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The Economic Regulation of the UK Airport Industry

by

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List for Abbreviations

AAR: Airport Average Revenue (Approach)

ATM: Air Transport Movement

BAA: BAA plc

BEA: British European Airways

CAA: Civil Aviation Authority

CCA: current cost accounts

CRS: constant returns to scale model for DEA

CUSUM: cumulative sum of residuals

DEA: Data Envelopment Analysis

DMU: decision making unit

HCA: historical cost accounts

ICAO: International Civil Aviation Organization

LRMC: Long-run marginal cost

MMC: Monopolies and Mergers Commission

MMC1: MMC's report on investigation of Manchester Airport (1987)

MMC2: MMC's report on investigation of BAA plc (1991)

MMC3: MMC's report on investigation of Manchester Airport (1992)

MMC4: MMC's report on onvestigation of BAA plc (1996)

MMC5: MMC's report on investigation of Manchester Airports (1997)

MOU: Mimorandum of Understanding between the Government of United States of America and the Government of the United Kingdom on Airport User Charges

NERA: National Economic Research Associates

RRR: Required Rate of Return

SEAL: South-East Airports Ltd of BAA plc

TDR: Test Discount Rate

TFP: total factor productivity

VRS: variable returns to scale model for DEA

Summary

The UK airport industry faced regulatory reform following the 1986 Airports Act. The regulatory reform not only included privatisation of the then nationalised British Airports Authority, but also changed the airports that used to be directly owned and managed by local authorities into autonomous plcs. As a result, the industry includes four categories of institutional arrangement for the airports in the UK, i.e., (1) privatised airports with price regulation, (2) privatised airports without price regulation, (3) a local authority airport plc with price regulation, and (4) local authority airports plc without price regulation. The regulatory reform involves the imposition of price cap regulation on 'designated' airports' average airport charge levels. In this thesis focus is placed upon the predictions of outcome changes in this industry by the regulatory reform. The framework of the analyses is based on applied microeconomics, particularly on the theory of regulation. The predictions regarding the airport charges rebalancing effect and productive efficiency are accompanied by empirical analyses as to finding any performance changes. Predictions and empirical analyses were carried out mainly with regard to (1) allocative efficiency in price rebalancing and (2) technical efficiency in production. The price regulation's constraint form is the 'Average Revenue Approach' and some economists suggest this leads to efficiency distortion. 'Designated' airports' price cap constraint uses only the passenger numbers to 'average' the level of total airport charge revenue. The thesis shows that this approach would produce a different outcome from the general outcome predicted through a typical 'Average Revenue Approach' using both a simple model and interdependency demand model, followed by an empirical analysis using price ratio data. As to productive efficiency, after predictions of the outcome I used Data Envelopment Analysis to test efficiency scores in (A) the then nationalised British Airports Authority/privatised BAA as time series, and (B) private airports and local authority airports after the reform as a panel comparison.

Papers and presentations at conferences consequent to the preparation of this thesis

- I published in September 1998 the results of a productivity efficiency study using the DEA with a CRS model as one of three authors in a research report (in Japanese) titled 'Performance of Liberalization and Privatization in Civil Aviation' by Institute for Transport Policy Studies in Japan.

- In March 1999 I published a short paper in Japanese, which was mainly a survey regarding the relationship between the UK nationalised industry and the concept of 'optimal regulation'. The content is related to the Appendix to Chapter 1.

- On 12/9/97 I made a presentation, based on the DEA efficiency measurement results using VRS model from my research related to Chapter 6, at the Conference of Operations Research held at Bath University.

- In May 1999 I made a presentation (in Japanese) at the annual conference of the Japan Society of Public Utility Economics. The subject was related to the positive approach model for analysing the then nationalised British Airports Authority which I have used in Chapter 3.

Chapter 1

Introduction to Regulatory Reform

1-1. Introduction

The purpose of this thesis is to investigate how the UK airport industry's performance has changed in response to recent regulatory reform. A change in performance is identified as a change in efficiency. I focus on both allocative efficiency in pricing and internal efficiency in production. The UK airport industry's structure has changed since April 1987 following the Airports Act 1986. The industry faced a drastic change not only with the privatisation of the then nationalised British Airports Authority into BAA plc (BAA, hereafter)[1], but also with the transformation of the airports that were directly owned and managed by local authorities into public limited companies. The airports' productive efficiency change analysed in this thesis is linked with these ownership changes. Following these ownership changes, the regulations of the UK airports were also changed. The allocative efficiency of the airport charge regulation is therefore also analysed in this thesis.

