tracking ratio, Fare regulation dummy （1: after introduction of zone airfare system in 1996, 0: before 1995）

[note]
※Passenger kilometer means that of domestic major three firms: JAL, ANA, JAS

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5 Figures are in 1995 values.

※To calculate real yield, we divided the passenger fare revenue on each firm's settlement report by passenger kilometer on Annual Statistics of Air Transport.

※Double/triple tracking ratio stands for ratio of available seats in routes with multiple airlines operating against total available seats in the domestic market.

Dependant variables and independent variables are arranged to time series data shown in the following table;

Table 2. Data for demand and supply curve estimation

year	Real yield (yen／km)	Demand (thousand passenger kilometer)	Real GDP (billion yen／year)	Haneda slots (flight/day)	Double-triple tracking ratio(%)	Fare regulation dummy
1985	24.2	32439440	368184	420	52.8	0
1986	22.6	34556953	379895	450	56.7	0
1987	22.7	37644097	399442	450	58.9	0
1988	22.8	39981259	424657	475	62.6	0
1989	22.4	45548871	445468	500	65.2	0
1990	21.8	49757408	469780	537	65.2	0
1991	21.3	52976756	481660	560	67.6	0
1992	20.8	53812133	483375	560	70.3	0
1993	20.1	53763359	485498	560	73.1	0
1994	19.2	57469086	490730	580	74.1	0
1995	18.6	61253846	502794	580	74.9	0
1996	18.3	64984883	520053	580	75.0	1
1997	17.2	68533194	521315	620	76.6	1
1998	16.6	70125605	518380	660	78.9	1
1999	16.4	72137620	525695	660	79.9	1

Source: Civil Aviation Bureau, MLIT

The estimated results of parameter are shown in Table 3.

Table 3. The Estimation Results (1)

【Demand curve】

ln(Passenger kilometer)＝-0.012＋1.522ln(Real GDP)-0.696ln（Real yield）

(-0.0108) (21.51) (-10.36)

adjusted R square = 0.997 Durbin-Watson Ratio=2.16

【Supply curve】

ln(real yield)＝-3.39-0.125 fare regulation dummy-0.0186DT-0.788ln（Haneda slots）

(-0.82) (-4.06) (-2.63) (-1.73)

+0.713ln（Passenger kilometer）

(2.05)

adjusted R square = 0.923 Durbin-Watson Ratio =1.72

* figures in ( ) below the parameter is t-ratio. DT is Double-triple tracking ratio（%）。

c.f. Income and price elasticity of aviation demand in precedent studies

Long-term income elasticity +1.32, Long-term price elasticity -0.82

（Masui-Yamanouchi（1990））

Parameters are significant at 5% level except for Haneda slots which is significant at 10% level, and adjusted R squares and Durbin-Watson ratios are also acceptable. Estimated values of the income elasticity, 1.522, and price elasticity, -0.696, is in the same order as those in Masui-Yamanouchi (1990). Therefore estimation results could be considered acceptable.

3.2 Evaluation of Aviation Policies

Here we evaluate the various policies conducted in the period from 1986 to 1999 using the model we examined in previous section.

Considering the results in previous section, we intend to evaluate following three policies. The figures in brackets denote duration of effect we measure.

Table 4. The policies measured in the partial equilibrium analysis

(A) Introduction of zone flexible fare (1996〜1999)
(B) Double-triple tracking (1986〜1999)
(C)Expansion of Haneda Slots（1986〜1999）

We estimate the users' benefits of (A)〜（C） using the demand curves estimated by 2SLS.

(1) Economic impact of zone airfare system, double/triple tracking, and capacity expansion of Haneda Airport

Since the fare regulation dummy, Double/triple tracking ratio and Haneda slots are included as policy variables in the supply curve estimated by 2SLS, the users' benefits can be measured by examining shifts of the supply curves caused by the change of these variables. This can be interpreted as the result of improved productivity of airline companies.

Based on the idea above, we show the results of incremental users' benefits of each policy. We measured the users' benefit of each fiscal year[6] setting "without" and "with" as following; For (A), "without" is the case that the zone airfare system was not introduced, and "with" is the case that it was introduced in 1996. For (B), "without" is the case that double-triple tracking ratio is fixed at the level of 1985, "with" is the case that double-triple tracking ratio has increased since 1986 as it actually did. For (C), "without" is the case that the Haneda slots was not changed and stay at the level of 1985, "with" is the case that the Haneda slots have increased since 1986 as it actually did.

