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26 March 2015

Policy of Airline Competition ~Monopoly or Duopoly~

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Abstract

We show that monopoly is better than competition in term of social welfare for low frequency routes. Competition affects both flight schedules and airfares. Flight schedules get un-even interval by competition and this leads to large scheduling delay cost (SDC). The increment of SDC is large when the number of flights is small. For low frequency routes, the increment of SDC by competition overwhelms the decreasing in the airfare, so monopoly is better than competition.

Key Words

Scheduling Delay Cost, Airline Competition, Scheduling

1. Introduction

Deregulation in aviation industry is intended to promote competition through new entries, which is expected to lower airfares and thereby raise the social welfare. In Japan, deregulation removed restrictions on entry, and four airlines started to flight services in 1996 and 1997. In the US, Department of Justice rejected American Airlines to merge US airway at first.

However, competition affects not only airfares but also flight schedules. Table 1 shows time tables for a monopolistic route (Tokyo-Toyama) and a competitive route (Tokyo-Kushiro). As can be seen in this table, flights depart at almost same intervals in the former route. In contrast, in the latter, departure times of two airlines (ANA and JAL) tend to be close to each other. This might be due to competition of Hotelling type to attract passengers whose desired departure times are distributed on the time axis. In this case, total scheduling delay cost (hereafter, SDC) in competitive routes would be higher than that in monopolistic ones. If this effect is significant, promoting entries may result in efficiency loss. In our paper, we focus on the scheduling effect of competition.

Some positive aspects of monopoly have been pointed out. Bruckner and Spiller [1991] introduced the economy of density. The higher traffic density allows the use of larger, more efficient aircrafts and this effect leads to lower cost per passenger-mile on dense route. Bruckner [2002] and Silva and Verhoef [2013] showed that airlines which have large share at their hub airports internalize congestion. Mayer and Sinai [2003] and Santos and Robin [2010] empirically showed that flight delays are lower at highly concentrated airports because the airline internalizes congestion.

Previous researches ignored flight schedules and SDC was given directly while SDC is linked with scheduling strongly. Brueckner [2004], Kawasaki [2012], Alderighi, Cento, Nijkamp and Rietveld [2005] and Flores-Fillol [2009] treated flight frequency as one of components of generalized cost. ($\mathrm{GC} = \mathrm{airgare} + 1/\mathrm{frequency}$) These models implicitly assume that all flights are at even interval and SDC is the inverse of frequency.

The purpose of this paper is to present the condition where monopoly is better than competition and contribute to establishment of anti-trust policies. Competition has two effects, that is, price effect and scheduling effect. The former effect increases demand and improve social welfare, which is shown as the left path in Figure 1. It has been pointed out traditionally and is the basis of anti-trust policies. The latter effect raises SDC and decreases demand, and then harms social welfare. It depends on the trade-off between the effects which monopoly or competition is better in term of social welfare.

This paper is organized as follows. Section 2 is the empirical part in which we verify that competition changes flight schedules and raise SDC by introducing un-evenness index. In section 3, we estimate the decrement of airfares by competition and the demand function to justify the theoretical model. Section 4 is the theoretical part. We establish the model based on empirical regressions to derive the condition where monopoly is more desirable than competition. Finally, section 5 concludes.

<Table 1: About Here>

<Figure 1: About Here>

2. Flight schedules and scheduling delay cost

In this section, we show empirical methodology to provide an evidence that flight schedules of monopolistic routes are at more even interval than competitive routes. First, to measure scheduling delay, we construct new variables based on intervals of air schedule and we define the metric which captures "un-evenness" of the air schedule using the variables. Second, we present the research design which connects schedule distortion and competition. Then, we discuss the data for empirical analysis. Finally, we derive the fact which supports our hypothesis aforementioned by the simple regression model.

