CHARGING FOR RUNWAY USE: THE CASE OF THE FEDERAL AIRPORTS CORPORATION

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ABSTRACT

After reviewing present and past practice in Australia and some other countries, and after evaluating that practice by reference to some principles of economic analysis, the study suggests a pricing strategy for the FAC. This strategy bases prices on social marginal cost (including any pollution externalities, and congestion costs where relevant), and adds a mark-up to each price, where needed to meet a financial target. The study proposes the use of separate financial targets for each airport, and possibly also for separate services or facilities at any one port, on grounds of equity and in order to discourage decisions that would lead to wasteful provision of services.

Introduction

The pricing of access to runways at commercial airports is a backward business in most countries; Australia has been no exception. For the politician and airport administrator, an important target has been to avoid provoking criticism from user groups, who often have been very vociferous (and sometimes short-sighted) in attending to selfish interests. For the airport owner, the only other target in view has been to raise enough revenue to cover a 'respectable' proportion of the total costs of airport operation; in this, Australian practice has been more venturesome than in some other countries, especially in recent years when full cost recovery has been both the target and, to some extent, the reality.

In contrast, the economic theorist has brought to the issues a welfare-economics framework which emphasizes the variety in the services provided by airport runways, and hence sees the importance of the structure of prices, as well as the overall level of revenue. A traditional concern has been that any individual price that exceeds the social marginal cost of the individual act of use unnecessarily impedes the extent of the use of the runway, and hence diminishes the level of economic welfare attained. The possibility of conflict between this principle and that of full cost recovery has been a source of unease.

In recent years, the gulf between the views of the airport administrator and the economist has begun to diminish. Economic theory has given greater emphasis to so-called quasi-optimal policies in which prices are set in such a way as to promote welfare-attainment, but subject to meeting a prescribed financial target; and considerable effort has gone into establishing how to apply this approach to public infrastructure such as airport runways. Thus the economist has moved closer to what the administrator regards as reality. And in some countries, administrative practice is becoming more ambitious: perhaps by coincidence rather than by conscious choice, the administrator has become a little more interested in the traditional economic issues, especially the role of price in influencing user behaviour.

This picture applies particularly in Australia. Before 1988, most of the major commercial airports had long been directly operated by a Commonwealth Government department. This was done with a singular lack of ambition, as may be seen from the absence of management accounting of any significance. In particular, analysis of costs by function and by airport was inadequate or, frequently, simply not done at all. Thus airport administrators did not pursue even commercial objectives, let alone any fancy concepts such as economic welfare.

This pattern was disturbed only when the Federal Airports Corporation, established in 1986 by the eponymous Act of that year, took charge on 1 January 1988 of a mixed bag of seventeen airports. Added to these (on 1 April 1989) were six more ports The details appear in Table 1. The Corporation has begun to address several

Table 1 The ports of the Federal Airports Corporation

The ports are categorised by the FAC according to function.

Group One: capital city international airports, having in close proximity alternative ports for general aviation (GA):
Sydney, Melbourne, Brisbane, Adelaide, Perth, Hobart

Group Two: designed primarily for use by large regular public transport (RPT) aircraft, but having no suitable GA ports nearby:
Essendon, Launceston, Coolangatta, and (from 1 April 1989) Canberra, Townsville, Darwin, Mt.Isa, Alice Springs, Tennant Creek

Group Three: intended primarily for GA use:
Bankstown, Hoxton Park, Camden, Moorabbin, Archerfield, Parafield, Jandakot, Cambridge

Source: FAC Aeronautical Charges from 1 April 1989

Note: The ports at Canberra, Townsville and Darwin are shared with the RAAF.

commercial issues, and in so doing, it is moving to an explicit position on some of the underlying economic questions.

This study describes and analyses economic aspects of the runway pricing issues now facing the FAC, and does so by reference to economic principles, as well as practices elsewhere.

Welfare economics and the financial target

According to traditional welfare economics, each price should be set equal to the respective social marginal cost. To set price below such cost results in some acts of use that are valued at less than the (direct, variable) cost to society of such use; welfare could be improved if price were raised to marginal cost to avoid this wasteful use. Similarly, a price above marginal cost inhibits some acts of use that are valued more highly than the social cost of use; if price were reduced to marginal cost, welfare is improved by avoiding such lost opportunities.

That analysis presupposes (1) that previous and subsequent investment in such publicly-owned facilities is also perfectly guided by welfare considerations, and (2) that any financial deficit incurred in providing the facilities is subsidized out of general government taxation revenues (and, on this, more later).

The first supposition is not tenable in practice: in particular, it is widely observed to be difficult to persuade public enterprise managers not to indulge in excessive or otherwise misdirected construction of facilities, and this difficulty is especially pronounced when the enterprise is supported by non-specific subsidies paid from consolidated revenue, subsidies that tend to become open-ended. In order to limit, if not wholly avoid, wasteful investment (i.e. construction of facilities whose social value is less than their social cost), there is a case for introducing the financial discipline that comes from requiring the enterprise to meet a financial target, usually one stipulating that the enterprise must break even.

This efficiency case is reinforced by the observation that payment of subsidy usually requires extra taxation in other sectors, leading to significant welfare losses in those sectors. There is also a distributional argument for requiring the users to pay the full costs of provision (including investment expenditures) rather than placing the burden on tax-payers in general (Faulhaber, 1983, p.14). This argument is particularly strong for aviation facilities; these are provided largely for passenger services, and the users are typically more affluent than the many who pay taxes but make little or no use of airports.

By imposing a break-even financial target, society requires (some or all) prices to be set higher than the respective social marginal costs. The argument for doing this is not that the traditional welfare principle does not apply. Rather it is that the welfare arguments for marginal-cost pricing seem to be outweighed by the welfare arguments for financial self-sufficiency.

Quasi-optimal prices to meet the financial target

Although the financial target requires prices to be raised above marginal costs, the traditional welfare measure is still important. Accordingly, among the many sets of prices that enable the target to be met (here assuming, of course, that the financial requirement can be met readily - as is often the case for public enterprises enjoying monopoly power), the best choice is that unique set of prices which results in the smallest reduction in the welfare measure, compared with the welfare value attainable under marginal cost pricing.

These prices are called quasi-optimal, or Ramsey, prices (after F.P. Ramsey who first suggested the idea - see Ramsey, 1927). Each price exceeds the respective marginal cost by an amount determined (in a very precise manner) by the demand elasticities. Broadly, the prices may be said to be based upon capacity to pay, with the surcharge above marginal cost being greatest for the type of use that is least deterred by higher prices, and vice-versa.