Table 5. Results of measured users' benefits by the partial equilibrium analysis
（billion yen/year, price at 1995）

year	(A) Introduction of zone flexible fare	(B) Double-triple tracking	(C)Expansion of Haneda Slots	sum
1985	0	0	0	
1986	0	39	29	68
1987	0	66	31	98
1988	0	116	61	177
1989	0	157	93	250
1990	0	170	143	313
1991	0	211	173	383
1992	0	250	172	422
1993	0	290	171	462
1994	0	308	195	502
1995	0	334	203	536
1996	102	346	209	657
1997	100	368	251	720
1998	98	394	285	777
1999	100	419	291	810
sum	399	3,468	2,307	6,175

6 Fiscal year in Japan starts from April and ends in March.

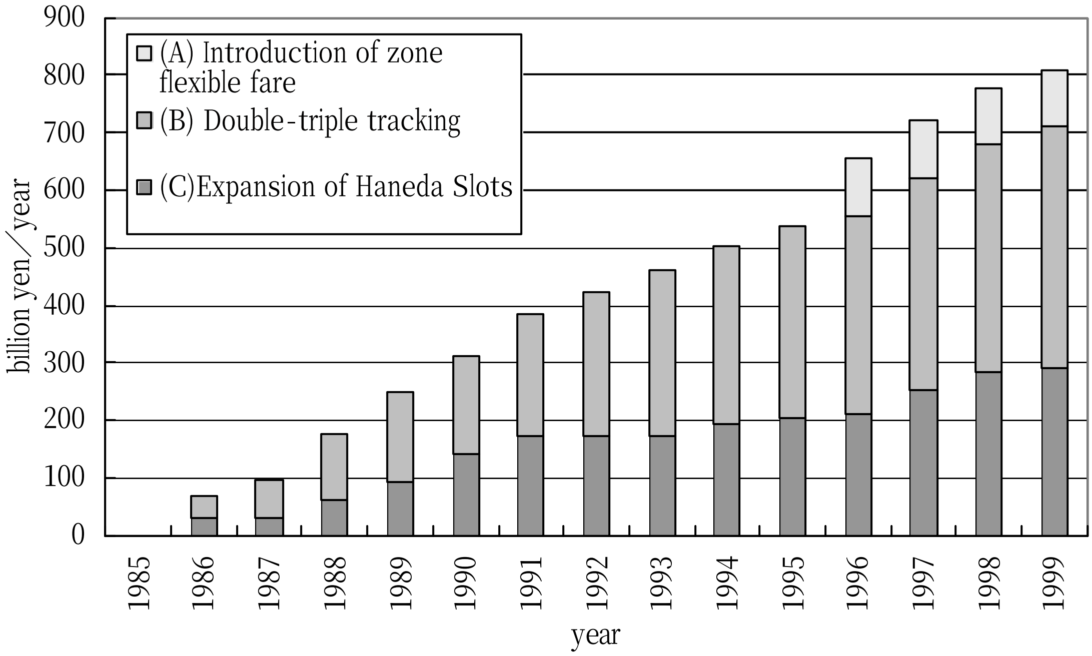

Figure4. Results of measured users' benefits by the partial equilibrium analysis (price at 1995)

Results show that the incremental users' benefit generated by the policy (A)～(C) during the 14 years is 6.2 trillion yen in aggregate, which is 440 billion yen in yearly average. This accounts for approximately 30% of market size of that period. (A) about 0.4 trillion yen by the introduction of zone flexible fare; (B) about 3.5 trillion yen by promoting double/triple tracking; (C) about 2.3 trillion yen by expansion of Haneda slots. In addition, the users' benefits increase year-by-year because the difference between the double-triple tracking ratio and Haneda slots from 1985 and those in the current year is magnified.