2.1. Scheduling Delay and Un-evenness index

Scheduling delay (hereafter, SD) is defined as the time difference between the desired departing time and actual flight schedule. We assume that all airports are operated from 6:00 through 21:00, that is, total business time of each airport is up to 900 minutes. This assumption is quite natural because most airports can be operated in this time range due to agreements with local residents or aviation policies. It is also note we could construct a circler timeframe by connecting 6:00 and 21:00. This implies that, for each route, departing times are arranged along the circle's perimeter with 900 minutes. Then we denote actual intervals between flights as $\{Int_j\,; j = 1,2,\cdots,f\}$, where f is its frequency. In addition, passengers' desired departure time is assumed to be continuous uniformly distribution across the perimeter. It is sure that, in actual, the size of demands is larger over some periods of time, thus we take account of the fluctuation to check robustness.[1] Figure 2 shows an example of intervals and passengers' desirable time (described as dashed line) for a route with three services. Then, we define SD for each service as a triangle-shaped time whose base is equal to each interval. The height of its edge captures the time difference between the flight schedule and desired departing time for the focal passenger.

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[1] See Appendix for this discussion.

<Figure 2: About Here>

Then, for a given route, we calculate the average of SD, which is equal to the average height of all triangles:

$$SD_i = \frac{\sum_{j=1}^{f} Int_j^2}{4\sum_{j=1}^{f} Int_j} = \frac{\sum_{j=1}^{f} Int_j^2}{3600}$$

where i denotes route. This metric is minimized when actual departing times are set at regular intervals, which we define minimum SD as follows:

$$SD_i^{min} = \frac{900}{4f} = \frac{225}{f}$$

It is note that, by definition, SD_i increases as the time schedule becomes uneven.

Together these SD metrics, we could construct the new measure which represents how the time schedule is distorted relative to the minimized case, that is, "unevenness". The most fundamental methodology is calculating how many times the actual SD value is larger than minimum SD value. Thus, for a given route, we define the SD metric divided by its minimum value as the unevenness index:

$$Index_i \equiv \frac{SD_i}{SD_i^{min}} \tag{1}$$

It is straightforward that this index is more than or equal to one for all routes, particularly as the degree of the distortion of flight schedule relative to optimal scheduling becomes larger, reflecting it, the index becomes larger. Since this index could capture the scheduling distortion by the standardized way for all routes, we employ it as a basis for analysis.

2.2. Un-evenness and Competition

To clarify the rigorous relationship between calculated unevenness index and competition among airlines, we introduce the simple regression model. To identify the competition and monopoly, we construct the dummy variable $Multi\_Dummy_i$, which is equal to one in the case with competition (i.e., more than or equal to two airlines) and zero otherwise. Then, we regress the unevenness index on the dummy variable:

$$Index_i = \alpha_0 + \alpha_1 \times Multi_{Dummy_i} + \varepsilon_i \tag{2}$$

where ε_i is an error term. If the competition leads to increase in scheduling distortion, coefficient α_1 must be positive. Negative estimate indicates the opposite. It should be considered that whether or not unevenness index depends on only competitive status. However, the airline schedule is rarely affected by other factors including the capacity of airplanes or the distance. We also could define the number of airlines as the explanatory variable instead of dummy variable, but all results remains to be unchanged. Therefore this simple reduced formulation could capture the causal effect of competition on unevenness of air scheduling.

2.3. Data

We briefly describe the data. We focus on all Japanese domestic routes with two or more flights in a day and 50,000 or more passengers per year. 85 routes[2] meet these conditions. We use the timetables published on September 1 in 2011 to calculate scheduling delays.

2.4. Results

Using the data, we could take a first look on the relationship between distorted air scheduling and competition. For example, the un-evenness index is 1.12 in Tokyo-Toyama route which is monopolistic route, while the value of competitive Tokyo-Kushiro route is 1.22. (See table 1 for the timetables of these routes.) To check our hypothesis the competition leads to un-even schedule, we estimate the regression model above and derive the main result:

$$\widehat{Index}_i = \underset{(9.25)}{0.436} \times \boldsymbol{I}(\text{Number of Airlines } \geq 2) + \underset{(32.28)}{1.121}$$

