Simultaneous Optimization of Airport-Related Tax and Charges Considering the Marginal Cost of Public Funds

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Airport management costs are financed by revenues from multiple airport-related charges (e.g., passenger service facility charge, and aviation fuel tax) and the general fund. A change in the rate of a charges affects revenues from other charges through changes in airlines supply (airfares and flight frequency) and passengers' trip decisions. That is, the charges are dependent on each other in terms of the total revenue. This study quantitatively optimizes the rates of three airport-related charges to maximize social welfare. The model includes consumers (demand side), airlines (supply side) and a government that sets the charge rates. The number of airlines is limited, so the air market is described by an oligopoly market. Our quantitative analyses show that long-distance routes are strongly affected by the oligopolistic competition among the airlines. In addition, we show that if we optimize the charges subject to the current total charge revenue, the marginal cost of public funds (MCPF) for the charges is calculated to be about 2.8. This MCPF is very large, compared to other government taxes, such as labor tax (which is estimated at 1.0-1.2).

Key Words : *Airport-related charge, Optimal taxation, Marginal cost of public funds*

1. INTRODUCTION

An airline industry is an important infrastructure for long-distance transportations. So, it is important to optimize airport-related charges that finance airport managing cost such as airport facilities. In this study, we consider three main charges: per-passenger charge, per-flight weight charge and aviation fuel tax. Per-passenger charge is imposed according to number of passengers, per-flight weight charge is imposed according to the number of landings and aviation fuel tax to fuel consumption.

This paper calculates the optimal airport-related charges quantitatively from the viewpoint of social welfare considering Marginal cost of public funds (MCPF). Results of analyses indicate oligopolistic competition effects strongly affect flight frequency on long-distance routes. Furthermore, we estimate the MCPF in the situation where the total charge revenue is fixed and the charges are optimized. The calculated MCPF is about 2.8, which is much larger than that of labor tax. So, it is desirable more subsidy from labor tax revenue should be invested to airport managing than the present level.

2. THE MODEL

The model includes airlines (supply side), consumers (demand side) and a tax-and-charge collecting agency (government). We analyze annual trips and a static situation.

Airlines simultaneously decide their airfares and flight frequency to maximize their own profits route by route. The maximization problem of airline j on route rs at time t is assumed

$$\max_{p_{jr_st},f_{jr_st}} \pi_{jr_st} = \left(p_{jr_st} - \overline{mc^q}_{jr_st} - AFC^Q_{jr_st}\right) q_{jr_st}(\mathbf{p}_{r_st}, \mathbf{f}_{r_st}) - \left\{\overline{mc^f}_{jr_st} + AFC^F_{jr_st} + (\bar{g}_t + TFuel) \times \bar{d}_{jr_st}\right\} f_{jr_st} \qquad (1)$$

where π_{jr_st} is the profit of airline j on route r_s at time t, $\bar{g}_t$ is fuel price, p_{jr_st} is airfare and f_{jr_st} is flight frequency. q_{jr_st} is the number of passengers which is a function of airfares and flight frequency of all airlines that operate on a route r_s at time t. $\overline{mc^q}_{jr_st}$ and $\overline{mc^f}_{jr_st}$ are the marginal cost with respect to the number of passengers and flight frequency respectively, and $\bar{d}_{jr_st}$ expresses the fuel consumption on a round trip. The three charges are represented by $AFC^Q{}_{jr_st}$ (per-passenger charge), $AFC^F{}_{jr_st}$ (per-flight weight charge) and $TFuel$ (aviation fuel tax). Airlines decide their airfares and flight frequency to satisfy the first-order conditions of Eq. (1).

A consumer decides his/her traveling decisions $\delta^i_{jr_st}$ on every route, his/her quantity of composite goods z^i and his/her leisure time y^i to maximize his/her utility. The consumer's time and budget constraints are

$$y^i + L^i + \sum_j \sum_{r_s} \sum_t \delta^i_{jr_st} T_{jr_st}(f_{jr_st}) + \sum_{r_s} \sum_t (1 - \sum_j \delta^i_{jr_st}) \overline{T}_{0r_st} = \overline{M} \quad (2)$$

$$z^i + \sum_j \sum_{r_s} \sum_t \delta^i_{jr_st} p_{jr_st} + \sum_{r_s} \sum_t (1 - \sum_j \delta^i_{jr_st}) \overline{p}_{0r_st} = \left(\overline{w}^i - \tau\right) L^i \quad (3)$$

where $\left(\overline{w}^i - \tau\right) L^i$ is the income composed of pretax wage $\overline{w}^i$ less the labor tax τ and labor time L^i for consumer i. p_{jr_st} is airfare and T_{jr_st} is travel time on route r_s. $\bar{p}_{0r_st}$ is cost and $\bar{T}_{0r_st}$ is time consumption of outside option (e.g. travel by train).

