QUALITY COMPETITION IN THE MARKET OF SCHEDULED PASSENGER TRANSPORTATION

YASUO USAMI*

Whether competition produces socially desirable results in the markets of scheduled passenger transportation in the United States has been an open question since they were brought under governmental regulation. The domestic airline markets under Civil Aeronautics Board regulation is characterized by vigorous nonprice competition which bids away most implicit rents. By describing scheduling competition in the domestic airline markets G. W. Douglas and J. C. Miller III analyzed the process of iteration of higher fares and increasing capacity [3, 4]. In these markets there is an endogenous relationship between the regulated price and the overall general quality level of the output. Carrier profits are a principal target of policy but the implications of price regulation are manifested in the overall quality level. The regulator's control of rents is more directly related to the nature of restraints on entry. In this note we will consider an alternative formulation of nonprice competition with a definition of quality as carrier's individual level of service convenience rather than the market's overall level of service convenience.

I. THE VALUE OF TIME AND THE DEMAND FOR TRANSPORTATION

In passenger transportation, the demand for the various transportation services is derived from the demand for trips. The demand for trips depends, in turn, on the utility they yield and on their contribution to the production of a visit to the point of destination. The activity "visit" is produced to yield direct utilities when the visit is for personal purposes, or to serve as an input in the production of market goods when the visit is for business purposes. But, whether the purpose of visit is personal or business, the customer desires the greatest possible speed and comfort at the lowest possible price, if the discomfort of traveling increases with traveling time or time itself is a scarce resource. The effect of traveling time on customer preference for the various transportation services can be discussed in either way. When the utility a traveler derives from a trip is directly related to the amount of traveling time involved, differences in traveling time by different modes of transportation serving the same route are reflected in the utilities these modes yield and the choice of a mode of travel is explained in terms of the amount of discomfort involved. When time is a scarce resource, on the other hand, elapsed time is considered as one of the factors affecting the total price of a trip. The

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latter approach was explored by R. Gronau, who applied the model of Becker's theory of time to the explanation of the modal choice of travel. In this explanation, a household can be regarded as a producer of activity "visit", combining its own time with market goods and services. The production process is subject to two constraints: the budget constraint determines the total expenditures on the market inputs and the time constraint determines the total expenditures of time inputs.

In this paper, we will assume that the trip does not convey any direct utility and time is a scarce resource. When the trip does not convey any direct utility, the various transportation services are regarded merely as different combination of the time and money inputs required to produce a trip. The derived demands for various transportation services are determined so as to minimize the total cost of trips. If price is regulated in the market of transportation services, the uniform price implies the equalization of travel time among the transportation companies. The market demand for them is thus expressed as:

$$\textstyle\sum_i x_i = x(p^x, T)\,,$$

and

$$T_i = T \qquad \text{for all} \quad i\,,$$

where

x_i = the number of passenger trips demanded for company i per time period,
p^x = the regulated average fare,
T_i = the traveling time of company i.

II. THE EXPECTED SCHEDULE DELAY

While the elapsed time the trip will require consists of enroute time alone if a vehicle is available at the traveler's desired departure time, this assumption of the instant availability does not hold for the scheduled passenger transportation. A period of time must elapse between the traveler's desired departure time and the first scheduled departure. Furthermore, when the first departure is sold out, the would-be traveler may incur additional delay. Douglas formulated these scheduling delay as a queuing phenomenon in a Markov process. The capacity of a vehicle is fixed and each vehicle is allowed to be dispatched once per time period. Then, given its total capacity, Q_i, and assuming that passengers arrive at a constant rate of x_i per time period, we can uniquely determine the expected schedule delay for an individual company i:

$$D_i = D^i(x_i, Q_i)\,,$$
$$D^i_x = \partial D^i/\partial x_i > 0\,, \qquad D^i_Q = \partial D^i/\partial Q_i < 0\,.$$

When the demand and the capacity increase keeping the average load factor, x_i/Q_i, constant, the expected schedule delay will decrease. Thus we assume:

$$D^i_x(x_i/D_i) + D^i_Q(Q_i/D_i) < 0\,,$$

which will turn out to be a crucial condition in the following analysis.

III. PRICE REGULATION AND QUALITY COMPETITION

An important characteristic of the Douglas-Miller model is that the market's overall level of service convenience and the market shares are both determined through scheduling competition among the carriers but there is no explicit consideration of quality competition. In this respect, it is important to note that there are two types of service quality: the market's over-all level of service conveninece and the firm's individual level of service convenience. There are some cases of market share competition where we may well consider the market's overall level of service convenience but we cannot specify the firm's individual level of service convenience. Congestion caused by the market share competition among taxicab companies is the case. The service quality of this type is a kind of public goods and the market's overall level of service quality gives effects upon the aggregate level of market demand but not upon its relative shares. It is necessary to introduce some additional mechanisms for the determination of the market shares. But in other cases, we can explicitly define the firm's individual level of service convenience, and the market shares themselves are determined through the equilibriating process of these service qualities among companies.