This approach works satisfactorily, however, only if certain conditions are met. First, it helps if there are no close substitutes for any of the types of service offered by the public infrastructure in question. In particular, there are problems if some but not all users can obtain substitute service from another public sector enterprise which has a similar problem in finding prices to meet a financial target; a particular example is freight transport by road in place of rail. (In principle, the rival transport modes can then be managed together, subject to an overall financial target - see Braeutigam (1979) and Taplin and Waters (1985). But whether this is practicable is moot.) For our present purpose, it may be noted that passenger air transport rarely has very close substitutes, especially in Australia; and that in nearly all cases, Australian commercial airports are sufficiently distant from each other not to compete for domestic traffic, though there are limited substitution possibilities for some international traffic.

The other prerequisite for successful application of the Ramsey approach is an ability to estimate with reasonable accuracy the demand elasticities for the various services. Without such objective foundation, the users may fear arbitrary exploitation at the hands of the price-setter. For runway use, the task seems not unusually difficult, as is argued later. This does not mean, however, that the various user groups will necessarily refrain from asserting that they are being asked to bear too great a share of the financial burden.

The facts of (airport) life

Although this study deals only with runway pricing, it is helpful to place that service in its airport context. Provision of other aviation services at Australian airports is now shared between the airport owner and the newly-created Civil Aviation Authority (which supplies terminal navigation and rescue services). The airport owner provides airside facilities (comprising taxiways and aprons besides runways), and groundside services such as space for passenger terminals (and sometimes operates these terminals directly). At FAC ports, the budgeted cost for 1988/89 of all services provided by the Corporation is approximately $220 million. (Separate figures for airside and groundside services are not available, apparently because the inherited accounting processes do not provide this break-down, while at the time the budget was prepared, the Corporation had not made the necessary revision of the accounting system.) The 1988/89 revenue from runway charges was budgeted to be $88 million.

Runway pricing is an important issue because the cost of runway provision is a major part of all airport costs, and because the structure of runway charges can significantly affect the pattern of use, including the extent and nature of any congestion. Also of interest is the structure of the costs of runways and of the associated taxiways and aprons. Construction (or enlargement) of a runway incurs the obvious capital outlays: land value, which varies significantly with location; and the cost of civil engineering work, which depends on length, width and pavement strength, and can vary significantly with soil and other site conditions. From a short-run point of view, the direct costs of runway use are principally wear-and-tear costs, which are greater for heavier aircraft, although the addition to such costs arising from extra weight is ameliorated by the design of landing gear.

There are also other airside (airfield) operating costs that are not so directly related to individual acts of runway use. These include cleaning of aprons and other built surfaces, maintenance of unsealed field areas, and the administrative costs of the management of airside facilities. In the case of a congested runway, there is also the cost of delays to aircraft. While such delays may create some additional costs for the airport operator, the principal effects are felt by the airlines (extra operating costs, and extra capital charges through lower productivity of aircraft), and their passengers (value of time lost). Last but by no means least comes the cost of noise and other pollution suffered by communities near to the airport.

Table 2 Air navigation charges[a] for airline flights, from 1 December 1978

For most domestic flight sectors[b], the total charge was calculated by multiplying the unit charge (shown below) by a 'flight factor'. This factor is an (integer) number specified for each flight sector, the number being broadly related to the sector distance.

For international flight sectors (i.e. between an Australian port and a port elsewhere), the total charge was again calculated by multiplying the unit charge by a flight factor. However a charge was levied both on landing and on take-off.

Unit charges (determined by aircraft maximum take-off weight)[c]

Weight range	Incremental charge per tonne, in cents	
	domestic sectors	international sectors
First 9 tonnes	38.9	33.8
Next 11 tonnes	83.8	72.8
Next 80 tonnes	103.0	89.6
Further tonnes beyond 100	95.4	83.0

Source: Air Navigation (Charges) Act 1952-1978

Notes:

(a) Payment of these charges entitles the aircraft operator to use en route navigation services and all airside services at Commonwealth airports

(b) Applies to most sectors actually operated, the only exception being flights between two different state/territory capital cities via one or more non-capital intermediate ports (for which, the intermediate stops are disregarded in assessing charges).

(c) This presentation of the structure of unit charges omits some insignificant detail.

Typical runway pricing structures

In practice, runway charges are usually related in one way or another to aircraft weight (typically maximum take-off weight, MTOW), the relationship often being linear, or approximately linear. This is illustrated by various Australian tariffs. Table 2 shows the composite 'air navigation charges' in effect at the end of 1978; this revenue contributed to the funding of all aviation infrastructure. For a given flight sector, the charge is piecewise linear in MTOW; besides the low unit charge in the first weight range, commuter airlines and GA did not pay flight charges. At the highest weights, the somewhat reduced unit charge favoured wide-bodied aircraft (cf Table 3) operated by international airlines, who according to the calculus of the day were covering a higher proportion of the costs attributed to them than was the case for domestic airlines and GA.

From 1 July 1986, the composite charging arrangement was abandoned in favour of separate charges for the various services. The landing charges for airfield services (ie runways etc, but not terminal navigation and rescue and fire-fighting) are shown in Table 4. The relationship with weight was made strictly proportional, except that commuter airlines, now paying movement charges for the first time, received a 50% discount as a transitional arrangement. For 1988, the upper part of Table 5 summarises the FAC charges. The charge is strictly proportional to weight, except that domestic airline flights by aircraft of more than 45 000 kg MTOW - almost all of the jet services - paid a 15% surcharge.

Table 3 Some maximum take-off weights assessed by the Federal Airports Corporation for charging purposes

Aircraft type	MTOW (kg)	Aircraft type	MTOW (kg)
Jets:		Other RPT:	
B747-300	375 000	F50	20 800
B747-200B	325 000	F27-500	20 000
A300	165 000	Dash 8	15 700
B767-200ER	156 000	Jetstream 31	6 900
B727-200	87 000	Bandeirante	5 900
		PA31	3 700
A320	73 000		
B737-300	61 000	GA:	
DC9-30	48 000		
F28-1000	33 000	Cessna 172	1 050

Source: FAC, personal communication, February 1989
Note: For some types, MTOW varies between individual aircraft; approximate weights given here are illustrative only.

Table 4 Commonwealth charges for airport use[(a)] 1986-87

Movement category	Airport category	Charge per landing ($ per 1000 kg)	Minimum fee per landing $
All airline flights,[(b)] and all other movements by aircraft in excess of 25 000 kg MTOW	Commonwealth	4.00	6.00
	Locally owned[(c)] (ALOP)	2.00	3.00
GA movements[(d)] (except by aircraft in excess of 25 000 kg MTOW)	All	Nil[(e)]	-

Source: Aviation Cost Recovery - Outline of Government Cost Recovery Plan Dept. of Aviation, Canberra 30 May 1986

Notes:

(a) Excludes charges (where applicable) for terminal navigation and rescue and fire-fighting services, as well as en route navigation services.

