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An economic analysis of risk management in the airline industry

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Abstract

The purpose of this article is to consider risk management in the airline industry using an economic model. An increase in the number of airlines can reduce the probability of passengers being unable to find substitutable flights, while it increases total entry costs. Thus, there is an optimal number of entries to the market, and we can evaluate whether the actual number of entries exceeds or falls short of the optimal level. On that basis, this article investigates the following two questions: (1)"Do excess or insufficient entries occur in the airline industry?" and (2)"If this is ambiguous, in what situations do excess or insufficient entries occur?" The conclusions of our analysis are as follows. First, it is ambiguous whether excess or insufficient entries occur. Second, the higher (lower) the cost of airfares, the probability of engine trouble, the number of flights and the number of passengers, the more likely is a situation of excess (insufficient) entries, while the higher (lower) the entry cost and flight cancellation cost, the more likely is a situation of insufficient (excess) entry.

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1 Introduction

An important part of conducting risk management is preparing substitutable options in the case of accidents. One example can be seen in the airline industry. If some passengers cannot board their flights because of engine trouble or for another reason, they may be able to board another flight to the same destination instead. However, especially for international flights, there are actually few flights. For example, consider the flight from Sydney (Australia) to Narita (Japan). As of April 2009, only two airlines fly the direct route: Qantas and Japan Airlines. Thus, if either flight is unfortunately cancelled because of engine trouble, the passengers may have to wait for a long time to board a next Qantas or Japan Airlines flight. In other words, because there are few flights, passengers face a greater risk of missing their flights and being unable to reach their final destination on schedule.

Of course, this risk is closely related to the profit of every airline because they must compensate passengers for accommodation and meal costs when they cannot find a substitutable flight. The more airlines there are, the lower the risk of this occurrence. In this regard, many airlines entering the market may be desirable in terms of risk management. On the other hand, it is easy to imagine huge entry costs when many airlines enter. In this regard, many airlines entering may be inefficient in terms of entry costs.

According to economic theories of market entry, such as that of Salop (1979), there is an optimal number of entries that balances both advantages (increasing the variety of products) and disadvantages (increasing entry costs). In our case, increasing the number of entries has another type of advantage that can increase the probability of substitutable flights being available. However, as Salop (1979) found, it increases total entry costs. Thus, an optimal number of entries exists in the airline industry.

Many previous studies in relation to economic models of entry, including Salop (1979), concluded that the number of entries in the free market exceeds the optimal level in terms of social welfare (for example, Mankiw and Whinston (1986), Suzumura and Kiyono (1987), Okuno-Fujiwara and Suzumura (1993), and Ghosh and Saha (2007)).

In contrast, Matsumura and Okamura (2006) showed that the insufficient entry case occurs when the disutility (transportation cost) function is concave and marginal production is an increasing function of amount of outputs. Another example of the insufficient entry case is provided by Ghosh and Morita (2007). They argued that the insufficient entry case occurs when there are suppliers of intermediate products that have very strong bargaining power to decide the allocation of profits between manufacturers and suppliers.

Proceeding from the above findings, the purpose of this article is to consider the following two questions about risk management in the airline industry using the economic model: "Do excess or insufficient entries occur in the airline industry?" and "If this is ambiguous, in what situations do excess or insufficient entries occur?" [1]

This article is organized as follows. Section 2 introduces an economic model for analyzing risk management. Comparative statics are presented in Section 3. Concluding remarks are presented in Section 4.

2 The Economic Model

2.1 Basic setting

Consider the following game. In the first stage, the number of airlines that enter the market, denoted by n_F^*, is decided. $F > 0$ represents the fixed entry cost. After deciding the number of entries, the nature chooses whether "engine trouble" or "no engine trouble". The probability of engine trouble is assumed to be equal and independent among all airlines and is denoted by $q \in (0,1)$. [2] If one airline suffers engine trouble and its flight is cancelled, the passengers can board another flight without engine trouble. In this case, the airline does not need to incur cancellation costs such as accommodation and meals. In contrast, if all flights are cancelled, each airline incurs flight cancellation costs. The flight cancellation cost per passenger is denoted by $d > 0$. Other types of cost are not considered.

Let p be the airfare, and assume that $p > d$. For simplicity, it is assumed to be an exogenous variable. N denotes the number of flights in a certain period (for example, one year) per airline. $n_C > 0$ represents the total number of passengers in a day. Assume that each airline has one flight every day and the number of passengers is equally divided. Thus, each airline carries $\frac{n_C}{n_F}$ passengers in a day. All airlines are assumed to be risk neutral.

Furthermore, let n_F^{**} be the optimal number of airlines to maximize total profits in the airline industry.

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[1] There are some studies investigating the number of airlines from other perspectives. For example, to explain deterrents to new entries in the airline industry, Lin (2005, 2008) focused on hub-spoke networks and code-sharing alliances.