The purpose of this chapter is to consider the basic concepts of institutional arrangements, derived from the microeconomics theory of regulation. I base the framework of this thesis on the firm's objectives and constraints, the relationship between them and the difference between the objectives of the firm and social welfare, and the role of any control mechanisms. Section 1-2 addresses the importance of examining a structural change as an institutional arrangement's change. Section 1-3 examines how we should look at a public corporation under direct control of the government, with a survey of the types of models that economists have adopted in the literature, whilst section 1-4 addresses why and how regulatory mechanisms play an important role in a privatised organisation. Section 1-5 gives brief preparatory comments for Chapter 3 where I explore the institutional arrangement's changes and predicted outcomes specifically applied to the UK airport industry.

1-2. Structural change, objectives and constraints

Recently in the UK there have been many changes in the structure of public corporations. These structural changes vary in many ways from one industry to another. By the word 'structural change' I mean 'changes in an institutional arrangement' in an industry. An institutional arrangement involves the objectives of owner(s), managers and workers of a firm and any control mechanisms between them (What links the objective of the owner(s) and that of the managers with regard to achieving the former can be called a 'control mechanism'), and the market structure. Structural changes affect the objectives of the stakeholders in the firm. Being simply put, 'structural change' is any change in the factors of the paradigm of the theory of industrial organisation which consists of market structure, market conduct and market performance. These factors are linked with each other by the objectives of the owner(s) and the managers of the firm, competitiveness of the product (and/or input factor) market and the strength of the control affecting the firm such as the capital market, managers' labour market, and union's negotiation power, etc..

The most drastic change for an organisation is a change of ownership because it is most likely to change the objectives of all the parties involved. The owners of a nationalised firm are the people of the country. The logic behind setting up a nationalised firm (in a capitalist economy where 'ideology' is irrelevant in establishing nationalised firms) is, or at least was thought to be by the advocates of nationalisation in the UK, that the public can entrust the managers of the firm with regard to maximising the social welfare. Whether or not the managers of a nationalised firm have the same objective of maximisation of social welfare, the style of operating a firm as a nationalised firm can be believed to be the least costly way to secure the objective of the whole nation's people. This is related to the concept of the transaction cost to a principal who aims to realise his/her objective via an agent in the framework of the Principal-Agent theory. In this case the principal is the public and the agents are the managers of the nationalised firm. The privatisation programme in the UK in many regulated industries can be understood in the light of the Principal-Agent problems.

Principal-Agent problems originated from the concept of the divergence of a firm between ownership and management. The owner of the firm as a principal wants the managers as the agent to achieve his/her objectives, because it would be more beneficial to the owner to let the specialist managers operate the firm. However, the management would not necessarily facilitate the optimum input necessary to achieve it. This problem is considered as inescapable and stems from the existence of the hierarchy in the management of a firm. The existence of any hierarchy means that those who belong to a certain level in the hierarchy have private information only available to their level. It either is impossible or requires enormous transaction costs in order for those who do not come into contact with the management activities in detail to obtain many types/levels of decision-making information. Information such as whether production costs are minimised or what kinds of potential initiatives are open to the managers are indeed their private information. The private information owned by any hierarchy in the management of the firm forms a 'rent' to the managers. Monitoring the agent with regard to reducing the rent from the private information is a 'price' to the owner of the firm to achieve his/her objective, as he/she had decided to use the agent. Unless the 'price' exceeds the marginal benefit to the owner as to the profit from the firm, spending himself/herself the monitoring cost is a rational behaviour. Principal-Agent problems when they are applied to a nationalised firm, can be looked upon at its simplest as follows: the government as the principal and the managers as the agent. The government, on behalf of the general public, is supposed to aim to maximise welfare via the managers of the firm (the relationship between the public and the government is also one between the principal and the agent). If there was no information asymmetry, which would be an unrealistic situation, i.e., if we assume that the government as the principal can perfectly monitor the behaviour and the performance by the managers as the agent, we could consider that the institutional arrangement of the nationalised firm is superior to any other form of institutional arrangement. However, information is asymmetric between the government and the managers as the government is not directly involved in the operation of the firm, so there is a need for monitoring by the government. If the monitoring cost to the government has become too large, the control mechanism having either ceased to work or never having worked, or if the market structure has changed there may have emerged a better way to secure the social welfare. Changes in the institutional arrangements would be called for.