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2 In order to focus on urban area rather than airports themselves, we integrate multi airports in same region. While there are alternative definitions, we consider urban employment area in Japan in 2005 defined by Kanemoto (2005). For instance, Kansai international airport, Itami (Osaka) airport, and Kobe airport are all in the Osaka area in terms of urban employment based data. Thus, we combine these airport and routes arriving and departing at these airports are regarded as a single route. Other areas are Tokyo area (including Narita airport and Haneda airport), Nagoya area (including Chubu international airport and Nagoya airport), Sapporo area (including Chitose airport and Sapporo Tamaoka airport), and Fukuoka area (including Fukuoka airport and Kita-Kyusyu airport).

where $\widehat{Index}_i$ is estimator of unevenness index and I is an indicator function. The numbers in a parenthesis show t value of coefficients. Strongly positive value and significance of the coefficient for competition imply that monopoly leads to more equalized schedules, while competition deteriorates them. This finding underpins our hypothesis. We conclude with the derived fact:

Fact

If competition status changes from monopoly to competition, the unevenness of air schedule becomes larger.

3. Preparation

This section provides empirical analysis on air demand and airfare. While plenty of previous literatures analyze the determinants of them, we still need parameters needed for theoretical analysis in the later section. Particularly, we focus on the relationship between competition and airfare. We first provide the data and the research design for it, the model of Ordinary Least Squares (OLS) estimation, then estimate it using Japanese data.

3.1. Regression model

For air demand, we estimate the following linear regression:

$$x_i = \beta_0 + \beta_1 Generalized\ cost_i + \beta_2\ Distance_i + \epsilon_i \tag{3}$$

where x_i is the relative demand size, $Generalized\ cost_i$ is generalized cost calculated for each route and $Distance_i$ is the distance of each route. ϵ_i is error term. For our purpose, coefficient β_1 captures how scheduling delay has impact on the air demand.

For airfare, we estimate the following linear equation:

$$Fare_i = \gamma_0 + \ \gamma_1\ Multi\_Dummy_i + \gamma_2 Distance_i + \gamma_3 New_{Dummy_i} + u_i \tag{4}$$

where $Fare_i$ is cut-rate airfare discussed above and $Multi\_Dummy_i$ is the same variable in section 2. u_i is error term. In addition, we add New_Dummy_i which is equal to one if the focal route is operated only by new airlines and zero otherwise. Because, in Japan, newly companies set the airfare lower than existing companies to attract more passengers, we control the effect. Among the coefficients, γ_1 captures how competition directly affects airfare. By definition, note that distance directly affect demand and indirectly affect through generalized cost. Therefore we have to consider multicollinearity problem. However, except for perfect multicollinearity, estimators satisfy consistency and efficiency. In fact, correlation between distance and fare is strictly lower than one, thus OLS estimator is BLUE. For our purpose, we emphasize the preferable feature of estimator to avoid the misspecification problem.

3.2. Data

Most data for airfares and demand is cross section data in 2010 obtained from *Survey of services conducted by specified Japanese air carrier*, *Survey of services conducted by Japanese air carrier other than specified Japanese air carrier*, and *Airline origin and destination survey* conducted by Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

We here define some variables for OLS estimation. First, population in each urban employment area (i.e., potential demand) is computed as the summation of population in each municipality constructing it. Given them, actual relative flight demand size for each route is defined by the actual number of passengers divided by population of urban employment areas linked by the route. This enables us to adjust demand size in terms of potential demand size. On the other hand, for each route, we calculate its airfare by averaging reported airfare taking account of discount. In fact, most passengers pay cut-rate price; for example, if a passenger reserve a seat 2 weeks advanced, she pay discounted price. To do this, we compute the average airfare with weighting the number of passengers who pay the discounted price. Thus we define the cut-rate airfare as an explained variable instead of a regular price. For other explanatory variables, distance is the cruising distance reported in the survey and its unit is kilometer. Generalized cost is calculated following previous studies. Generalized cost is defined as summation of airfare and scheduling delay cost. We compute the scheduling delay cost by multiplying scheduling delay SD_i by value of scheduling delay, which is equal to 10.9 Yen per minute in line with Tseng, Ubbels and Verhoef [2005].

