Airport charges, economic growth, and cost recovery

Anming Zhang¹, Yimin Zhang*

Department of Economics and Finance, City University of Hong Kong, Kowloon, Hong Kong

Received 26 October 1999; received in revised form 20 March 2000; accepted 3 April 2000

Abstract

This paper shows that “strict” financial break-even for airports may not be socially desirable. To maximize social welfare, airports should be allowed to take losses or make profits at different times while achieving break-even only in the long run. In particular, with economies growing over time, socially optimal pricing for a new airport can involve deficit in its early years and surplus in its later years. This result has practical policy implications for the newly-built or expanded airports especially in the Asia-Pacific region. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Airport charge; Cost recovery; Long-run break-even

1. Introduction

Airport services are crucial to the development of air transportation. Although for many countries in the world airports are still managed by governments, major airports in North America and Europe have been moved to local airport authorities or privatized. These airports are run like a business and must be financially self-reliant. Because airports generally have a captive market, however, privatized airports may also cause public concerns in that the airports might exploit their market power and extract monopoly rents from the airlines and passengers. As a consequence, airports should in principle be managed on cost recovery or financial break-even.

The purpose of this paper is to show that, when the policy of financial break-even is implemented, “strict” financial break-even on an annual or even short run basis may not be socially desirable. To maximize social welfare, airports should be allowed to take losses or make profits at different times while achieving break-even only in the long run. In particular, with economies...
growing over time, socially optimal pricing for a new airport can involve a deficit in its early years and surplus in its later years. Over its entire life span, the airport can however still achieve cost recovery.

There is a large body of literature on airport pricing and cost recovery. Useful references include Levine (1969), Carlin and Park (1970), Walters (1973), Morrison (1983, 1987), Gillen (1994), Gillen et al. (1987, 1989) Oum and Zhang (1990), Oum et al. (1996) and Zhang and Zhang (1997). Following a similar argument to that in Mohring (1970, 1976) and Mohring and Harwitz (1962) who studied highway pricing, Morrison (1983) showed that if capacity is divisible and costs are homogeneous in the volume/capacity ratio, then social-marginal-cost pricing leads to exact cost recovery for airports. Oum and Zhang (1990) showed that if capacity is lumpy, then social-marginal-cost pricing would not guarantee cost recovery for the airport. Zhang and Zhang (1997) considered the effects of concession operations by the airports in a setting where capacity is divisible but social costs are not homogeneous in the volume/capacity ratio.

This paper contributes to the literature in that we look at airport charges and cost recovery policies where neither capacity divisibility nor a homogeneous cost function is assumed. In this more general setting, we study the optimal airport charge with the financial constraint of cost recovery. As discussed below, our results should contribute to the on-going debate in Hong Kong and around Asia about the merits of reducing airport charges for new airports hit hard by the Asian financial crisis.

The paper is organized as follows. Section 2 provides an intuitive explanation for the main results of the paper. Section 3 sets up the model and investigates the properties of two alternative airport charges policies: one is based on financial break-even for every sub-period, the other on break-even for the entire period. Finally, Section 4 discusses policy implications of the results.

2. Traffic growth and cost recovery: economic intuitions

The economic intuitions behind our results relate to the nature of changing demand and supply of the airport services. The demand for airport services, measured in terms of air traffic flow, increases with economic growth that tends to have a positive time trend. According to the statistics by the Boeing Corporation, world air traffic increased on average by 5.3% per year from 1985 to 1997. During that period, the fastest growing area was the Asia-Pacific region with regional traffic growing on average by 9.2% per year. The recent Asian financial crisis has severely slowed economic growth and depressed air traffic in the region. Nevertheless, economists are still optimistic about the economic growth in the long run. By Boeing’s forecast, the average annual growth of passenger traffic in the Asia-Pacific region for the period 1998–2008 will be 6.1% per year while the world average growth for the same period will be 4.7% per year.

An airport supplies aviation services to airlines and passengers. These services include runway facilities for aircraft landing and takeoff, terminal buildings for passenger traffic, technical services to the aircraft such as fueling and maintenance, and navigational services, etc. Although the demand is growing over time, the supply of airport services remains largely fixed for an airport during its economic life span. This is because the capacity of an airport is constrained by its runways and terminal buildings. Once put in place, the runways and terminal buildings can serve for many years and cannot be expanded quickly or in fraction. An airport can have one, two,
three or more runways, but cannot have 1.2 or 2.5 runways. Of course, given a fixed number of runways, the capacity can still be expanded by improving the airport’s navigation and traffic control systems, but these marginal expansions do have limits. Even thinking of additions in the long run, these are not achieved easily in most areas due to environmental issues.