3.3. EVALUATION OF USERS' BENEFIT FROM IMPROVEMENT IN AVIATION NETWORK

In the previous parts, we have calculated impact of policies on airfares. This assesses "out of the pocket cost" of the total generalized cost associated with aviation. Another important component of generalized cost is reduction in travel time. This can be assessed as utility of aviation network. In this part, we use the utility function included in the air traffic demand forecasting model built for airport construction planning in the Civil Aviation Bureau to assess users' benefit generated by the improvement in routes and frequencies in the domestic aviation market.

The air traffic demand forecasting model we used is described in the report of aviation demand forecasting model by Institution for Transport Policy Studies under the supervision of Civil Aviation Bureau. A general description of the model is shown in Figure 5. The model is based on a common four step-estimation approach, which is composed of a series of sub-models from trip generation model to transportation mode selection model. Sub-models are combined by log sum variables so that change in the number of flights, for instance, affects each of the steps through log sum variable. As a result, this allows us to assess the impact of improvement in routes and frequencies taking account of induced transportation by altering traffic convenience. For details of the model see ITPS (2000).

Due to data constraints, aviation network in 1995 and 1999 was compared. Level of airfare is fixed so that we could capture only the reduction of generalized cost associated with travel time. With this method, we have estimated that users' benefit went up approximately 29 billion yen/year between 1995 and 1999.

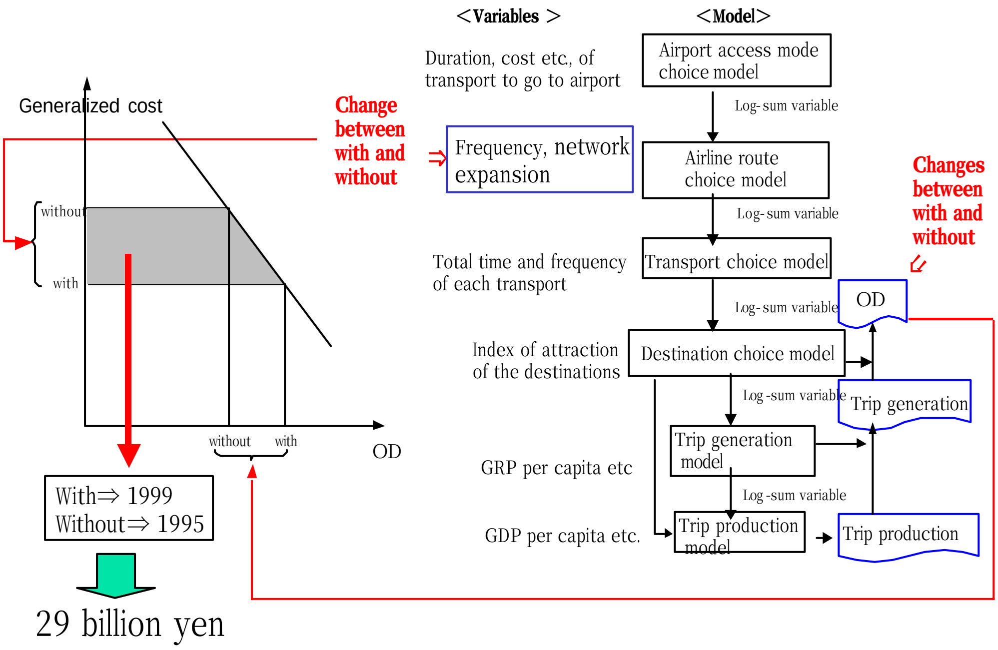

Figure5. Estimating users' benefits by air traffic demand forecasting model

4. EVALUATION OF SOCIAL WELFARE INCLUDING SPILLOVER EFFECT BY CGE MODEL

4.1 Introduction

In this chapter, in order to capture the impact of aviation policy including the spill-over effect of the policy, we utilize CGE model which is presented in Ueda, Kawai and Hayashiyama(1999). We evaluate the effect of double/triple tracking, fare deregulation, expansion of aviation network.

4.2. Model

The following description is based on Ueda, Kawai and Hayashiyama(1999).

(1)Outline

The model in this chapter has the following assumptions:

i) In the economy that we model, there are N households which can be aggregated into the representative one. There also exist a representative private firm which produces composite goods, and a representative of the transportation sectors road (r), railway (t), and aviation (a).

ii) The economy is in long-term equilibrium in the sense of the Walrasian tradition.

iii) Households have demand only for passenger transport service, while private firms have demand for both passenger and freight transport services.