3.3. Results

Table 2 shows the results of regression presented above. All coefficients are strongly significant. It is apparently showed that air demand decreases when generalized cost increases. This implies that scheduling delay cost has negative (indirect) impact on demand. For airfare, competition between multiple airlines sufficiently decreases its airfare. Combining these results and fact in section 2 could support our main idea that competition has negative impact on demand through distortion of time schedule, on the other hand, it decreases airfare, which leads to positive effect on demand.

Also note that other results including the impacts of distance and newly airline are quite natural and in line with previous literatures.

In the next section, based on the empirical results, we provide theoretical explanation for our idea.

<Table 2: About Here>

4. Theoretical Analysis

In this section, we analyze how competition affect the social welfare based on the results of the empirical part. We clarify the condition in which monopoly is better than competition in terms of the social welfare. At first, we introduce the model which represents the effect of competition on the SDC and the airfare.

4.1. Model

As shown in (1), the average scheduling delay is calculated as

$$s = s^{min} i = kf^{-1} i. \tag{5}$$

k is a positive constant and f represents the frequency. Based on regression (2), we formulate un-evenness index as

$$i^m = a_0 \tag{6.1}$$

$$i^c = a_0 + a_1 \tag{6.2}$$

$$\Delta i = a_1 \tag{6.3}$$

The subscripts m and c stand for monopoly and competition, respectively. Δ indicates the difference between competition and monopoly. a_0 and a_1 are corresponding to α_0 and α_1 in the regression equation (2) respectively. (6.3) indicates that competition leads to more un-even schedule by a_1. Using equations (6) on un-evenness of the schedule, we rewrite scheduling delay as

$$s^m = a_0 k f^{-1} \tag{7.1}$$

$$s^c = (a_0 + a_1) k f^{-1} \tag{7.2}$$

$$\Delta s = a_1 k f^{-1}. \tag{7.3}$$

We formulate the airfare as

$$p^m = b_o \tag{8.1}$$

$$p^c = b_o - b_1 \tag{8.2}$$

$$\Delta p = -b_1 \tag{8.3}$$

b_o and b_1 are corresponding to $\beta_0 + \beta_2 Distance + \beta_3 New\_Dummy$ and $-\beta_1$ in regression equation (3) respectively. (8.3) indicates that competition leads to lower airfare by b_1.

We assume the linear demand function as

$$x = c_0 - c_1 p - c_2 s. \tag{9}$$

Here, the generalized cost is $p + c_2/c_1 \cdot s$ and c_2/c_1 is value of scheduling delay[3]. c_0 and c_1 are corresponding to $\gamma_0 + \gamma_2 Distance$ and $-\gamma_1$ in equation (4) respectively. Using equations (8) and (9), we obtain the demand functions for monopolistic and competitive cases.

$$x^m = c_0 - b_o c_1 - a_0 c_2 k f^{-1} \tag{10.1}$$

$$x^c = c_0 - (b_o - b_1) c_1 - (a_0 + a_1) c_2 k f^{-1} \tag{10.2}$$

$$\Delta x = b_1 c_1 - a_1 c_2 k f^{-1} \tag{10.3}$$

The first term in (10.3) is the decrement of the airfare and the second term is the increment of SD by competition.

We assume three assumptions as following.

Assumption 1:

The airfare in monopolistic case is higher than the increment of SDC.

$$b_0 > a_1 c_1^{-1} c_2 k f^{-1} \Leftrightarrow p^m > c_2/c_1 \cdot \Delta s$$

$p^m = 28{,}402$ and $c_2/c_1 \cdot \Delta s = 214$ when $Distance = 1{,}000$, $New\_Dummy = 0$ and $f = 5$. Therefore, this assumption is acceptable.

Assumption 2:

In monopolistic case, the demand is positive even if SDC gets double.

$$c_0 - b_0 c_1 - 2 a_0 c_2 k f^{-1} > 0 \Leftrightarrow x^m > c_2 s^m$$

$x^m = 0.0373$ and $c_2 s^m = 0.0037$ when $Distance = 1{,}000$, $New\_Dummy = 0$ and $f = 5$. Therefore, this assumption is acceptable.