In sum, the demand for airport services tends to grow over time while the supply at a given airport is largely fixed due, for example, to environmental concerns of a major airport expansion. Accordingly, if the market mechanism based on demand and supply were at work, the equilibrium price of using the airport would rise over time. In effect, as traffic increases towards the capacity of an airport, congestion at the airport will build up. This leads many airports in the world to levy so-called “peak hour” surcharges. The purpose of the surcharge is twofold. First, the extra charge amounts to an increased price, which discourages the demand for airport services during the busy hours when the capacity has been reached. Second, the surcharge will bring in extra revenues, which can be used to finance future expansions of airport capacity.

We now discuss airport charges and cost recovery for a new airport over its life span. When the demand is low relative to the capacity as in the early stage of a new airport or as an airport that just added new capacity, the market mechanism based on demand and supply dictates that the equilibrium airport charge be low. Likewise, when the demand is high relative to the capacity, the equilibrium charge must be high. Therefore, by the market mechanism, the revenues arising from airport charges are low when the demand is low relative to the capacity, but will be high when the demand is high. On the other hand, the capacity costs that include depreciation, maintenance and financing charges are normally insensitive to demand and are more or less constant over the years. As a result, there will be a deficit at the early stage of an airport with its new capacity and surplus when traffic builds up later. This is a natural cycle of cost recovery. For the airport to maintain a financial break-even, the airport authority needs to take a long-term view towards cost recovery.

Given the market mechanism, it is therefore natural that airport authorities suffer from a short-run deficit after the new capacity is put into place. It is also natural, however, for the authorities to have a desire to show a financially healthy balance sheet to the public. For instance, the authorities may desire that financial break-even be achieved every year. Such a “short run” break-even policy, however, is against the demand cycle. When the new capacity is just put into place, or when there is an economic crisis, or when both events occur as has happened in some Asian airports, the demand for airport services will be low relative to capacity. In this situation, to achieve financial break-even, a very high airport charge must be levied to the airlines and/or passengers. Such a high charge has the undesirable effect of suppressing demand further when the demand is already low. On the other hand, when the demand is high, approaching capacity limit, the airport charge will have to be lowered to avoid financial surplus. A low charge in this case will stimulate the demand, thereby further worsening the problem of congestion and capacity shortage.

Alternatively, if the airport authorities take a “long term” view towards cost recovery, the demand cycle would be managed better. When the demand is low, the airport incurs a deficit but nevertheless can still lower the airport charge to encourage more flights and better utilization of the new capacity. Later, when the demand approaches airport capacity, the authorities can raise airport charges to discourage further increase in demand, meanwhile reaping a surplus which can be used to cover the losses incurred earlier. Over the entire cycle, the airport can still achieve break-even.
3. Models of optimal airport charges

In this section, we model the above two alternative pricing schemes of airport services and derive their necessary conditions for optimal airport charges.

In many airports, flights are often delayed due to airport congestion. The costs of the delay are part of the social costs that should be taken into account when airport authorities consider the charges to the users of the airports. The delay might be anticipated since the airlines over time will learn where and when they need to extend or even pad the schedule. Hence, the delay time might be disguised as part of flight time as opposed to the additional time beyond the scheduled flight time. In any case, this delay time, being anticipated or not, increases with the level of congestion at the airport. Now we consider an airport and let

\[ \rho_i = P_i + D(Q_i, K) \] the full price perceived by the passengers which is reflected in the carriers’ demand for airport facilities

\[ P_i \] the airport charges for a flight during hour \( i \), including both landing fees and passenger fees

\[ Q_i \] the demand (number of flights) for landing during hour \( i \)

\( K \) the capacity of the airport

\[ D(Q_i, K) \] the flight delay costs experienced by each aircraft during hour \( i \) (D for “delay”)

\[ C(\sum Q_i) \] the operating costs of the airport

\( r \) the cost of capital per period including interest and depreciation.

For simplicity, we assume that the capacity of the airport, \( K \), is fixed for a period of \( T \), where \( T \) represents the economic life of the airport. (For analysis with divisible capacity, see Zhang and Zhang, 1997.) We define, as is common in the literature, that the social welfare function is the sum of consumer surplus and producer surplus.

3.1. The short-run financial break-even policy

To maximize the social welfare subject to a “short run”, say annual, financial break-even constraint, the airport authority faces the following problem:

\[
\max_p \sum P_i Q_i - C(\sum Q_i) - Kr
\]

subject to

\[
\sum P_i Q_i - C(\sum Q_i) - Kr = 0.
\]

Given that the capacity is lumpy, the first-order conditions for an optimum lead to

\[
P_i - D_i Q_i - C = \frac{\rho_i}{\bar{\rho}_i} \frac{\lambda}{1 + \lambda}
\]

and

\[
\frac{\lambda}{1 + \lambda} = \frac{Kr + C - \sum C' Q_i - \sum D_i Q_i^2}{\sum Q_i \rho_i / \bar{\rho}_i},
\]

where

\[
\rho_i = P_i + D(Q_i, K)
\]

is the full price perceived by the passengers which is reflected in the carriers’ demand for airport facilities.