In the model of scheduled passenger transportation, we will consider the expected schedule delay as the firm's individual level of service quality. Given their flight frequencies and total capacities, $(Q_1, \cdots, Q_n)$, the transportation companies adjust their flight schedule to the incoming demand flows, $(x_1^0, \cdots, x_n^0)$, resulting in the expected schedule delays, $(D_1^1, \cdots, D_n^1)$. But this state of service qualities may cause the customers' reswitching of demand and bring about new stationary demand flows, $(x_1^1, \cdots, x_n^1)$, which, in turn, necessitate the readjustment of flight scheduling, and so on. The equilibrium level of sercice qualities and the market shares corresponding to the given total capacities must satisfy the following system of equations:

$$\begin{aligned} &\textstyle\sum_i x_i = x(p^x, T)\,, \\ &T = D + t\,, \\ &D = D^i(x_i, Q_i) \qquad (i = 1, \cdots, n)\,, \end{aligned}$$

where t is the common enroute time.

Totally differentiating the market demand function and the quality equalization equations, we will obtain

$$\begin{bmatrix} dx_1 \\ \vdots \\ \vdots \\ dx_n \\ dD \end{bmatrix} = \begin{bmatrix} D_x^1 & 0 \cdots 0 & -1 \\ 0 & \vdots & \vdots \\ \vdots & \vdots & \vdots \\ 0 & \cdots\cdots D_x^n & -1 \\ -1 & \cdots\cdots -1 & x_D \end{bmatrix}^{-1} \begin{bmatrix} -D_Q^1 & 0 \cdots 0 \\ 0 & \vdots \\ \vdots & \vdots \\ 0 & \cdots\cdots -D_Q^n \\ 0 & \cdots\cdots 0 \end{bmatrix} \begin{bmatrix} dQ_1 \\ \vdots \\ \vdots \\ \vdots \\ dQ_n \end{bmatrix}$$

We will assume the perfectness about the carriers' perception of the impact on firm demands of any change in flight frequencies.

With the regulated price, p^x, as a parameter, then, the aim of carrier i in the market of scheduled passenger transportation is to maximize:

$$P_i = p^x x^i(Q_1, \cdots, Q_n) - (wL_i + rK_i + p^Q Q_i)\,,$$

subject to,

$$x^i(Q_1, \cdots, Q_n) = f^i(L_i, K_i),$$
$$x^i(Q_1, \ldots, Q_n) \leqq Q_i\,,$$

where

P_i = the profits of carrier i
w = the rate of wage
r = the rate of interest
p^Q = the price of a vehicle
L_i = the labor input for providing passenger services
K_i = the capital input for providing passenger services
f^i = the production function of carrier i.

The second behavioral assumption is that a unilateral increase in flight frequency is thought to cause no rivals' response. Without scale economies associated with firm size in providing passenger services,

$$(wL_i + rK_i)/x_i = c\,,$$

where c is a constant. Since $D^i(x_i, Q_i)$ tends to be infinitive as x_i/Q_i goes to one, D_i is finite only if the second constraint in the maximization problem does hold. Thus, the first-order conditions are expressed as:

$$(p^x - c)\partial x_i/\partial Q_i = p^Q\,,$$
$$cf_L^i = w\,,$$
$$cf_K^i = r\,,$$

where the impact on firm demand of a unilateral increase in flight frequency, $\partial x_i/\partial Q_i$, would be obtained from the system of equations formulated above;

$$E(x_i, Q_i) = -(1 - k_i s)\cdot e(D, Q_i)/e(D, x_i)\,,$$
$$E(D, Q_i) = k_i \cdot s \cdot e(D, Q_i)\,,$$

where

$$E(x_i, Q_i) = (Q_i/x_i)(\partial x_i/\partial Q_i)\,,$$
$$E(D, Q_i) = (Q_i/D)(\partial D/\partial Q_i)\,,$$
$$e(D, Q_i) = (Q_i/D)\cdot D_Q^i\,,$$
$$e(D, x_i) = (x_i/D)\cdot D_x^i\,,$$
$$k_i = \frac{a_i/e(D, x_i)}{\sum_j a_j/e(D, x_j)}\,,$$

$$s = \frac{-\sum_j a_j/e(D, x_j)}{e(x, D) - \sum_j a_j/e(D, x_j)},$$
$$e(x, D) = (D/x)\cdot x_D,$$
$$a_i = x_i/\sum_j x_j.$$

$E(D, Q_i)$ denotes the elasticity of the expected schedule delay with respect to a unilateral increase in flight frequency while repercussions on demand are allowed, and $e(D, Q_i)$ without repercussions.