The Consumer's decision of traveling is specified by a nested logit model. From the two constraints, the consumer's indirect utility function is specified as follows.

$$v^i_{jr_st} = \alpha p_{jr_st} + \beta f^{\rho}_{jr_st} + \mathbf{x}'_{jr_st} \gamma + \xi_{jr_st} + \nu_{ir_st} + (1 - \sigma_{r_s}) \epsilon_{ij} \quad (4)$$

$\mathbf{x}'_{jr_st}$ expresses the observable airline-route characteristics such as aircraft size and ξ_{jr_st} is the unobserved characteristics. ν_{ir_st} and ϵ_{ijr_st} are error terms which produce the nest structure. When σ_{r_s} is zero, the model is a standard logit model. As σ_{r_s} approaches one, the substitutability between airlines becomes high.

The government set the charge rates to finance an expenditure for airports $\bar{G}$. The government budget constraint is

$$\begin{aligned} \overline{G} &= K + T \\ &= \sum_s \sum_j \sum_{r_s} \sum_t \left\{ AFC^Q_{jr_st} \times q_{jr_st}(\cdot) + \left(AFC^F_{jr_st} + TFuel \times \overline{d}_{jr_st} \right) \times f_{jr_st} \right\} + a \sum_i \tau L^{i*} \end{aligned} \quad (5)$$

The total charge revenue is K, the first term of the right-hand side and the labor subsidy from labor tax revenue is T, the second term. The subsidy rate is expressed by parameter a. This rate is set endogenously as well as exogenously for our study. $\bar{G}$ is set exogenously.

This paper explores three scenarios. Scenario 1 supposes ideal situation where the government optimizes all the three charges and Scenario 2 supposes real situation where the government optimizes only per-flight weight charge and aviation fuel tax. In scenario 1 and 2, The subsidy rate a is set endogenously. In Scenario 3, the government optimizes all the three charges but a is set as exogenously.

The social welfare function is composed of consumer surplus CS_{r_st} and producer surplus PS_{r_st}. The Lagrangian formulation of social welfare maximization problem with the budget constraint is

$$\Phi = \sum_s \sum_{r_s} \sum_t CS_{r_st} + \sum_s \sum_{r_s} \sum_j \sum_t PS_{jr_st} + \varphi \left(K - \overline{K} \right) \quad (6)$$

$\overline{K}$ is the present total charge revenue. Lagrange multiplier φ express –MCPF.

3. PARAMETERS

This study uses monthly data by route and airline from 2000 to 2005.

We estimate the demand parameters by using a generalized method of moments (GMM) approach with the population moment condition of a product of ξ_{jr_st} and the exogenous variables. We use the method of instrumental variables to address endogeneity problem between ξ_{jr_st} and airfares, flight frequency and share within airlines.

The result of estimation is omitted due to space limitations.

4. OPTIMIZATION OF CHARGES

We calculate the optimal airport-related tax and charges and labor tax τ with the real data in 2005. The result of optimization under scenario 1 with MCPF = 1.2 is shown in Table 1.

Table 1 shows that the optimization of the charges is important to improve social welfare.

Table 1 Optimal tax and charges under scenario 1

	Present	Scenario1 (MCPF = 1.2)
Per-passenger charge [10^3 yen]	0.1	2.0
Per-flight weight charge [10^3 yen]	100	120
Aviation fuel tax [10^3 yen]	26.0	**-134**
The total charge revenue [10^{10} yen]	15.6	-33.3
Social welfare [10^{10} yen]	66.9	**118.5**
Flight frequency [round trip per day]	**3.38**	**8.73**

As shown in Table 1, Per-flight weight charge is 120 percent of the present level. This result implies MCPF with respect to per-flight weight charge is less than 1.2. On the other hand, the optimized fuel tax is negative, which means MCPF with respect to the aviation fuel tax is more than 1.2. This result indicates that long-distance routes make relatively larger dead weight loss than short-distance routes do, because aviation fuel tax can affect more flight frequency of long-distance routes than that of short-distance routes. So, oligopolistic competition effects affect more strongly on long-distance routes than short-distance routes.
Table 1 also indicates the present flight frequency is not sufficient and it should be corrected to improve the social welfare with aviation fuel tax subsidy.
The result of optimization under scenario 3 is shown in Table 2. And we calculate MCPF of the charges numerically.

Table 2 Optimal tax and charges under scenario 3

	Present	Scenario3
Per-passenger charge [10^3 yen]	0.1	2.4
Per-flight weight charge [10^3 yen]	100	100
Aviation fuel tax [10^3 yen]	26.0	**-42**
The total charge revenue [10^{10} yen]	**15.6**	**15.6**
Social welfare [10^{10} yen]	66.9	**95.1**
Flight frequency [round trip per day]	3.38	4.10

Table 2 shows that if the subsidy from labor tax revenue is limited, social welfare can be improved by the optimization of the charges.

The MCPF in this situation is calculated to be about 2.8. This implies more subsidy from labor tax revenue should be invested to the airport managing than the present level because the MCPF of the charges is larger than that of labor tax.

5. CONCLUSION

This paper optimizes the airport-related charges considering MCPF and calculated MCPF of the charges. The results of calculation are that the optimized aviation fuel tax rate is negative and MCPF of the charges is about 2.8. These results show that long-distance route is affected strongly by an oligopolistic competition and the subsidy from labor tax revenue should be invested more to improve social welfare.

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