Assumption 3:

We set the lower bound of f as

$$\underline{f} \equiv c_0^{-1} c_2 (2a_0 + a_1) k$$

$\underline{f} = 0.1908$ when $Distance = 1{,}000$ and $New\_Dummy = 0$. Frequency should be two or larger so that competition can occur. Therefore, this assumption is acceptable.

4.2. Discussion

In this subsection, we analyze the effects of competition on the demand and the social

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[3] According to Tseng, Ubbels and Verhoef [2005], Value of Scheduling Delay is 4.6566€ /hour. We convert it to Yen by $1€ = 140¥$ and obtain c_2/c_1 is 10.9 Yen per minute.

welfare focusing on the frequency. Differentiating (7.3) with respect to f, we obtain Lemma 1

Lemma 1

As the flight service becomes frequent, the increment in SD by competition becomes small.

$$\frac{\partial \Delta s}{\partial f} = -d_1 k f^{-2} < 0$$

Flight intervals are short for high frequency route, therefore the increment in SD is small while the flight schedule gets un-even by competition.

We differentiate (10.3) with respect to f and obtain Lemma 2.

Lemma 2

As the flight service becomes frequent, the increment in demand becomes large.

$$\frac{\partial \Delta x}{\partial f} = {a_1}^{-1} a_2 d_1 k f^{-2} > 0$$

The first term in the right hand side of Eq. (10.3) is the decrement of the airfare and the second term is the increment of SDC. The former independents of frequency while the latter is decreasing function of frequency. Therefore, the change in the generalized cost by competition also decreases in frequency.

We analyze the social welfare. We define the welfare as the social benefit minus social cost. The former is consumers' benefit from their flights and it is depicted as the lower part of the invers demand function. The latter is SDC which is taken by consumers and we ignore the operating cost of airlines.

We define two effects of competition, namely, "demand effect" and "SD effect". "Demand effect" is the improvement of the social welfare by the increase in demand due to the decreasing in the airfare by competition. This effect is shown as the square BEFG in Figure 3 and $\Delta SW_D \equiv \frac{1}{2}(GC^m + GC^c - 2{c_1}^{-1} c_2 s^c)\,\Delta x$. "SD effect" is the decrement of the social welfare by the increase in SDC. This effect is depicted as the square ABCD and $\Delta SW_S \equiv {c_1}^{-1} c_2 \Delta s \cdot x$.

The change in the social welfare is $\Delta SW \equiv \Delta SW_D - \Delta SW_S$ and it depends on the trade-off between two effects which monopoly or competition is better in term of the social welfare.

<Figure 3: About Here>

We calculate the values of both effects by using equations (7), (8) and (10).

$$\Delta SW_D = \frac{1}{2}\{2b_0 - b_1 - a_1 c_1{}^{-1} c_2 k f^{-1}\}(b_1 c_1 - a_1 c_2 k f^{-1}) \tag{11.1}$$

$$\Delta SW_S = a_1 c_1{}^{-1} c_2 k f^{-1}(c_0 - b_0 c_1 - a_0 c_2 k f^{-1}) \tag{11.2}$$

We differentiate (11)s with respect to f and obtain Lemma 3.

Lemma 3-1

As the flight service becomes frequent, the improvement in social welfare by demand effect is large.

Proof:

$$\frac{\partial \Delta SW_D}{\partial f} = a_1 c_2 k f^{-2}(b_0 - a_1 c_1^{-1} c_2 k f^{-1})$$

According to assumption 1, $b_0 - a_1 c_1^{-1} c_2 k f^{-1} > 0$ and then $\partial \Delta SW_D / \partial f > 0$.

(Q.E.D.)

As shown in Lemma 2, the increment of demand is large for routes with high frequency, so demand effect is large when the number of flights is large.

Lemma 3-2

As the flight service becomes frequent, welfare loss by SD effect becomes small.

Proof:

$$\frac{\partial \Delta SW_S}{\partial f} = -a_1 c_1^{-1} c_2 k f^{-2}(c_0 - b_0 c_1 - 2a_0 c_2 k f^{-1})$$

According to assumption 2, $c_0 - b_0 c_1 - 2a_0 c_2 k f^{-1} > 0$. Therefore, $\partial \Delta SW_S / \partial f < 0$.