[2] In contrast, when considering flight cancellation caused by weather conditions such as typhoons and heavy snow, the flight cancellation probabilities are (almost) perfectly corrected. However, because flight cancellations caused by weather conditions are covered by escape clauses, airlines do not have the responsibility to compensate the passengers for their losses.

2.2 Derive the equilibrium

$n_F{}^*$ is set to satisfy the following zero expected profit condition.

$$N\left\{\left(\frac{n_C}{n_F{}^*}\right)p - q^{n_F{}^*}\left(\frac{n_C}{n_F{}^*}\right)d\right\} - F = 0 \Rightarrow Nn_C\left(p - q^{n_F{}^*}d\right) - n_F{}^*F = 0\,. \tag{1}$$

Suppose that $f(n_F) \equiv Nn_C\left(p - q^{n_F}d\right) - n_F F$. Because $f(0) = Nn_C(p-d) > 0$, $f(\infty) = -\infty < 0$, and $\dfrac{\partial^2 f}{\partial(n_F)^2} = -Nn_C dq^{n_F}(\ln q)^2 < 0$, there is a unique and strictly positive $n_F{}^*$ that satisfies $f\left(n_F{}^*\right) = 0$.

In contrast, $n_F{}^{**}$ can maximize SD , which is described as

$$SD = -Nn_C q^{n_F} d - n_F F\,. \tag{2}$$

Thus, first-order condition can be written as

$$\frac{\partial SD}{\partial n_F} = -Nn_C q^{n_F{}^{**}} d\ln q - F = 0\,. \tag{3}$$

Suppose that $g(n_F) \equiv -Nn_C q^{n_F} d\ln q - F = 0$. In order to guarantee that $n_F{}^{**} > 0$, we assume that $g(0) = -Nn_C d\ln q - F > 0$. Also, because $g(\infty) = -F < 0$ and $\dfrac{\partial^2 SD}{\partial(n_F)^2} = -Nn_C q^{n_F} d(\ln q)^2 < 0$, there is a unique and strictly positive $n_F{}^{**}$ that satisfies the equation (3).

Next, we compare both $n_F{}^*$ and $n_F{}^{**}$. Because the computation to derive $n_F{}^*$ is very complicated ($n_F{}^*$ follows the Lambert W-function), $q^{n_F{}^{**}}$ and $n_F{}^{**}$ are substituted into the left-hand side of the equation (1).

From the equation (3), we have

$$q^{n_F^{**}} \equiv z = \frac{F}{-Nn_C d \ln q}, \tag{4}$$

$$n_F^{**} = \log_q \frac{F}{-Nn_C d \ln q} = \log_q z = \frac{\ln z}{\ln q}. \tag{5}$$

Because $-Nn_C d \ln q > F > 0$, $z \in (0,1)$ and $\ln z < 0$.

Substituting the equations (4) and (5) into the left-hand side of the equation (1),

$$h \equiv Nn_C(p - zd) - \frac{\ln z}{\ln q} F. \tag{6}$$

The sign of h is meaningful. If $h > 0$, then $n_F^* > n_F^{**}$. Hereafter, we call this case "excess entry". In contrast, if $h < 0$, then $n_F^* < n_F^{**}$. Hereafter, we call this case "insufficient entry".[3] However, the sign of the right-hand side of the equation (6) is ambiguous because both first and second terms are positive. Thus, we cannot clearly know whether excess or insufficient entry occurs.

3 Comparative Statics

This section focuses on the exogenous conditions where excess or insufficient entry occurs. More specifically, to derive the exogenous characteristics necessary to realize the excess or insufficient entry cases, comparative statics will be conducted.

3.1 The effect of airfare

It is easy to derive that

$$\frac{\partial h}{\partial p} = Nn_C > 0. \tag{7}$$

Thus, the higher (lower) airfare cost, the more likely is the excess entry case ($h > 0$) (the insufficient entry case ($h < 0$)). In reality, changes in airfares are hard to evaluate because there are two opposite circumstances affecting the airfares. The recent fierce competition in the airline industry has reduced airfares. For example, regulations about the discount rate of international airfares in Japan were abolished in March 2008. After

[3] Of course, if $h = 0$, then $n_F^* = n_F^{**}$. In this case, free entry can allow the optimal number of entries.

this deregulation, Japanese airlines could set more discounted rates. In contrast, many airfares had increased especially in the middle of 2008 because of increased insurance and fuel surcharges.