Another tier of principal and agent should be added when considering a nationalised firm's institutional arrangement, i.e., the public as the real owners and the government. Unlike in the case of private firms, the owner of any nationalised firm is the wider public. Considering the existence of the taxpayers, consumers, and at the same time voters as the wider public, there is room for moral hazard that government ministers might have against the principal. A Minister of the department that is in charge of a particular nationalised firm is able to act so as to influence the voters. Suppose the Minister knows the exact meaning of total welfare and knows how to increase it through an efficiency gain, e.g., total cost reduction, would it be plausible that he/she can let the wider public know the correct effect of what he/she has done? Even if it would be plausible, he/she would have no incentive to do so, if his/her action is not linked directly with his/her ultimate likely objective, i.e., the contribution toward the election of the political party he/she belongs to[2]. Another complication is that at the lower level of the hierarchy, there is a relationship between the minister and the non-elected department officials (Civil Servants), adding other Principal-Agent problems. Typically, as the public choice academics explain, department officials may be budget maximisers and their objectives may include maximising their department's size, i.e., they are most interested in 'empire building'. The structure of these multiple and complex relationships between the principal and the agent in each tier observed in a nationalised firm can also be seen in the institutional arrangements of a firm which is directly owned and managed by local authorities. Changes in ownership of nationalised firms and local authority firms involve changes in the relationships between the principal and the agent in all the tiers, as well as changes in the objectives of the stakeholders.

As there are many changes included in the change in property right's allocation, normative microeconomics has reached a limit in analysing the changes of institutional arrangements within its traditional framework because it assumes full information setting. Instead, 'how do the participants in an industry actually behave?' has become a more important question, and thus the positive approach has become useful as the theory of information asymmetry has become sophisticated (see Appendix at the end of this chapter for the relationship between the development of this field and mechanism design).

1-3. Nationalised firm's control mechanisms

An inherent problem regarding nationalisation is a constraint from the capital market as one of the external controls. Whatever the constraint imposed on a nationalised firm, it cannot be stronger than that from the capital market. The pressure on the private firms' manager mainly comes from the threat of take-over. Although there would be X-inefficiency, at least the managers try to perform above the level where their performance would reduce the value of the firm, because in the case of a take-over, there would be a chance that the managers would be redundant. The possibility of being sacked is a real threat to the managers, though the recent theory of the firm confirms that it would be a '*satisficing*' behaviour that the managers are likely to conduct under the threat of take-over, and the managers are not likely to try 'maximising the profit' for the shareholders.

There is also a problem with control mechanisms as an incentive structure. There are arguments that the control mechanisms under nationalisation were not correctly designed. An interesting question is whether a nationalised firm can become more efficient if its control mechanism is 'incentive-wisely' designed. The history of control mechanisms in the UK nationalised industries makes one doubt if the managers had welfare in their minds as their objective. If the managers of nationalised industries had been welfare-oriented, why control constraints as such? Why did successive governments always try to create constraints and change them often?

Thus in the remainder of this section I summarise some models which public enterprise economists have established with regard to determining the problems of control mechanisms in nationalised industries.

I adopt the following notations in this chapter:

q: product output

p: product price

$q = q(p)$: demand function

R: revenue

Π: profit

S: consumers' surplus

W: total welfare

$V(q)$: consumers' willingness to pay

C: total cost of production

c: non-capital cost

f: production function

w: wage rate

l: labour input

r: opportunity cost of capital

k: capital input

θ: target rate of return

Another common assumption as well as that of information asymmetry is that the managers are not allowed to raise profits (which is always the case and described in each Act of Parliament establishing relevant public corporations) and also that the managers' salaries are not performance-related[3].

(1) models in which the manager's objective function includes welfare, and the theme of which is to examine why control mechanisms are technically imperfect

In the model of Gravelle (1977) the problem the manager has to solve is:

$$\begin{aligned} &\text{Max} \quad W(= V(q) - wl - rk) \\ &\text{s.t.} \quad f(q, l, k) \geq 0 \\ &R - wl - \theta k \geq 0 \qquad\qquad (1\text{-}1) \end{aligned}$$

The result, $f_k/f_l > r/w$ is shown, which is the other way round to the well-known Averch-Johnson effect. (Because in the US type rate of return regulation the constraint is a maximum requirement unlike a minimum requirement here). Gravelle proved that because of this marginal cost is not minimised, which is a technical bottleneck deduced from this type of financial target constraint. The concept of the 'financial target' applied to the UK nationalised industries, which were different from industry to industry, was introduced by the guidelines in the 1961 White Paper on the nationalised industries. It was typically 'a rate of return on net assets' in a financial year.