(Q.E.D.)

As shown in Lemma 1, the increment of SDC is small for route with high frequency, SD effect is small when the number of flight is large.

Finally, we analyze the relationship between the total effect and frequency. Using (11), we rewrite the total effect as

$$\begin{aligned}\Delta SW &= \Delta SW_D - \Delta SW_S \\ &= \frac{1}{2}(2a_0 + a_1) a_1 c_1^{-1} c_2^2 k^2 f^{-2} - a_1 c_0 c_1^{-1} c_2 k f^{-1} + A,\end{aligned}$$

where, $A \equiv \frac{1}{2}(2b_0 - b_1) b_1 c_1 = \frac{1}{2}(p^m + p^c) b_1 c_1 > 0$.

Lemma 4

As the flight service becomes frequent, change in social welfare by competition is large.

Proof:

$$\frac{\partial \Delta SW}{\partial f} = a_1 c_0 c_1^{-1} c_2 k f^{-3}\{f - (2a_0 + a_1)c_0^{-1} c_2 k\}$$

According to assumption 3, $f > \underline{f} = (2a_0 + a_1)c_0^{-1}c_2 k$. Therefore, $\partial \Delta SW/\partial f > 0$.

(Q.E.D.)

Lemma 4 indicates $\Delta SW(f)$ is decreasing in the area $f > \underline{f}$ as depicted in Figure 4. $\Delta SW(f)$ is minimum at $f = \underline{f}$ and maximum value is A when $f \to \infty$. We summarize results and obtain

(i) When $\Delta SW\left(\underline{f}\right) < 0$, the solution f^* exists and

$$\Delta SW < 0 \quad if \quad \underline{f} < f < f^*,$$
$$\Delta SW > 0 \quad if \quad f^* < f.$$

(ii) When $\Delta SW\left(\underline{f}\right) > 0$,

$$\Delta SW > 0 \quad \text{for all} \quad f > \underline{f}$$

<Figure 4: About Here>

From the form of $\Delta SW\left(\underline{f}\right)$, we obtain

Proposition

When $\Delta SW\left(\underline{f}\right) < 0$ and $\underline{f} < f < f^*$, monopoly is better than competition in terms of the social welfare.

For low frequency routes, SD increases largely by competition as shown in Lemma 1 and demand increases only a little or decreases as shown in Lemma 2. Therefore, monopoly is better than competition for low frequency routes.

5. Conclusion

The present analysis shows that competition leads to un-even flight schedule. This result holds if we set demand peak times and the un-evenness index independents from flight frequency. In theoretical part, we show that monopoly is better than competition for routes with low frequency. SD effect is large when the number of flights is small because SDC for low frequency routes is large even in monopolistic case. On the other hand, the demand effect independents of flight frequency. Therefore, the SD effect overwhelms the demand effect for low frequency routes.

We have two tasks for the future. First, we should consider airline networks. Hub-Spoke networks are adopted by airlines, and then many passengers make transit at the hub. Second, other major topics such as congestion should be taken into account.

References:

1. Alderighi, M., Cento, A., Nijkamp, P. and Rietveld, P., "Network competition—the coexistence of hub-and-spoke and point-to-point systems", Journal of Air Transport Management 11 (2011) 328–334.
2. Brueckner, J.K. and Spiller, P.T., "Competition and mergers in airline networks", International Journal of Industrial Organization 9 (1991) 323-342.
3. Brueckner, J.K., "Airport Congestion When Carriers Have Market Power", The American Economic Review 90 (2002) 1357-1375.
4. Brueckner, J.K., "Network Structure and Airline Scheduling", The Journal of Industrial Economics 52 (2004) 291–312.
5. Flores-Fillol, R., "Airline competition and network structure", Transportation Research Part B 43 (2009) 966–983.
6. Kawasaki, A., "Hub location with scheduling effects in a monopoly airline market", The Annals of Regional Science 49 (2012) 805-819.
7. Mayer, C. and Sinai, T., "Why do airlines systematically schedule their flights to arrive late?", The Wharton School, University of Pennsylvania (2003).
8. Santos, G. and Robin, M., "Determinants of delays at European airports", Transportation Research Part B 44 (2010) 392–403.
9. Silva, H.E. and Verhoef, E.T., "Optimal pricing of flights and passengers at congested airports and the efficiency of atomistic charges", Journal of Public Economics 106 (2013) 1–13.
10. Tseng, Y.Y., Ubbels, B. and Verhoef, E.T., "Value of time, schedule delay and reliability", ERSA conference papers (2005)