A. Zhang, Y. Zhang / Transportation Research Part E 37 (2001) 25–33
where \( e \) is the demand elasticity with respect to the full price \( \rho_i \). The numerator on the right-hand side of Eq. (3) is the difference between the total costs of the airport and the sum of social marginal costs. Hence, Eq. (3) indicates that when the total costs are just covered by the social marginal costs, the Lagrangean multiplier, \( \lambda \), will be zero, and the optimal pricing policy for the airport will be social-marginal-cost pricing. Otherwise, the financial constraint will be binding and Eq. (2) gives the so-called Ramsey pricing. With such a pricing policy, the mark-up of airport charge over the social-marginal-cost as a percentage of the full price, \( \rho_i \), is inversely related to the demand elasticity.

In what follows, we consider situations where the demand for airport services depends on both full price and time, with a positive trend in the demand, i.e.,

\[
Qi \hat{Q}i q_i t^\dagger; o Qi o q_i t^\dagger > 0
\]

Here, the time \( t \) should not be confused with the subscript \( i \). The latter is used to indicate peak or off-peak hours during a day while the former reflects long-term trend in traffic growth.

We have the following proposition:

**Proposition 1.** Under the short-run financial break-even policy, a weighted average of airport charges will decline as the traffic volume grows over time.

**Proof.** Differentiating the budget constraint with respect to time gives

\[
\sum Q_i \frac{dP_i}{dt} + \sum (P_i - C') \left( \frac{\partial Q_i}{\partial P_i} \frac{dP_i}{dt} + \frac{\partial Q_i}{\partial t} \right) = 0
\]

or

\[
\sum Q_i \left( 1 - \frac{P_i - C'}{P_i} \eta_i ^\dagger \right) \frac{dP_i}{dt} + \sum (P_i - C') \frac{\partial Q_i}{\partial t} = 0,
\]

where \( \eta_i \) is the demand elasticity (an absolute value) with respect to airport charge \( P_i \). It is reasonable to assume that \( \eta_i < 1 \), i.e., the demand for aircraft movements is relatively inelastic with respect to changes in airport charges. The first summation in Eq. (5) may be converted into a weighted average of price changes. As the second summation is positive, the first summation must be negative, implying that weighted average airport charge must decline over time as the traffic builds up.

This result is quite intuitive as the costs of capacity are fixed and so the unit costs decline as the traffic volume increases. This pricing policy is not desirable, however, because airport charges are high when the demand is low and when there is an excess capacity. On the other hand, airport charges are low when the demand is high and when there is congestion in the airport. Furthermore, we have the following proposition.

**Proposition 2.** Under the short-run financial break-even policy and assuming that airport operations are characterized by constant returns to scale, then the optimal mark-up over the social marginal cost
decreases with traffic volume. Indeed, it is likely that the mark-up is positive for the low level of demand and negative for the high level of demand.

**Proof.** Eq. (3) reveals that \( \lambda \) is a function of \( t \). By assumption of constant return, \( C - \sum C'Q_i = 0 \). Hence, the sign of \( \lambda \) is determined by the magnitude of \( \sum D'_iQ^2_i \) relative to the fixed capacity costs. Earlier in the cycle the demand is low relative to the capacity, so the congestion at the airport is negligible. According to Eq. (3), \( \lambda \) will be positive. Therefore, by Eq. (2) the airport charge will be higher than the social-marginal cost. Later when the congestion builds up as the demand increases over time, \( \lambda \) will decrease. Indeed, when the congestion becomes serious, \( \lambda \) is likely to turn into negative and in that case the airport charge will be lower than the social-marginal cost.

In the above proposition, the assumption of constant return is not essential. What is required is that the effect of congestion delay costs eventually outweighs the effect of scale economies or diseconomies.

### 3.2. The long-run financial break-even policy

An alternative to the above pricing policy is to allow airport to have a financial deficit and surplus at different times but achieve break-even over the entire period of \( T \). This leads to the following form of optimization:

\[
\max_{\lambda} \int_0^T \left\{ \sum \left[ \int_0^Q \rho_i \, dQ_i - \rho_i Q_i \right] + \sum P_i Q_i - C \left( \sum Q_i \right) - Kr \right\} e^{-rt} \, dt
\]

\[
\text{s.t. } \int_0^T \left\{ \sum P_i Q_i - C \left( \sum Q_i \right) - Kr \right\} e^{-rt} \, dt = 0.
\]