The outline of the model is illustrated in Figure 6.

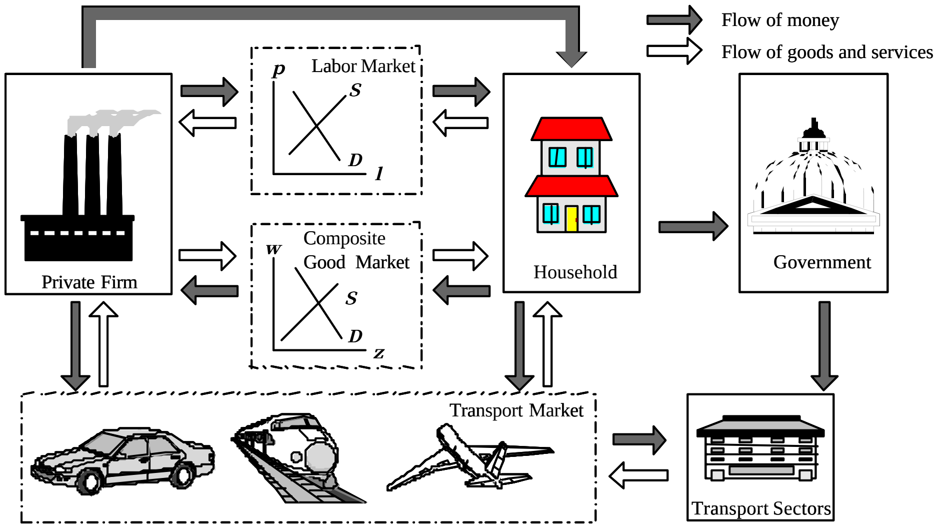

Figure6. Sketch of the Model

(2)Household

Any household behaves so as to maximize utility,
$U(z,s,x):(z,s,x)\in R_+\times R_+\times R_+^3 \mapsto U\in R$
which is a function of the consumption of a composite good, $z\in R_+$, leisure time $s\in R_+$ and passenger transport service $x=(x_r, x_t, x_a)\in R_+^3$, where r, t and a are for road, railway and aviation respectively. The household is subject to monetary and time resource constraints. Monetary constraint means that the expenditure for the composite good z, passenger transport service $px\in R_+$ and lump-sum tax $m\in R_+$ must be equal to the sum of wage income wl and dividend income $y\in R_+$. $p=(p_r, p_t, p_a)\in R_+^3$ is the vector associated with transportation service prices or out-of-pocket costs which are for road, railway and aviation, respectively. $w\in R_+$ is the wage rate and $l\in R_+$ is the labor or working time which the household provides. Time resource constraint means that the sum of leisure time s, working time $l\in R_+$ and time spent for trips $tx\in R_+$ must be equal to total available time $\Omega\in R_+$. $t=(t_r,t_t,t_a)\in R_+^3$ is the vector associated with average travel time which are for road, railway and aviation, respectively. With these notations, the household's behavior is formalized:

$$V(w\Omega+y-m, p+wt, w)=\max_{z,s,x} U(z,s,x) \qquad \text{......(1)}$$

$$s.t. \quad z+px+m=wl+y \qquad \text{......(2)}$$

$$l+s+tx=\Omega. \qquad \text{......(3)}$$

$p+wt\in R_+^3$ is the vector of generalized transport service price which includes out-of-pocket cost and time cost, and $w\Omega\in R_+$ is the full wage income which the household is able to receive when providing all time resources.

(3) Private Firms

In the economy that we model, the private firm behaves so as to maximize profit under the constraint of progressive production technology. We assume that technology progresses as the years go by. The firm is assumed to be a price taker because markets, except for transport markets, are competitive. Technology means that inputs of labor $L\in R_+$, passenger transport service $X\in R_+^3$ and road flight transport service Q are transformed into output, or composite good Z.