In contrast to this Gravelle model whose purpose was to examine allocative efficiency, Gravelle and Katz (1976) aimed mainly at an examination of the link between the form of the financial target and X-efficiency. The problem that the manager faces is:

$$\begin{aligned} &\text{Max} \quad U(W,E) \\ &\text{s.t.} \quad R - C(l,k) - f(l,k,q,\theta) \geq 0 \qquad \text{(1-2)} \end{aligned}$$

U is manager's utility and E is the amount of effort to reduce total cost. One of their contributions is that they showed that one of the conditions satisfied allocative efficiency (marginal cost pricing), but effort level input is not sufficient when compared to the optimum. They also examined variations of financial targets (i.e., specification of $f(\bullet)$), lump sum constraint, and target rate imposed on total cost and target rate on capital. However, they found that none of these forms can *a priori* lead the firm to improve welfare without specifying the production function.

These two models show the relationship between control mechanisms and both allocative and X- efficiency. Vickers and Yarrow's model (1988) allows us to find the condition as to investment policy efficiency, by dividing total cost into non-capital cost and capital cost. Their manager's problem is to solve:

$$\begin{aligned} &\text{Max} \quad W = V(q) - c(q,k,x) - bx - rk \\ &\text{s.t.} \quad R - C(q,k,x) - x - \theta(k)k \geq 0 \qquad \text{(1-3)} \end{aligned}$$

Here x denotes a factor in terms of cost reduction. Though it would cost bx to the manager as his/her disutility of effort if he/she inputs effort, the input of effort reduces the total cost by x. bx has a similar role as Laffont and Tirole's assumption $\varphi'(e) > 0$ and $\varphi''(e) > 0$ meaning manager's disincentive (see Appendix in this chapter). bx is disutility itself here, i.e., $\varphi(e) = bx$. By putting an assumption of $b > 1$, that the manager does not have the right incentive towards cost reduction, effort can be expressed, though it is linear. The outstanding point Vickers and Yarrow made is that θ is a function of capital employed. From the Vickers and Yarrow model the following three efficiency conditions are derived:

$$\frac{p-c_q}{p} = \frac{\epsilon\lambda}{1+\lambda} \qquad (1\text{-}4)$$

$$-c_x = \frac{b}{1+\lambda} + \frac{\lambda}{1+\lambda} \qquad (1\text{-}5)$$

$$-c_k = \frac{r}{1+\lambda} + \frac{\lambda\theta\{1-\eta(k)\}}{1+\lambda} \qquad (1\text{-}6)$$

where ϵ is inverse elasticity of demand and $\eta(k) = -\frac{\partial\theta}{\partial k}\frac{k}{\theta}$ meaning the elasticity of the financial target with regard to capital input. These conditions can be usefully compared with a benchmark set of conditions derived from maximisation of total welfare:

$$\text{Max } V(q) - c(q,k,x) - x - rk \qquad (1\text{-}7)$$

Benchmarks (optimum) are:

$$p = c_q \qquad (1\text{-}8)$$

$$-c_x = 1 \qquad (1\text{-}9)$$

$$-c_k = r \qquad (1\text{-}10)$$

(2) a model in which the manager's objective includes welfare and union's utility

Rees (1984) set a model where the manager can solve:

$$\begin{aligned}
\text{Max} \quad & E[U(q)] + \rho u(w,l) \\
\text{s.t.} \quad & f(q,l,k) \geq 0 \\
& R - wl - rk - \Pi^0 \geq 0 \\
& \overline{K} - k \geq 0 \qquad \text{(1-11)}
\end{aligned}$$

where U is the manager's utility, u is the union's representative's utility, ρ is a parameter expressing the union's bargaining power, Π^0 is an absolute term target constraint and $\overline{K}$ is the maximum capital amount the firm can use. $u(w,l)$ expresses the trade-off to the union between wage rate and employment. The excessive labour intensity resulting from the solution is of a similar kind as that from Gravelle (1982), though the labour-intensity problem is suggested to be stronger due to the capital constraint. This capital constraint encapsulates 'cash limits' (called also external financing limits) which were introduced in 1976/77 by the government. These were used as tools for reducing PSBR by the government when it faced a deficit burden.