(b) For the first time, movement charges were payable by supplementary airline licence holders (commuter airlines); as a transitional arrangement, each charge for commuter flights was 50% of that shown here.

(c) Except that at those ALOP ports where there had been no significant Commonwealth expenditure in the previous four years, there was no landing charge imposed by the Commonwealth.

(d) Excludes international GA (for which specific charges were levied).

(e) But GA aircraft paid a fixed annual charge.

Table 5 Federal Airports Corporation aeronautical charges[a]

Aircraft category	Charge per landing[b] ($ per 1000 kg MTOW), effective 1 January 1988	1 July 1988
Group One and Group Two ports		
Domestic airline aircraft exceeding 45 000 kg MTOW	5.06	5.36
All other aircraft	4.40	4.66
Group Three ports[c]		
All avtur aircraft	4.40	4.66

Aircraft category	Charges from 1 April 1989 ($ per 1000 kg, per landing or per period)	
Group One ports	Per landing	
Domestic airline aircraft exceeding 45 000 kg MTOW	5.75	Minimum total fee is $25, save that for non-RPT at Sydney, 0730 to 1000 hours, and 1630 to 1900 hours, minimum is $200.
All other aircraft	5.00	
Group Two and Group Three ports	Group Two per landing	Group Three per landing
Domestic airline aircraft exceeding 45 000 kg MTOW	5.75	n.a.
Other RPT aircraft not less than 10 000 kg MTOW	5.00	n.a.
Other RPT aircraft	5.00	GAIT[d]
GA aircraft not less than 10,000 kg MTOW	5.00	5.00
Other GA aircraft	GAIT[d]	GAIT[d]

Sources: Notice issued by FAC, 31 December 1987; FAC Determination of Aeronautical Charges 22 June 1988; FAC Aeronautical Charges from 1 April 1989 March 1989

Notes:

(a) Charges for fixed wing aircraft for the use of airside facilities provided by the FAC.

(b) Subject to a minimum total fee of $6.60 (January), $7.00 (July).

(c) At these ports, no aeronautical charge for aircraft using avgas.

(d) This charge (the General Aviation Infrastructure Tariff) is levied not per landing but per period, at these rates (per 1000 kg MTOW): per day - $3.80; per month - $80; per six months - $350; per year - $500.

In other countries, too, charges vary with aircraft weight, often being proportional or at least a linear function. In the UK, such a relationship was and is characteristic - see, for example, Little and Mcleod (1972) p. 113 for BAA's London airports in 1972 and Appendix 3.1 of Monopolies and Mergers Commission (1987) for Manchester Airport. However in the UK and in other European countries, the charge often depends also on other factors. In the UK, there is commonly some discrimination, on the basis of presumed capacity-to-pay, between domestic, European and inter-continental flights. And there is sometimes an additional charge, levied on the airlines, for each arriving passenger. As explained in Table 2, the 1978 Australian air navigation charges depended on sector distance as well as weight. But from 1986, the Australian runway charges depend on weight only (save for the limited discrimination by purpose of flight, already noted).

Alternative pricing approaches: uncongested runways

Even an airport with as few as (say) ten aircraft movements a day can experience congestion. At most airports, however, runway congestion is spasmodic, the aircraft delays are of short duration, and congestion may be disregarded in the design of runway charges.

In looking at alternative pricing schemes for an uncongested runway, it is convenient to begin not with Ramsey pricing but with the approach to cost recovery known as fully distributed costing (FDC): to each service (or product) is assigned each and every cost that is incurred exclusively on behalf of that service; and then costs jointly incurred in the provision of two or more services are divided between the services according to some numerical measure, typically a physical basis. (For example, the cost of a piece of plant could be divided in proportion to the amount of time the plant is employed in the production of each service.) The price of a service is then set equal to the sum of these allocated unit costs. This approach has at least a superficial appearance of objectivity, and may thus be palatable to interested parties. Even at that level, however, the approach is seen to be arbitrary whenever there are rival physical bases, as is often the case.

Economists worry about the FDC approach because it pays no attention to demand elasticity (capacity to pay) - see Braeutigam (1980). Besides leading to unnecessary loss of economic welfare, its deployment may even prevent any use of the joint facility in the production of a low-value service, and in some circumstances this threatens the financial viability of the facility as a whole.

Nevertheless FDC thinking has often been employed to allocate runway costs and hence to determine landing charges. The simplest such approach might be to divide the anticipated annual total cost by the forecast annual number of landings, to give a uniform allocated cost per landing and hence a uniform landing charge. In practice, a much more sophisticated variant is employed: total use is divided into relatively homogeneous categories, with aircraft types grouped together according to the length of runway required. In one case (Bureau of Transport Economics, 1977, pp.83-4), the runway length was divided into four parts, with the first part considered as being used by all four aircraft categories, the second as used only by the three categories that need the extra length, and so on. For each part, the cost of provision was allocated to the four flight categories in proportion to the number of aircraft movements using the part. Thus each flight category is awarded cost responsibility only for its share and only for the part(s) of the runway used by the flights in question.

For the determination of landing charges, a further cost allocation is needed within each of the four categories. In this case, allocation within a category was related to maximum take-off weight. This procedure does not appear to reflect FDC thinking - or at least does not employ the simple physical-use basis that is applied in the allocation of costs between the four flight categories. Nevertheless the within-category procedure and the across-category allocation reinforced each other, to produce a weight-related scale of landing charges, broadly similar to that already shown in Table 2.

If prices are to be based upon costs, then the next task is to identify the costs that are to be allocated. One approach is given in Table 6, where the first thing to note is that while three of the four activities incur costs that are opportunity costs (i.e. costs that are incurred if and only if the airport continues in use), the past expense of the engineering work is a bygone. The final column of Table 6 looks at concepts of cost responsibility. If a particular individual aircraft movement did not occur, the only significant cost saving would be in some wear-and-tear on the runway surface (item 3 in the table), with possibly a small saving in routine operating costs (item 4).

Even if that individual movement were by an aircraft in international service and requiring the full length of the runway, the cessation of that one flight does not allow the runway to be shortened. However if all the movements requiring that last part of the runway were to cease, then the surplus length of runway could be removed, and the land applied to some other use, thereby saving part of the annual land cost (item 1), together with some of the routine expenditures such as runway cleaning and field maintenance (item 4). Hence these costs are the responsibility of the entire category of aircraft movements, though none of this responsibility can be ascribed to the individual movement (unlike the wear-and-tear cost).