$X=(X_r, X_t, X_a)^t\in R_+^3$ is the vector associated with passenger transport services which are fore road, rail and air, respectively. Since the volume of freight transport by rail and aviation has been very small compared to freight by road ,we consider only road freight transport in the model, while keeping in mind that industrial shift in the past decades was an important factor in the freight transport market as well as in flight costs. The firm must allocate a portion of labor in terms of working time to passenger trips and freight trips, which are measured by travel time, $t X \in R_+$ and $t_q Q \in R_+$. $t_q \in R_+$ is the average travel time of a flight trip. Then we can define the function, $z\left(L - t_q Q_q - t X,\ Q, X, n\right): \left(L - t_q Q_q - t X,\ Q, X\right) \in R_+ \times R_+ \times R_+^3 \mapsto Z \in R_+$. Since we are interested in technological progress, we assume that the production technology depends on the index for year n.

As the price of the composite good is normalized to be one, Z directly represents the revenue. Cost terms are freight cost, $p_q Q \in R_+$, passenger transport cost $pX \in R_+$ and labor cost $wL \in R_+$.
$R_q \in R_+$ is the price of freight transport service.

$$p\ \left(p + wt,\ p_q + wt_q,\ w,\ n\right) = \max_{Q,X,L} Z - p_q Q - p\,X - w\,L \text{ .... (4)}$$

$$s.t.\quad Z = Z\left(L - t_q Q - t' X,\ Q,\ X, n\right) \text{ .... (5)}$$

where we also assume

$$\frac{\partial Z}{\partial\left(L - t_q Q_q - t X\right)} > 0 \quad (6), \qquad \frac{\partial Z}{\partial Q_i} > 0 \quad (7), \qquad \text{and} \quad \frac{\partial Z}{\partial X_i} > 0\left(i \in \{r, t, a\}\right). \qquad (8)$$

(4) The Transport Sector

Each of the transport sectors is assumed always to keep zero profit. The revenue is always equal to the running cost in terms of the composite goods, c_r and $c_i\left(i \in \{r, a\}\right)$. Investment is covered by the lump-sum tax m through the government. Then m is to be allocated into the investment in each transportation mode $m_i\, i \in \{r,\ t,\ a\}$, and therefore $m = m_r + m_t + m_a$.

$$c_r = p_r\left(Nx_r + X_r\right) p_q Q \text{ .... (9)}$$

$$c_i = p_i\left(Nx_i + X_i\right) \text{ .... (10)}$$

(5) Modification of Generalized Cost

Accumulation of stock of transportation infrastructure not only reduces travel time but also improves availability of transportation service for all households and private firms in the economy. Since we ignore the spatial structure of the economy in this model, changes in travel time may insufficiently represent the impact of high-speed transport projects. We may therefore modify generalized cost of transportation service so that the accumulation of stock of transportation infrastructure would be reflected.

First we calculate the generalized cost by using average out-of-pocket cost per distance (km), average travel time per distance and average wage rate as the value of time. Then we multiply the generalized cost with the coefficient $S_i(n)$ for mode i and in the year n, which is a decreasing function of stock of transportation infrastructure $I_i(n)$, as in

$$S_i(n) = 1 + b_i \exp\left(-a_i\ I_i\ (n)\right) \text{ .... (11)}$$

where a_i and $b_i\left(i \in \{r,\ t, a, q\}\right)$ are positive parameters. As the stock of transportation infrastructure $I_i(n)$ is accumulated, $S_i(n)$ decreases. This means that accumulation of stock plays the same role in inducing transport demand as a reduction in the generalized cost. The term $1/S_i(n)$, which will later appear in specified transport demand function , has the same form as a logistic function. Hence, the marginal effect of accumulation of stock on the induction of transportation demand has a property of diminishing return to scale with respect to $I_i(n)$. We employ the total network length of expressway, the total length of Shinkansen (the "Bullet Train"), and the total length of airport runway as a proxy for infrastructure stock $I_i(n)$ in each year n.

By replacing the generalized transport service price in the indirect utility function already defined in (1) with the above modified one, the stock of transport infrastructure becomes an ingredient of utility function and therefore plays a key role in demand functions. Hence we can estimate the parameters in the function $S_i(n)$ from the observed transport demand as well as other parameters in the demand functions specified later.