3.2 The effect of entry cost

In order to confirm the effect of entry cost, differentiating h with respect to F,

$$\frac{\partial h}{\partial F} = -Nn_C d \frac{\partial z}{\partial F} - \frac{F}{\ln q} \frac{\partial z / \partial F}{z} - \frac{\ln z}{\ln q}, \tag{8}$$

and then,

$$\frac{\partial h}{\partial F} = -\frac{\ln z}{\ln q} < 0. \tag{9}$$

Thus, the higher (lower) the entry cost, the more likely is the excess entry case ($h > 0$) (the insufficient entry case ($h < 0$)). Actually, entry cost tends to be higher because each airline is required to maintain higher levels of safety, and airport landing fees in Narita Airport is one of highest in the world. Ultimately, these circumstances lead to insufficient entry.

3.3 The effect of engine trouble probability

Differentiating h with respect to q,

$$\frac{\partial h}{\partial q} = -Nn_C \frac{\partial z}{\partial q} d - \frac{\frac{\partial z / \partial q}{z} \ln q - \frac{\ln z}{q}}{(\ln q)^2} F. \tag{10}$$

Also, we can rewrite the above derivative as

$$\frac{\partial h}{\partial q} = -\frac{F \ln z}{q (\ln q)^2} > 0. \tag{11}$$

Thus, The higher (lower) the probability of engine trouble, the more likely is the excess entry case ($h > 0$) (the insufficient entry case ($h < 0$)). However, it is not easy to determine the probability of engine trouble. On the one hand, the safety level requirement increases and the possibility that an aircraft is evaluated as having engine trouble may increase if other conditions are constant. On the other hand, modern aircraft are manufactured in accordance with strict safety measures. From that perspective, the probability of engine trouble may have decreased.

3.4 The number of flights

It is easy to derive that

$$\frac{\partial h}{\partial N} = n_C\left(p - zd\right) > 0\,. \tag{12}$$

Thus, the higher (lower) the number of flights, the likely is the excess entry case ($h > 0$) (the insufficient entry case ($h < 0$)). According to the information from the Narita Airport webpage, the number of flights has almost unchanged in recent years, and this effect is recently small in the case of Narita Airport.[4]

3.5 The number of passengers

Differentiating h with respect to n_C,

$$\frac{\partial h}{\partial n_C} = N\left(p - zd\right) - Nn_C \frac{\partial z}{\partial n_C} d - \frac{F}{\ln q} \frac{\partial z / \partial n_C}{z}\,. \tag{13}$$

Also, we have

$$\frac{\partial h}{\partial n_C} = N\left(p - zd\right) > 0\,. \tag{14}$$

Thus, the higher (lower) the number of passengers, the more likely is the excess entry case ($h > 0$) (the insufficient entry case ($h < 0$)). According to information from Narita Airport webpage, the number of passengers passing through Narita Airport was 35,556,839 in 2007 and 33,531,284 in 2008. Such a decrease in the number of passengers suggests that it becomes an insufficient entry case.

3.6 The flight cancellation cost

Differentiating h with respect to d,

[4] According to the Monthly Traffic Statistics of Narita Airport (http://www.naa.jp/en/traffic/index.html (accessed April 1, 2009)), the number of frights to or from Narita Airport was 193,748 in 2007 and 193,321 in 2008, respectively.

$$\frac{\partial h}{\partial d} = -Nn_C z - Nn_C \frac{\partial z}{\partial d} d - \frac{F}{\ln q} \frac{\partial z / \partial d}{z} \tag{15}$$

and

$$\frac{\partial h}{\partial d} = -Nn_C z < 0 . \tag{16}$$

Thus, the lower (higher) the flight cancellation cost, the more likely is the excess entry case ($h > 0$) (the insufficient entry case ($h < 0$)). Then, if the flight cancellation cost decreases (increases) for some reason, the excess (insufficient) entry case may appear relatively easily.

4 Concluding Remarks

This article mainly considers risk management using an economic model. An increase in the number of entries reduces the probability of compensating passengers for losses. This point implies that encouraging new entries may be a risk management method. On the other hand, too many entries waste money on entry costs. Thus, there is an optimal number of entries that has been discussed in many previous studies. This article investigates the number of entries in the airline industry, which faces risk management problems concerning flight cancellations.

The conclusions of our model are very simple. First, whether excess or insufficient entries occur is ambiguous. Second, the higher (lower) the cost of an airfare, the probability of engine trouble, the number of flights and the number of passengers, the more likely is the excess (insufficient) entry case, while the higher (lower) the entry cost and flight cancellation cost, the more likely is the insufficient (excess) entry case.

However, there are some limitations in our model. For example, because our model eliminates the airfare competition phase, it cannot explain the effect of competitive pressures in the airline industry. Another example is that our model cannot explain the case of heterogeneous airlines. Actually, the probability of engine trouble differs among airlines. For simplicity, if there are two types of airlines, with high and low probabilities of engine trouble, how would the results derived from our model change? Is the possibility of excess or insufficient entry case being realized higher? In order to enrich the implications of our results, we must reconsider and extend the model in accordance with more realistic situations in the future.

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