This distinction between group cost responsibility and individual cost responsibility helps to clarify one of the differences between Ramsey pricing and FDC pricing. In the Ramsey approach, the first component of the price recovers marginal cost, which here is the wear-and-tear cost of the individual movement. This marginal cost excludes all other costs, because they are not the responsibility of the individual movement. In determining the second Ramsey component, these other costs are pooled, and the share attributed to the individual movement is related to the movement's capacity to pay.

In contrast, the FDC approach uses the presence of group cost responsibility to divide up each cost falling outside the marginal cost. Many of the costs are recovered differentially from the different categories of movement, with (for example) international flights paying more per movement than flights in the other categories. Any remaining costs (e.g. indirect or overhead administrative costs)

Table 6 A conceptual analysis of airfield costs

Activity	Included in opportunity cost of continued provision?	Annual measure of opportunity cost	Cost responsibility (for details, see text)
Provision of airfield site	Yes	Annual value of land	May be ascribed to user groups, defined in terms of runway length required.
Past construction and resealing of runways, taxiways and aprons	No	-	-
Future resealing of runways etc.	Yes	Year's contribution to eventual expenditure	Wear-and-tear cost is direct responsibility of the individual aircraft movement.
Routine operations and maintenance	Yes	Current expenditure	(1) A few small elements (perhaps billing costs) are direct responsibility of aircraft movement. (2) Some costs (e.g. runway cleaning) depend on length of runway provided, and hence may be ascribed to user groups, as above. (3) Indirect costs (e.g. administration) can not be ascribed differentially to individual movements or to user groups.

that can not be allocated differentially to categories are then shared out across all movements, often on a uniform basis.

From the Ramsey point of view, this FDC allocation of the costs outside the marginal cost of the individual movement is unsatisfactory because it ignores differences in capacity to pay (the price elasticity of the demand for runway services expressed by the operator of the individual aircraft), and instead uses some other criterion (for example, the length of runway required). Thus, on grounds of welfare maximisation, Ramsey pricing is the preferred route to meeting the prescribed financial target. On the other hand, the FDC approach may be preferred - by some of the parties, at least - for its distributional consequences, and because it can be explained in cost responsibility terms, even though the explanation is couched largely in terms of group cost responsibility only (and for some costs, the group is merely the entire set of users).

But any equity arguments advanced for FDC pricing must be treated with caution. To avoid dealing with a concept that has about as much objectivity as the concept of beauty, economists recognise very few principles of equity. When services or goods are produced jointly, the major equity requirements in economic thinking are that the purchasers of a service should pay at least the incremental cost of providing the service (i.e. how much would be saved if it were not provided), and should not be asked to pay more than the stand-alone cost (i.e. what it would cost if this service was produced by itself) - see Faulhaber (1975). As a matter of general principle, it may be shown that Ramsey prices may not satisfy this latter requirement. On the other hand, FDC prices may also fail this test. For runway pricing, however, because of the particular structure of runway costs, it seems likely that both the Ramsey principle and any sensible application of the FDC approach will result in prices that do pass the test. In that sense there is nothing to choose between the two approaches on equity grounds.

There remain the empirical questions of (1) how to implement the two approaches in a real-world context of imperfect data, and (2) whether, and to what extent, the two approaches lead to significantly different outcomes. These questions are tackled next.

Some empirical aspects

Empirical comparison of FDC and Ramsey pricing must recognise the common if not inevitable practice of basing the price schedule on approximate methods of calculation. Although individual prices may be stated for specific aircraft/flight categories, it is common instead to use a formula which relates price to variables such as aircraft weight (MTOW). Accordingly FDC and Ramsey pricing are compared here in formulae terms.

As already noted, in earlier Australian practice, runway costs were allocated to individual movements according to the runway length required, but the formula was based on MTOW. Clearly the two measures are positively (but not perfectly) correlated.

A recent study (Travers Morgan, 1988) takes a mixed approach. Airfield capital costs are allocated on an FDC basis reflecting the required runway area and numbers of movements. Airfield maintenance costs are divided into two categories. Items such as routine pavement expenditure, resealing costs, land tax and rates are recovered also mainly in proportion to runway area, though a small part (25%) of resealing costs are regarded as damage-related and recovered by an appropriate formulation. Other costs, totalling 60% of all maintenance costs and including rescue and fire-fighting services and maintenance of grassed areas are regarded as joint, and recovered according to the Ramsey principle, with the number of passenger seats serving as the proxy for demand elasticity.

The study applies this methodology to the New Zealand case of Nelson Airport (Travers Morgan, 1988, Appendix B, especially Tables 3, 14 and 15). For eight (principal) user categories, ranging from F27 RPT flights to the lightest of GA movements, the resulting allocated airfield costs (in NZ $ per landing) range from $114 to $6.50. Going beyond the Travers Morgan study, it may be noted that the implied charges per landing per 1000 kg MTOW are about $5.20 for most GA, and $6.21 for F27 movements. (There are however some outliers, notably the figure of $8.56 for the lightest GA category.) Overall there is a strong correlation between MTOW and the allocated costs calculated in the study. Indeed, if as an alternative, a formula that is linear in MTOW were used to raise the same revenue (and assuming that the changes in prices resulted in no significant change in the numbers of landings), then the charge would be NZ$6.10 per landing per 1,000 kg of MTOW.

Similar empirical questions may be asked about the structure of Ramsey prices, and about the use of proxies for demand elasticities. Looking at U.S. data, Morrison (1982) finds (i) that for a given aircraft type, the Ramsey price increases with sector distance - because although demand for air travel becomes a little more elastic as distance increases, this is far outweighed by the increase in total aircraft operating cost for the sector (which makes a fixed landing charge a smaller proportion of that total cost), and (ii) that (relative to Ramsey pricing) a price formula based only on MTOW overprices the heavier aircraft relative to the lighter aircraft. Morrison also studies a very simple proxy formula, in which the landing charge is given by a fixed amount plus a fixed fee per available seat-kilometre (on the sector flown). By regression analysis he finds that an appropriately calibrated formula captures almost all (specifically, 96% of)the variation in his calculated Ramsey prices.

At the broad-brush level of policy-making, there seem to be two simple conclusions. The FDC approach to cost responsibility can be implemented by basing prices on MTOW only - probably using a simple proportional relationship with weight. Similarly, the Ramsey principle can be implemented by using a linear function of available seat-kilometres which has a positive constant term (implying a landing charge that increases less than proportionately with available seat-kilometres). These alternatives give significantly different results. And the major policy question is whether to recognise sector distance in the charging mechanism.

Congested runways: economic analysis

Among Australian airports, Sydney is notorious for delays arising from runway congestion; there are some noticeable delays at peak times elsewhere. In the case of a congested runway, the previous analysis has to be supplemented in order to take account of the fact that an individual aircraft movement can delay other aircraft, causing extra costs for those others.