(6) Equilibrium Conditions

In equilibrium, aggregate demand should be cleared with aggregate supply in both the composite goods market and the labor market:

$$N(z+m)+C'I=Z \quad \text{.........} (12)$$

$$Nl=L, \quad \text{.........} (13)$$

where $C=(c_r, c_t, c_a)\in R_+^3$. With the constraint for household and the adding up condition for the dividend income $p=Ny$, the Walras Law must hold as well as the standard Walrasian General Equilibrium Model. Then the one equation of (12) and (13) is redundant while the other alone determines the wage rate w in equilibrium.

4.3 Specification of Functions

(1) Households

We first specity the utility function $U(z,s,x)$ as the log linear type:

$$U(z,s,x)=b_z In\,z+b_r\,I\,n\,x_r+b_t\,I\,n\,x_t+b_a\,I\,n\,x_a+b_s\,I\,n\,s, \text{....} (14)$$

where b_i , $i\in\{z,r,t,a,s\}$ is a positive parameter and $b_z+b_r+b_t+b_a+b_x=1$.

(2)Private Firms

We specify the production function as the Cobb-Douglas type and describe the technological progress term by a power function:

$$Z=A(n-n_0)^{a_n}\left(L-t_q Q-t'X\right)^{a_1} Q^{a_q}\ X_r^{a_r}\ X_t^{at}\ X_a^{a_a} \text{............} (15)$$

where n denotes a year and $A, n_0, a_i\,(i\in\{l, q, r, t, a, n\})$ are positive parameters.

4.4 Benefit Definition by Equivalent Variation(EV)

We use Equivalent Variation (EV) as a benefit measure:

$$V\left(w_o\,\Omega+y_o-m_o+EV,\ p_o+w_o\,t_o\,,\ w_o\right)=V\left(w_w\,\Omega+y_w-m_w\,,\ p_w+w_w\,t_w\,,\ w_w\right),$$

$$\text{.........} (16)$$

where subscripts w and o mean with project and without project, respectively.

4.5 Date Source

We have employed data extracted from the sources listed in Table 6. Most of the sources were developed by the Japanese central government.

Table 6. Date Source

Date Item		Source
Economic Indicators	Production Z	National Economic Accounting
	Population N	Population Census, Citizen Registration
	Labor L	Lobor Annual Statistics
Transport Volume	Rail x_t, X_t	20 Years of Shinkansen, Perspection of Shinkansen
	Road x_r, X_r, Q	Handbook of Expressway
	Air x_a, X_a	Air Transport Annual Statitics
Investment/ Running Cost	Rail m_t, c_t	20 Years of Shinkansen, Rail Transport Annual Statistics
	Road m_r, c_r	Annual Report of Expressway
	Air m_a, c_a	Air Transport Annual Statitics, Public Investment
Out-of-Pocket Cost	Rail p_t	Estimated by Authors
	Road p_r, p_q	Estimated by Authors
	Air p_a	Estimated by Authors
Travel Speed	Rail	160km/h
	Road	80km/h
	Air	500km/h

4.6 Evaluation of the aviation policies

(1) Policies to be evaluated

In this section, we evaluate the effect of various policies implemented between 1986 and 1999 using CGE model as indicated above.

In addition to the introducing zone airfare system, double/triple tracking, expanding Haneda slots, expansion of the aviation network targeted in the partial equilibrium analysis, we assess the consequence of the reduction of landing fee implemented in 1999 at the second class air port. The chart below is listing of targeted governmental policies. The number in parentheses shows evaluating period.

Table 7. Policies evaluated by CGE model

（A） Introduction of zone flexible fare （1996～1999）
（B） Double-triple tracking (1986～1999)
（C） Expansion of Haneda Slots (1986～1999)
（D） Expansion of aero network （1986～1999）

As to (A),(B),(C), we calculate the percentage of airfare change by demand and supply curve estimated by 2SLS, and we input this into CGE model and evaluate EV.
As to （D）, we assume ‘without case’ for any year in the period is the situation in which the stock of airports is the same as in 1985, and ‘with case’ is the situation in which the stock of airports is accumulated like the actual case.

(2)Result of evaluation

Table8. shows the result of evaluation. In this table, spillover effect is feedback effect from the markets other than transport market. Spillover effect accounts for about 20～30% of EV in each result. Large potential of the spillover effect of aviation policy should also be noted.