Here, the future revenues and costs are discounted using the cost of capital as the discount rate. The Euler equation for the optimum leads to (Kamien and Schwartz, 1991):

\[
P_i - D'_iQ_i - C' = \frac{P_i}{\rho_i} \frac{\lambda}{1 + \lambda} \tag{7}
\]

and

\[
\frac{\lambda}{1 + \lambda} = \frac{\int \left[ Kr + C \left( \sum Q_i \right) - \sum C'Q_i - \sum D'_iQ^2_i \right] e^{-rt} \, dt}{\int \sum (Q_i \rho_i / \rho_i) e^{-rt} \, dt}. \tag{8}
\]

Unlike (2) and (3), the multiplier \( \lambda \) in Eqs. (7) and (8) is a constant independent of time. The results are summarized below:

**Proposition 3.** Under the long-run financial break-even policy, the optimal airport charge has the following properties:

1. If \( \lambda = 0 \), the optimal airport charge equals the social-marginal cost.
2. If \( \lambda \neq 0 \), the mark-up (over the social-marginal cost) as a percentage of the full price is inversely related to the demand elasticity.
3. The mark-up as a percentage of the full price does not depend on time.
The third property indicates that, when the financial constraint is binding, either the mark-up is positive over the entire period or negative throughout. Nevertheless, the level of optimal airport charges changes over time. Differentiating Eq. (7) with respect to $t$ and noting that $\lambda$ does not depend on $t$, we have

$$\frac{dP_i}{dt} - D''_i Q_i \frac{dQ_i}{dt} - D'_i \frac{dQ_i}{dt} - C'' \frac{dQ_i}{dt} = \alpha_i \left( \frac{dP_i}{dt} + D'_i \frac{dQ_i}{dt} \right),$$

where

$$\alpha_i = \frac{\lambda}{1 + \lambda \epsilon_i}.$$ 

Solving for $dP_i/dt$, we obtain

$$\frac{dP_i}{dt} = \frac{[(1 + \alpha_i)D'_i + D'_i Q_i + C''] \partial Q_i \partial t}{(1 - \alpha_i) + [(1 + \alpha_i)D'_i + D'_i Q_i + C''](- \partial Q_i \partial P_i)}.$$ 

This implies that if $\epsilon_i$ is not too small and $C''$ is not too negative, then $\alpha_i < 1$ and it follows that $dP_i/dt > 0$. This pricing policy is more desirable as the airport charge will increase as the demand grows and congestion builds up over time.

**Proposition 4.** The optimal airport pricing under the long-run financial break-even will yield a higher level of social welfare than under the short-run financial break-even, unless the demand is constant, i.e., $\partial Q_i \partial t = 0$.

The proof is straightforward. It is obvious that the constraint of financial break-even being achieved over the entire period is also satisfied by the constraint that financial break-even be maintained every year. Hence, the set of feasible solutions of the first optimization problem is a subset of feasible solutions of the second optimization problem. Then it follows that the maximal social welfare attained by the solution of the second optimization problem is higher than that attained by the solution of the first problem. In the special case that the demand is constant, $\lambda$ in (2) and (3) will also be constant. Only in this case, can the solutions of the two optimization problems be identical.

### 4. Policy implications

The models of airport charges and cost recovery discussed above have implications for financial and pricing policy at many new airports or airports which have recently undergone major capacity expansion. For example, in the Asia–Pacific region, many new airports have opened recently such as the new airports in Kuala Lumpur, Hong Kong, and Shanghai. However, stricken by the Asian financial crisis, the demand for air transportation in the region has been far below expectation. Many airlines had to cut the frequency of flights in order to maintain a decent load factor. Airports in the region also faced a dilemma. At the present level of traffic, airport facilities are underutilized and the airports are suffering from financial losses. Raising airport charges might reduce losses temporarily but will depress demand further and may lose traffic to other competing
airports in the long run. Lowering airport charges may stimulate the demand but in the short run, may actually worsen the financial status of the airports.

In Hong Kong, for example, the new Chek Lap Kok airport opened in July 1998 and the airport authority lost about US $50 million in the first eight months of operation. The airport has been underutilized; for a design capacity of 35 million passengers per year with one runway, the airport actually handled about 29 million passengers in the first year. Now the second runway and a new wing of the terminal building are also in operation, the under-utilization becomes even more conspicuous. After months of negotiation with the airlines, the airport authority finally decided to cut landing and aircraft parking charges by 15%.

Our analysis suggests that the problem of airport financing or cost recovery should be tackled with a long-term view. As the new airport has excess capacity and the general demand for air transportation in the region suffers from recession, it is quite natural for the airport to incur financial losses. Trying to recover these losses by maintaining high airport charges is short sighted and welfare reducing. A better alternative would be for the airport (and the government) to lower airport charges and take losses in the short run, wait for the demand to recover in the future and recover the losses by the surplus in the future.

Acknowledgements

The authors thank the anonymous referee for helpful comments and suggestions. Financial support from the Competitive Earmarked Research Grant (CERG) of Research Grants Council of Hong Kong is gratefully acknowledged.

References