In the 1960's, lengthy delays became apparent at some major airports, especially in the U.S.; economists soon attributed these to misguided policies on runway pricing and airport funding (Levine, 1969). The situation also prompted conceptual studies (Abouchar, 1970, and Park, 1971) proposing the use of prices to internalise the external costs of congestion (i.e. the use of surcharges to force the aircraft operator to take account of the delay costs imposed on others), in order to maximise (aggregate) economic welfare.

The runway congestion problem arises because for brief (and sometimes not so brief) periods, the arrival rate exceeds the runway capacity. For this, queueing theory is not appropriate; rather a dynamic analysis is required, and this is neatly presented on pp.38-41 of Carlin and Park (1970a).

The basic idea is this. An extra movement occurring at a particular time during a busy period delays all aircraft using the runway after that movement but before the end of the busy period i.e. before the next occasion that the runway is idle. For the sake of a simple exposition, suppose that all movements are by the same type of aircraft, and such that each movement occupies the runway for the same amount of time, say d minutes. If the remaining busy period is T minutes, then there will be T/d movements before the end of the busy period; thus T/d aircraft are delayed, each for d minutes; the total delay occurring because of the single extra movement is T aircraft-minutes (Farrell, 1988 - also the result is implicit in equation (4) of Carlin and Park, 1970b).

An important implication is that this incremental delay - and hence the delay cost - is greater for an additional movement near the beginning of a busy period than for a movement later in the period; the relevant factor is not the number of aircraft waiting at the time the movement occurs, but the total number following before the busy period ends. Now, in reality, there are different aircraft types; also it is necessary to distinguish between landings and take-offs (especially to measure delay costs per aircraft per movement). Nevertheless the general character of the analysis is much the same. Under severe congestion, the delay cost which is the direct cost responsibility of a single aircraft movement can amount to hundreds (possibly, thousands) of dollars (Carlin and Park, 1970b).

Accordingly, the runway charge should include a component that reflects this delay cost. In principle, this component should vary with time, being higher at the beginning of a busy period, and then reducing gradually as the time approaches the end of a busy period. In practice, a uniform component could be set for each sub-period, say every half-hour, with separate charges for landing and take-off. If the duration of runway occupancy does not vary significantly with the type of aircraft making the movement, the congestion component will not vary with the aircraft type. Equally, all users will pay the same congestion charge, no matter what the category of the flight (airline, GA, business etc.).

The precise construction of runway charges in the presence of congestion must depend on the impact of the financial target. At an airport with severe congestion, revenue may be so buoyant as to surpass that needed to meet the target. Where that is so, then the total charge should comprise simply the congestion component, set equal to the full delay cost caused by the movement, together with a component matching the wear-and-tear cost (and any other cost) directly caused by the individual movement. Because there is no need to obtain any additional revenue to meet the financial budget, there is no place for any Ramsey (capacity-to-pay) component.

However there may be mildly-congested airports where the congestion is serious enough to merit recognition in the charging structure, but where revenue from charges based only on directly-attributable costs is insufficient to meet the financial target. In that case, the total user charge should include a capacity-to-pay element, as well as the social marginal cost components. But, because Ramsey pricing involves price discrimination (i.e. relies on differences in demand elasticities), the price differential between any two services will not generally match the difference in marginal costs. In the present case, the difference between the charges for peak and off-peak periods (other things being held equal) will not generally match the delay cost (Oum and Tretheway, 1988).

In both cases (i.e. whether or not the financial target is a binding constraint), the full delay cost (to which the congestion surcharge is to be related) is that obtaining in equilibrium i.e. when the congestion surcharge results in a level of delay costs that matches the level supposed in calculating the surcharge. If congestion pricing is introduced at a heavily congested port, and if the charges are based on delay costs observed before such pricing is used, then it is likely that a significant number of movements will be priced out, resulting in lower congestion costs and hence congestion charges that are too high. Because of the difficulty in forecasting how many movements will be priced out, the practicable approach seems to be to aim to under-price initially, and then adjust the congestion charge until the equilibrium is reached.

Note that in such equilibrium, some congestion generally persists. In the short term, optimal use of the limited capacity is likely to trade-off delays against the benefits of accommodating additional flights. Even in the longer term, when an additional runway/airport may be built, it will be best to limit capacity so as to leave significant congestion, when the delay costs are less than the extra investment outlays otherwise needed.

Congestion pricing in practice

As already noted, the basic congestion pricing ideas had become commonplace by 1972. But there was little implementation. An early exception, however, was the policy of the British Airports Authority, which in April 1972 introduced a peak-period surcharge at Heathrow of £20 per movement (landing or takeoff) (Little and McLeod, 1972, p.113). (Although the congestion surcharge was uniform across all aircraft and flight categories, the ostensible reasoning behind that uniformity differs from the analysis given in the previous section; see p.112 of Little and McLeod, and note that McLeod was an officer of the (then public-sector) Authority and Little an economist appointed to its board.) The BAA also increased the minimum landing fee at Gatwick for designated peak weekends, to discourage GA movements.

Since 1972, peak surcharges of one form or another, together with sizeable minimum landing fees, have become common practice at several major ports in the UK. A recent sample of illustrative charges for specified aircraft/flight categories is given as Appendix 3.2 of Monopolies and Mergers Commission (1987). Among other instances, this shows that at Heathrow and Gatwick charges in the peak were generally more than twice the off-peak charges. (However, in this source document, the charges are presented on a per passenger basis; in some cases, part of the differential may reflect passenger fees, introduced to limit terminal rather than runway congestion.)

Notwithstanding the severe delays at several major airports in the US., the lack of enthusiasm for congestion pricing was particularly noticeable in that country. Instead, at some ports, the Federal Aviation Authority undertook an administrative allocation of scarce runway slots on a grandfather basis which granted valuable property rights to established airlines, and handicapped entrants to the industry as well as those airline companies coming anew to the particular port. This hindrance to competition became especially important after deregulation, and remains a problem to this day.

One exception, however, is the Massachusetts Port Authority, which has recently decided to act in the face of severe congestion at Logan Airport (Boston). First, it added a modest minimum landing fee of US$25 to a uniform weight-related scale; this discouraged only a few GA flights. Then, in July 1988, Massport reduced the weight-related component and introduced a fixed component of $88, thereby reducing fees for jets larger than the DC9-30, and greatly increasing the fees for small aircraft.

In its initial proposal (Massport, 1987), the Authority had sought to justify the new charges on FDC grounds, saying that these days a large part of its costs are not related to aircraft weight, and should be shared out equally among all movements. Yet much of its report addresses the problems of congestion: the introduction of the fixed charge was clearly intended to reduce the number of movements made by smaller aircraft, and hence to reduce the delays to airline flights. In the outcome, there was a significant reduction in delays, even while passenger numbers increased slightly (Aviation Daily, 1988).