Further, when we compare respective effect among policies, it is possible to confirm that the effects, such as that of （C） Expanding Haneda slots and （D） Expansion of the aviation network, which are thought to fortify the airport facilities, gave figures in trillions as a grand total for 14 year and also that promoting the steady airport facility construction to date brought about a great advantages to the users. In the meantime, the deregulation initiative lik （A） Introducing flexible fare delivered the benefit of two hundred millions. We need to bear in mind the importance of the deregulation initiatives. An important implication from this analysis is that deregulation and airport capacity expansion both play significant roles in realizing full benefit of aviation market growth.

Table 8. Result of Evaluation by CGE model

(billion yen/year, price at 1995)

	(A)		(B)		C)		D)	
fiscal year	EV	Spill over effect	EV	Spill over effect	EV	Spill over effect	EV	Spill over effect
1986			82	31	61	23	72	25
1987			135	50	64	24	114	41
1988			228	87	121	46	153	57
1989			295	113	175	67	219	83
1990			305	120	257	101	424	166
1991			359	131	295	107	490	179
1992			419	145	291	101	533	186
1993			479	149	286	89	561	177
1994			494	139	316	89	549	158
1995			529	151	325	93	570	166
1996	169	51	562	171	344	105	587	181
1997	177	54	629	191	435	132	476	143
1998	175	48	678	186	497	137	449	122
1999	185	52	740	207	523	146	387	105
sum	706	205	5,932	1,870	3,991	1,260	5,583	1,790

(3) Comparison of the results from partial equilibrium analysis and CGE model

In this section, we evaluate the outcome of (A), (B), (C), and (D) policies based on partial equilibrium analysis that uses CGE model by supposing 1995 as ‘without’ and 1999 as ‘with’. We summarize the conclusion of the comparing two measures as below. In a theoretical sense, consumer surplus calculated by partial equilibrium analysis should be equivalent to the EV based on CGE model minus the spillover effect. From the chart below, we can see these figures are not exactly the same but almost equivalent. There is considerable difference in data used for partial equilibrium analysis and for CGE model here, however, we can reach to the conclusion that the evaluation result with CGE model carries the reasonable degree of validity as the calculated effect figure of two approaches are in the same order.

Table 9. Result of Evaluation by CGE model

（with:1999、 without:1995）

	Annual benefit calculated by partial equilibrium analysis （billion yen, price at 1995）	Annual benefit calculated by CGE （billion yen, price at 1995 ） (［ ］: spillover effect)
(A) Introduction of zone flexible fare	97※1	177 [50]
(B) Double-triple tracking	71※1	129 ［36］
(C) Expansion of Haneda Slots	79※1	143 ［43］
(D) Expansion of aero network	29※2	25 ［9］

*1：The effect of fare reduction estimated by 2SLS.
*2：Estimated by utility function in the aviation demand forecast model .

5. CONCLUSION

In this paper, social welfare of deregulation and airport capacity expansion in Japan was analyzed using both partial and general equilibrium approaches. The impact of the aviation policy was first evaluated by calculating decrease in out-of-pocket cost of domestic aviation passengers using demand and supply curve estimation by 2SLS. The result was then applied to a SAM based CGE model to capture social welfare including spillover effect that is fed back to the aviation market from other industries and households.

From our analysis, incremental users' benefit between 1985 to 1999 from deregulation and expansion of Haneda Airport amounts to 440 billion Japanese yen in yearly average. This accounts for approximately 30% of market size of that period. In addition, 60% of the users' benefit, 280 billion Japanese yen, was assessed as the consequence of deregulation. Further, as a result of CGE model analysis, we learn that spillover effect accounts for 30% of the total social welfare derived from these policies.

As a result of this analysis, it was confirmed that in order to realize social welfare by expanding domestic aviation market, both aviation policies in economic areas and those in infrastructure both play significant roles. In addition, we should pay attention to the fact that aviation policies are capable of inducing considerable spillover effect from their impact on various industries and households.

An important implication from this analysis is that inter-city transportation policy in the economic regulation area and infrastructure investment both play significant role in realizing tfull benefit of market growth. Large potential of the spillover effect of inter-city transportation policy should also be noted. Further study is deemed important in modeling oligopolistic nature of the aviation market as well as to identify current and future bottlenecks in airport capacity.

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