The equilibrium in the market of scheduled passenger transportation would be attained at the point, $(Q_1^*, \cdots, Q_n^*)$, which satisfies the above first-order conditions for n individual companies. The resulting profits will be

$$P_i^* = (p^x - c)\cdot x^i(Q_1^*, \cdots, Q_1^*)(1 - E(x_i, Q_i^*)),$$

which will be positive if and only if $E(x_i, Q_i)$ is less than unity.

The proposition of Douglas and Miller, that is "... scheduling competition bids away all rents and if the Board attempts to prop up carrier profits with a general rate increase it implicitly rationalizes the lower load factors and sets the stage for another iteration of higher fares and increasing capacity.... The regultation of rents is more directly related to the nature of restraints on entry," is thus restated in terms of the elasticity of firm demand with respect to a unilateral increase in flight frequency while repercussions on demand are allowed. It means that

$$\lim_{a_i \to 0} E(x_i, Q_i) > 1 \quad \text{and} \quad \lim_{a_i \to 0} P_i^* < 0.$$

Now, by definition,

$$0 < k_i < 1 \quad \text{and} \quad 0 < s < 1,$$

and we can normally suppose that k_i tends to be zero as a_i goes to zero. Then the assumed property of the expected schedule delay functions implies that

$$\lim_{a_i \to 0} E(x_i, Q_i) = -e(D, Q_i)/e(D, x_i) > 1.$$

Intuitively it means that, as the number of firms increases, a unilateral increase in flight frequency has no significant influence on the market's overall level of the expected schedule delay. But, since the expected schedule delay would decrease if the firm demand increased keeping the average load factor constant, it should increase more than proportionally and the profits will be negative at the point of market equilibrium.

An intrinsic difficulty in this model of quality competition is the possibility of causal relation between externality and the second-order conditions.[1] The impact on the overall quality level of a unilateral increase in flight frequency embodies the external effects caused by quality competition and the elasticity of firm demand with respect to a unilateral increase in flight frequency behaves in parallel with it. If the second-order conditions are disturbed when the impact on the overall

[1] Professor Ohyama pointed out this difficulty in the model. and I weakened the conclusions of the original paper as stated here.

quality level of a unilateral increase in flight frequency tends to be negligible, transportation companies may change their behaviors.

Thus we will conclude: the market of scheduled passenger transportation under price regulation tends to be characterized by vigorous nonprice competition which bids away most implicit profits at a rather moderate number of firms and the existence of rents is more directly related to the nature of restraints on entry rather than the control of price.

IV. THE EFFICIENCY OF THE REGULATED PRICE AND EXTERNALITIES

Douglas and Miller proposed an efficient price-quality equilibrium point which would be characterized by the equality of the technical tradeoff between price and quality in a market with the subjective tradeoff of passengers. But the subjective tradeoff in their model does not reflect the externality of queuing. In this section we will consider the role of externality in the determination of the optimal price for regulation in a second best problem similar to the formulation of Sheshinski.

Since the demand for air services is derived demand from the production of final goods, we can set this second best problem as the maximization of the social return with respect to the regulated price:

To maximize

$$R = p^y y - w(L^y + \textstyle\sum_i x_i(D_i + t) + \sum_i L_i) - r(K^y + \sum_i K_i) - p^Q \sum_i Q_i ,$$

subject to

$$y = g(L^y, K^y, \textstyle\sum_i x_i) ,$$
$$x_i = f^i(L_i, K_i) ,$$
$$D_i = D^i(x_i, Q_i) ,$$
$$x_i \leqq Q_i , \qquad (i = 1, \cdots, n) ,$$

where

y = the amount of final goods
L^y = the labor input for the production of final goods
K^y = the capital input for the production of final goods
p^y = the price of final goods
R = the social return.

The first-order condition would be

$$dR/dp^x = (p^y g_L - w)dL^y/dp^x + (p^y g_K - r)dK^y/dp^x + \textstyle\sum_i (p^y g_x - w(D_i + t + x_i D^i_x))dx_i/dp^x - \sum_i (w dL_i/dp^x + r dK_i/dp^x) - \sum_i (w x_i D^i_Q + p^Q) dQ_i/dp^x = 0 .$$

Substituting the conditions for market equilibrium into this equation

$$
\begin{aligned}
dR/dp^x &= \textstyle\sum_i (p^x - c - wx_i D_x^i) dx_i/dp^x - \sum_i (wx_i D_Q^i + p^Q) dQ_i/dp^x \\
&= p^x dx/dp^x - \textstyle\sum_i dC_i/dp^x - wxdD/dp^x \\
&= 0\,,
\end{aligned}
$$

where C_i is the total cost of firm i, $cx_i + p^Q Q_i$. Here, we did not give any explicit expression for the optimal regulated price, but the above equation shows that the optimal price should be greater than the marginal cost, $\sum_i dC_i/dx$, by the amount corresponding to the value of the external effects of queuing.

Keio University

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