Acting upon complaints made by operators of small aircraft, a DOT Administrative Law Judge concluded that the fees were not "fair and reasonable" and were "unjustly discriminatory" (Department of Transportation, 1988, p.4). Subsequently, the Department required the charging scheme to be rescinded; Massport then appealed this decision.

In its order, the Department found that some aspects of the Massport fee structure were not devised "on a rational and economically justified basis" (Department of Transportation, 1988, p.11). For those who remain to be convinced, it may be noted that the Department dislikes Massport's FDC allocation of certain costs on a uniform per-landing basis (because the allocation departs from considerations of cost responsibility), criticises Massport's use of a large fee even at off-peak times (but apparently might accept a peak-period surcharge), and rejects Massport's exemptions for selected commuter flights, not on grounds of welfare theory but because some details of the scheme conflict with the federal subsidy programme for (so-called) essential air services (for small communities).

In Australia, too, old pricing habits have been slow to change. In the face of congestion at Sydney and calls for additional capacity there, various commentators (including Kolsen, 1979 and Mills, 1979) put the arguments - by then, the well-worn arguments - for congestion pricing. Soon thereafter the Department of Transport advocated sizeable minimum landing fees and even mentioned congestion pricing. But in July 1981, following lobbying by GA interests, the then Minister for Transport rejected these proposals (Mills, 1982 pp.199-200).

In 1983, the newly-elected government appointed an Independent Inquiry into Aviation Cost Recovery (the Bosch committee). Among the many recommendations in the Inquiry's 1984 report were those proposing the introduction of separate airport and airways charges, to be "set as far as possible according to the costs of and demand for particular facilities and services and not on average system costs" (recommendation 70), with "surcharges on aircraft movement charges ... as a means of dealing with congestion at busy airports" (recommendation 71).

As already seen (Table 4), while the government did introduce separate charges in 1986, the new airport landing charges were motivated by little other than average system costs. However, "congestion charging at Sydney" was listed among the "issues for future consideration" (p.4 of Department of Aviation, 1986).

In its early days, the FAC continued to apply charges based on average system costs (Table 5). However, in April 1989, the Corporation introduced a limited form of peak surcharge at Sydney, as part of a revised structure for aeronautical charges, shown also in Table 5. Although this is clearly a step towards greater economic efficiency, the form of the surcharge raises some misgivings. Particularly troubling is the fact that the $200 minimum fee applies only to GA movements, which total about 13% of all peak-period movements (Joint Task Force, 1988 p.9). In consequence, landing charges payable by commuter airlines flights (about 25% of all peak-period movements) and even by some regional airline flights are considerably smaller; examples are the approximate charges of $105 for a F50 and $30 for a Bandeirante. Thus like the ill-fated Boston scheme, the surcharge is not applied indiscriminately across all aircraft categories; and in favouring airlines, it may be regarded as inequitable. (However, unlike the Boston scheme, the charge does apply only in peak periods.)

Further, the significantly lower charges for commuter and most regional airline flights imply some (avoidable) loss of economic efficiency, though this may be of modest amount. If the $200 surcharge were applied to all, some commuter airline flights would cease, or divert to non-peak periods, or be merged into flights by larger aircraft. On the other hand, the demand elasticity for flights by the larger non-jet aircraft is probably low. However there are some efficiency implications even for some jet aircraft; for example, the landing charge for a DC9-30 is about $240, and for a B737-300 it is $350; if $200 of this is regarded as the congestion surcharge, the Ramsey mark-up is very small indeed. Universal application of the $200 surcharge would give the airlines some further incentive to substitute somewhat larger aircraft, especially on high-density routes such as Sydney-Melbourne.

The remaining issue is the level of the surcharge. At pre-existing levels of congestion, the delay cost is probably very much higher than $200 for much of the defined peak period. Hence even the equilibrium level for the charge may well be more than $200. Nevertheless, the choice of $200 as an initial value seems sensible. Measurements of delays and delay costs should be made to guide subsequent adjustments.

A pricing strategy for the FAC

For the FAC, the financial constraint seems to be severe enough to require prices in excess of the social marginal cost of individual aircraft movements. On that basis, the implications of the previous analysis may be summarised.

The pursuit of welfare maximisation, subject to the financial constraint, requires that:

(1) For a runway without significant congestion, the charge per landing should comprise -

(a) A component matching the social marginal cost of the individual aircraft movement, being
- wear-and-tear costs
- noise and other pollution costs (at least in those cases where noise is a significant problem).

Both cost elements require differentiation by aircraft type.

(b) A Ramsey mark-up above marginal cost, based on available seat-kilometres (for the sector just flown) as a proxy for demand elasticity.

(2) For any peak period in which the runway has significant congestion, the first component of the landing charge should also include the incremental delay cost, which might be charged separately for landing and take-off. (Note the Ramsey mark-up will generally differ from the corresponding off-peak mark-up.)

Before developing the financial analysis of the FAC's position, it may be noted that (of course) revenue from pollution charges should not remain with the FAC. Rather it should be disbursed, wherever possible, to those individual parties who suffer the pollution; where that is not feasible, the revenue should go to government - possibly local government. It is important that the industry (and its customers) should not merely recognise the pollution problem, and take steps to curtail the amount of pollution; it must also pay for the costs of the pollution actually created. This will provide a further incentive to limit pollution. In particular it will help in the making of decisions about curfews, and about the location of airports. (Media reports following the March 1989 "decision" in favour of a third runway at Sydney suggest that the Government may have been unduly influenced by the comparison of the civil engineering costs of the extra runway/extra airport alternatives. A requirement for actual payments to compensate for pollution will focus minds powerfully.)

The financial position of the Corporation

Some revealing fragments of information are now available for individual ports, and are reported here in Table 7. The revenue figures describe income from all sources. Further, the audited accounts show that aeronautical income (ie landing charges) comprised in aggregate about 40% of the total. Note also that some 70% of income from all sources was received at Sydney and Melbourne, and a further 25% at Brisbane, Adelaide and Perth.

Expenditure relates to both airside and landside activities. Here, there is no detail for individual ports. The aggregate data show that three categories (viz. salaries and wages, depreciation -principally plant and equipment rather than buildings - and interest) each accounted for about 25% of the total expenditure. The initial capital structure of the Corporation included borrowings from the Commonwealth of $400 million, and Commonwealth equity of $648 million.

The 1987-88 interest payment represents a rate of about 12% per annum on the debt; but there was no provision made for any dividend on the equity.