Tokyo-Toyama		Tokyo-Kushiro	
Dep. Time	Airline	Dep. Time	Airline
6:40	ANA	7:40	ANA
9:45	ANA	8:10	JAL
13:40	ANA	11:20	ANA
15:35	ANA	12:30	JAL
18:25	ANA	17:00	ANA
19:50	ANA	17:50	JAL

Table 1: Flight schedules for monopolistic and competitive routes

Each entry reports OLS estimator	Demand size	Airfare
Generalized Cost	- 0.00000683	
	(-4.19)	
Distance	0.000143	15.645
	(5.06)	(18.77)
Multi Dummy		-1724.10
		(-3.40)
New Dummy		-8240.49
		(-5.22)
Constant	0.0926	12757.57
	(3.83)	(19.41)
Adjusted R^2	0.2203	0.8188
Observations	85	85

Table 2: Estimation of demand size and airfare

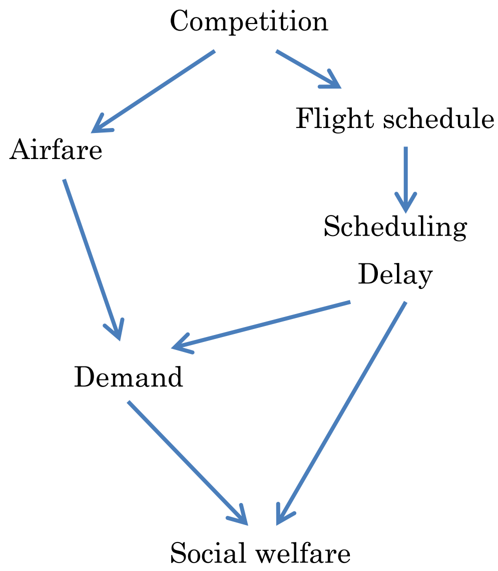

Figure 1: Effect paths of competition to social welfare

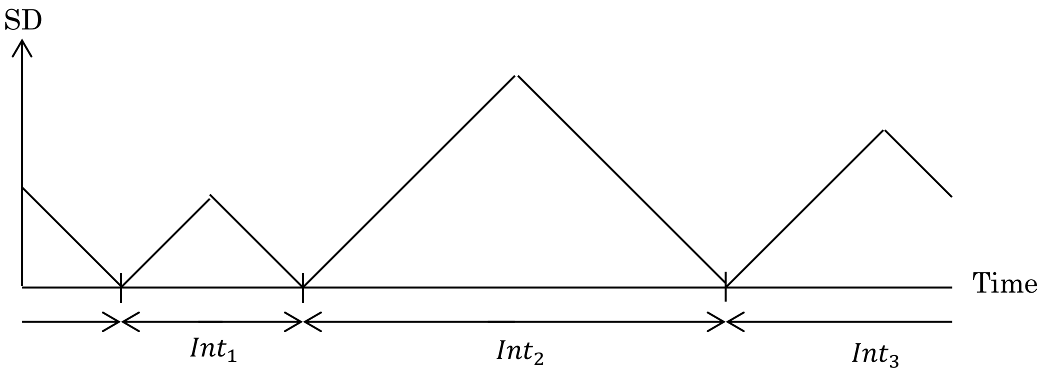

Figure 2: Flight intervals and Scheduling delay

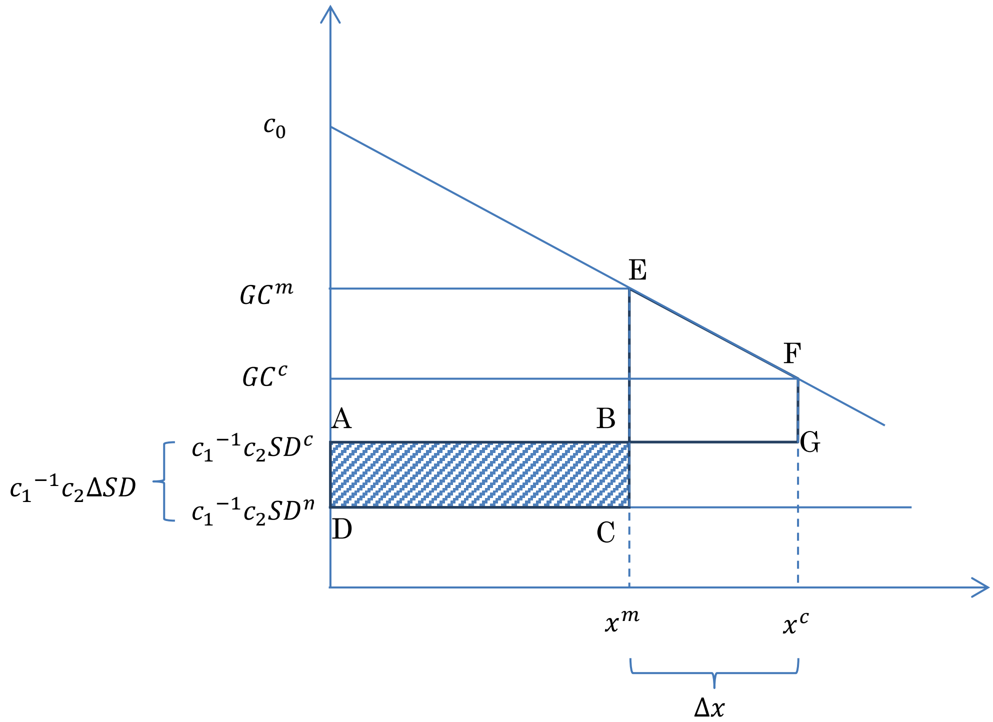

Figure 3: “Demand effect” and “SD effect”

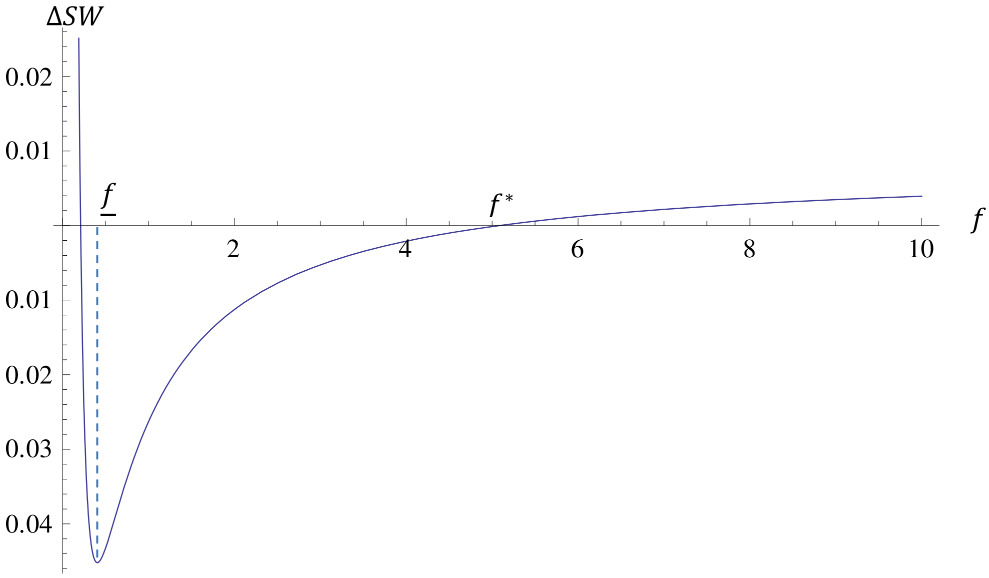

Figure 4: Change in the social welfare and frequency