Comparison between the Corporation aggregate and the sum of the expenditures at the individual ports makes it clear that, notwithstanding the use of the term 'operating', the profit or loss at each port is that obtaining after allowing for interest. Although the report gives no detail, it is to be hoped that in determining the initial capital structure, the Commonwealth calculated debt and equity capital in relation to asset values at individual ports, and that the individual interest charges have been calculated on this basis.

Whatever the details, those data make it clear that most ports operated in financial deficit, and that for the GA ports the deficits were not far short of the total expenditures. These deficits were funded by a modest surplus at Melbourne (which surplus might well disappear once dividend payments are introduced) and a larger surplus at Sydney where the port is operating close to its capacity limitations.

Although the accounting data in Table 7 do not relate very closely to the opportunity cost concept (Table 6), a little more insight can be obtained from data for the Group Three ports (Federal Airports Corporation, 1988a), which shows that there are substantial losses on both airside and landside activities. The airside position is portrayed in Table 8. At these ports, the expected aeronautical income is tiny because in 1988-89 landing charges were collected only from aircraft using avtur fuel (cf. Table 7), while most movements at these ports were by aircraft using avgas.

With the introduction of the General Aviation Infrastructure Tariff on 1 April 1989 (see Table 5), there will be extra income in 1989-90 (Table 8), and a modest reduction in the losses at these ports. Although the cost analysis of Table 8 is still not based on opportunity cost, it is clear that any conceivable financial target in the opportunity cost mould would require still more aeronautical income and/or significant reductions in costs incurred. In that sense, increased airside cost recovery at the GA ports - and seemingly at some others - should be part of the FAC's strategy.

In that light, the structural changes introduced in April 1989 are seen as a desirable first step towards both full cost recovery and a more equitable division of the financial burden. There remain two questions. First, what should be the ultimate financial target for each airport? Secondly, what additional measures should be introduced to help ensure that specific kinds of service are provided if and only if the users want them enough to pay for their full costs?

Table 7 Some operating and financial statistics by port, Federal Airports Corporation, January to March 1988

Airport	Chargeable aircraft movements (thousands)	Passengers[a] (thousands)		Total revenue	Total exp.	Operating profit /(loss)[b]
		Dom.	International	($ million)		
Group One[c]						
Sydney	51.6	1775	1036	22.3	14.8	7.5
Melbourne	26.7	1426	416	13.6	12.4	1.2
Brisbane	25.2	744	197	5.8	6.2	(0.5)
Adelaide	20.5	439	39	2.9	3.5	(0.6)
Perth	14.5	353	192	4.1	5.5	(1.4)
Hobart	4.1	146	5	0.7	1.2	(0.5)
Group Two[c]						
Launceston	6.9	106	-	0.9	1.1	(0.2)
Coolangatta	9.9	255	-	1.3	1.1	0.1
Essendon	17.7	-	-	0.5	1.7	(1.2)
Group Three[c]						
Bankstown	1.1	-	-	0.2	1.2	(1.0)
Jandakot	0.4	-	-	0.1	0.4	(0.3)
Parafield	0.3	-	-	0.1	0.5	(0.4)
Moorabbin	0.6	-	-	0.1	0.8	(0.7)
Archerfield	0.1	-	-	0.1	0.4	(0.4)
All ports[d]	179.6	5244	1885	52.8	51.0	1.8

Source: Federal Airports Corporation Annual Report 1987-88 Sydney

Notes:

(a) Total of embarking and disembarking passengers; transit passengers are excluded.

(b) After all outlays including interest payable to the Commonwealth, but not including any dividend payment on Commonwealth equity.

(c) For the definition of airport groups, see Table 1. (Here, data for Hobart include Cambridge; those for Bankstown include Camden and Hoxton Park.)

(d) These aggregate figures are from the audited accounts, and are for the financial year ending 31 March 1988; the other data are from a table on p.4, describing the Corporation's first three months of airport operation.

Financial targets for individual ports

The Federal Airports Corporation Act 1986 imposes an overall financial constraint on the Corporation - although the government may adjust that constraint from time to time by altering the interest payments required on borrowings from the Commonwealth, and by making annual determinations of the dividend on equity capital to be paid to the Commonwealth (sections 46 and 47 of the Act). The proposition examined here is that in addition to this overall financial target, a separate financial target should be established by the FAC for each of its airports.

As already seen, at the Group Three ports and perhaps elsewhere, the income from aeronautical charges is very low relative to airside costs (Table 8). In consequence, it is clear that revenue does not cover even the opportunity cost of continued provision of the service (as defined in Table 6). Yet on grounds of equity and efficiency, there is a case for requiring that such individual targets be met.

Suppose, for the moment, that this is feasible i.e. that demand is sufficiently elastic for it to be possible to find Ramsey prices that generate revenue large enough to cover opportunity cost, after those costs have been reduced to a minimum. Then, if at each and every port this financial constraint is only just satisfied, and assuming (i) that the Corporation's assets have been 'properly' valued, and also

Table 8 FAC airside budgets for 1988-89, GA ports[a] and Essendon, with estimated extra income 1989-90[b]

$000

Airport	Expenses			Income	Loss	1989-90 extra income
	Operating costs	Depreciation	Interest			
Bankstown[c]	890	464	906	12	2248	213
Archerfield	410	200	388	9	989	91
Jandakot	292	83	65	19	421	83
Moorabbin	681	399	779	33	1826	182
Parafield	502	326	437	0	1265	130
Essendon	843	913	933	472	2217	-

Source: FAC Financial Viability of GA Airports Sydney 1988 together with later extension of the data.

Notes:
(a) Excl. Cambridge, which is not separated from Hobart.
(b) FAC forecasts of extra income under General Aviation Infrastructure Tariff, introduced 1 April, 1989.
(c) Includes Camden and Hoxton Park.

(ii) that the Government requires 'proper' levels of interest and dividend payments, then the overall financial constraint would not be met (because, in addition to opportunity cost, that constraint reflects past engineering expenditures, which are bygones). Thus the overall financial constraint would need to be imposed explicitly; and to meet it, charges at a few ports (notably Sydney) would need to be higher than those needed simply to meet the individual targets for those ports; and the consequent cross-subsidies would be smaller.

On the other hand, if some of these financial targets for individual ports proved to be infeasible (as may well be the case for some of the Group Three ports), then in the short-term the corresponding financial constraints would have to be relaxed; larger cross-subsidies would be required, with higher prices at the busy ports. In the longer-term, the FAC should seek to reduce the scale of activity at the 'unfinancial' ports - perhaps by selling off land, or perhaps even by closing the ports altogether (though in the latter case it may prove economically attractive to build new GA ports on less valuable land, in those situations where there is no existing alternative provision). (In such longer-term calculations, the Corporation should examine the financial position of airside and groundside facilities jointly; this is not pursued here.)

Such surgery would no doubt provoke voluble protests from users of these ports. But it is not clear that there are <u>any</u> public-interest reasons for such subsidy to general aviation, in which case the protests should be borne with fortitude.

Ramsey pricing, incentives and equity

The use of the Ramsey principle to determine prices sometimes provokes objections to the effect that capacity to pay may not be well correlated with use of the facility. In an extreme case, a new facility or service may be used solely by one group of airport customers (GA perhaps) while the capacity to pay (under a global airport financial constraint) may rest almost entirely with another group (say the major airline users). It is then argued that it is inequitable for the airlines to have to pay for the GA facility. Such an arrangement may also be detrimental to economic efficiency, to the extent that it leads to provision which is valued by its users at less than its cost of provision. (While the analysis of the preceding section dealt with the provision of different services at different airports, the present concern is similar but addresses different services provided to different customer groups within the one airport.)

Thus it may be desirable to supplement any airport financial constraint by separate financial tests on separable services or facilities. As an example, consider a proposal to invest in a new facility to better serve a subset of the airport's customers. The evaluation of the investment proposal may then be done by judging whether a set of prices (for the facility) can be found such that the users as a group will pay enough to cover the cost of the facility. If the investment is undertaken, then these prices are implemented, so that the users do actually pay.

The task of sharing the costs among those who will use it may still be done by using the capacity-to-pay principle, but this is now applied to that customer subset who will be actual users. Furthermore, this argument leads to the proposition that airside facilities should be funded solely from aeronautical income, and landside costs from other charges. (Apparently, the FAC does not presently follow this practice, though the extent of the cross-subsidy is not yet clear, because it is only now that accounting procedures are being developed to separate the two cost areas.)

This approach disaggregates even the finances of a single airport, and adds a further level to the hierarchy of financial constraints. Generally, this further disaggregation will again lead to an additional welfare loss, to the extent that it rules out price patterns that would be permitted under a more aggregated financial constraint. But this loss may be more than offset by the equity aspects, and by efficiency gains from tighter control over longer-term issues such as investment decisions.

Conclusions

Whatever the precise strategy adopted by the FAC, it seems safe to predict that there will be a marked increase in the percentage recovery of costs at GA and other smaller ports. To provide for a dividend on the equity capital, it appears that there will need to be an increase in the real level of charges overall. And this may also be needed if and to the extent that the cost of further capacity is to be funded by charges on present customers, rather than by the external (money-market) borrowing which is permitted under section 48 of the FAC Act.

Given the effective regional monopoly power of each of the Corporation's major ports, increases in real charges may well raise questions about regulation of the Corporation's prices. Under the FAC Act (see section 56) the Minister has power to disallow proposed aeronautical charges (and only these charges). It remains to be seen whether and how this power will be used, and whether there will be a case for public monitoring - and perhaps regulation - of these prices.

References

Abouchar, A. (1970) Air transport demand, congestion costs and the theory of optimal airport use Canadian Journal of Economics 3 463-475.

Aviation Daily (1988) Delays down, traffic up under PACE plan, Massport says Aviation Daily November 17, 1988 p. 252

Braeutigam, R. R. (1979) Optimal pricing with intermodal competition American Economic Review 69 38-49

Braeutigam, R. R. (1980) An analysis of fully distributed cost pricing in regulated industries Bell Journal of Economics 11 182-196

Bureau of Transport Economics (1977) Cost Recovery in Australian Transport 1974-75 AGPS, Canberra

Carlin, A. and Park, R. E. (1970a) A model of long delays at busy airports Journal of Transport Economics and Policy 4 37-52.

Carlin, A. and Park, R. E. (1970b) Marginal cost pricing of airport runway capacity American Economic Review 60 310-319.

Department of Aviation (1986) Aviation Cost Recovery - Outline of Government Policy Plan Canberra, 30 May 1986.

Department of Transport (1980) Transport Pricing and Cost Recovery Seminar - Papers and Proceedings Canberra July 1979 AGPS, Canberra.

Department of Transportation (1988) Investigation into Massport's Landing Fees (FAA Docket 13-88-2) Washington DC, 22 December 1988.

Farrell, J. (1988) Puzzles: Sylvia, ice cream and more Journal of Economic Perspectives 2 (No. 3) 175-182.

Faulhaber, G. R. (1975) Cross-subsidisation in public enterprise pricing American Economic Review 65 966-977

Faulhaber, G. R. (1983) A public enterprise pricing primer, pp. 11-26 of J. Finsinger (ed.) Public Sector Economics Macmillan, London.

Federal Airports Corporation (1988a) Financial Viability of GA Airports FAC, Sydney.

Federal Airports Corporation (1988b) Annual Report 1987-88 FAC, Sydney.

Federal Airports Corporation (1989) Aeronautical Charges from 1 April 1989 FAC, Sydney.

Independent Inquiry into Aviation Cost Recovery (1984) Report (H. Bosch, Chairman) AGPS, Canberra.

Joint Task Force (1988) The Airport Needs of the Sydney Basin (Report of the Joint Commonwealth/New South Wales Government Task Force) (Publisher and place of publication not stated.)

Kolsen, H.M. (1979) Efficient resource allocation: Theory and practice in the transport industries, pp.97-111 of Department of Transport (1980).

Levine, M.E. (1969) Landing fees and the airport congestion problem Journal of Law and Economics 12 79-108

Little, I.M.D. and McLeod, K.M. (1972) The new pricing policy of the British Airports Authority Journal of Transport Economics and Policy 6 101-115

Massport (1987) Massport's Program for Airport Capacity Efficiency Massachusetts Port Authority, Boston.

Mills, G. (1979) Pricing principles and cost recovery in transport, pp.112-127 of Department of Transport (1980).

Mills, G. (1982) Investment in airport capacity - a critical review of the MANS (Major Airport Needs of Sydney) study, pp.171-210 of Seventh Australian Transport Research Forum Papers Hobart.

Monopolies and Mergers Commission (1987) Manchester Airport plc - A report on the economic regulation of the airport Civil Aviation Authority, London

Morrison, S.A. (1982) The structure of landing fees at uncongested airports Journal of Transport Economics and Policy 16 151-159

Oum, T.H. and Tretheway, M.W. (1988) Ramsey pricing in the presence of externality costs Journal of Transport Economics and Policy 22 307-317.

Park, R.E. (1971) Congestion tolls for commercial airports Econometrica 39 683-694.

Ramsey, F.P. (1927) A contribution to the theory of taxation Economic Journal 37 47-61

Taplin, J.H.E. and Waters, W.G. (1985) Boiteux-Ramsey pricing of road and rail under a single budget constraint Australian Economic Papers 24 337-349

Travers Morgan Pty Ltd (1988) Airport Charging (Report for NZ Organisation of Airport Authorities and Ministry of Transport).