(3) a model which can allow room for the parties to try to influence constraints

Rees (1989) proposed another way of looking at the above model, i.e., an extension of the model to a two stage game. His game's players are: the government, the manager, and the union official. The way the constraints are set should be, according to his idea, the result of bargaining between the government and managers which is followed by bargaining between the managers and the union officials, which is the first stage. As workers know there is room for rent extraction, they want the target to be set as loosely as possible. The managers also know the room for rent extraction. The second stage is solved by examining how the firm would behave under a given set of constraints. Looking at the procedure in this way, we can say that the other models mentioned earlier are all 'reduced form' models mainly focusing on the second stage game.

1-4. A privatised industry's institutional arrangement

When we take privatisation as an example of regulatory reform, it is necessary to discuss the following points in order to evaluate a change into a new institutional arrangement:

1) How can the manager's objective become closer to those of the shareholders?

2) How strong is the pressure on the manager from the external control? In particular, how effective is the monitoring ability of the capital market, i.e., how strong is the shareholders' interest in the value of the firm (in a collective sense)?; how do the private capital lenders evaluate the firm? and how effective is the threat from potential hostile bidders?

3) What kind of 'artificial' regulation should be introduced in the case of weak competition in the product market?

4) Is the degree of hierarchy smaller than under the nationalisation framework?

In terms of 1) the key is how the manager's performance is linked to his/her income, going back to the original sense of the Principal-Agent problem.

Vickers and Yarrow (1988) considered this point with regard to the disutility function shown in the previous section. They compared the nationalised firm's manager's disutility for cost reduction bx with the equivalent of the private firm's manager, ax. They tried answering the question: under which condition would $a < b$ be held. The answer depends both on elasticity of x with respect to reduction of c, and price elasticity.

As to 2) the strength of the pressure from the capital market is very much related to the size of the firm. The point 3) is the most crucial as it is directly to do with allocative efficiency. Obviously the market in which a former nationalised firm has been operating would not be changed just by a change of ownership. As the factor of natural monopoly was very often one of the reasons for nationalisation, many former nationalised firms, when privatised, had monopolistic power. Socially it is necessary to prevent welfare loss through monopolistic pricing, which was the obvious reason for setting up new regulatory mechanisms. Like the point in 2), it is impossible to generalise about this, because in some industries deregulation in the product market was introduced (or began to be introduced) at the same time as their regulatory reforms, but other industries still remain monopolistic (or locally monopolistic). Needless to say replacement by competition in the product market is the best regulation. In reality, most of the industries are multiple product suppliers. Thus in the UK the introduction of deregulation is often adopted in the relatively competitive markets with other markets being left as regulated. Another dimension is that newly privatised firms are allowed to go into the markets where they used to be prohibited from operation. Although I do not define 'core' or 'non-core' markets in general terms, it goes without saying that 'ring-fencing' is required between the two kinds of markets for protecting the consumers in the 'core' markets which are quite often still natural monopolistic. Doing this is one of the duties of the independent regulators to whose position we now turn.

The answer to the last point, 4), would be 'yes', if we refer to the argument in section 2, on condition that there is no new regulation as such. The question to ask is: can the general public trust the government when it sets up 'independent' regulators? It seems strange when we think about privatisation of firms which used to be owned by the public. There is a logic here. We can look at the procedure of privatisation: an alternative way of funding, other than through taxation, of nationalised firms in order to improve their performance. This was accepted by the public who also accepted the expectation that improvement of the performance would contribute to total welfare gain. On behalf of the public as the principal, the government as the agent made the decision to implement this logic. The government happened to be able to commit themselves in the implementation of this logic because their action was linked to the electoral commitment of the Conservative party, which gave the government an incentive to create regulators legally bound by their duties. Further, their duties which are described in the relevant Acts are better-defined as 'welfare and efficiency' duties at least compared with the objectives set out in those Acts relevant to each nationalised firm.

1-5. Conclusion of this chapter and some preparatory comments for Chapter 3

In this chapter we have examined how we should look at an institutional arrangement's change, mainly by focusing on the form of the changes involved in privatisation of a nationalised firm. In Chapter 3 where I analyse the privatisation of the then nationalised British Airports Authority, which had been a major UK airport operator, I use the concept of this chapter. An interesting feature resulting from the regulatory reform of the airport industry in the UK is that there is not only privatisation, but also a legislation change in which local authorities' directly owned and managed airports became autonomous plcs. In this chapter I raised the question: whether a regulatory reform creates a different performance of a firm because it mainly changes the objective of the firm's management, or because it mainly changes its constraints? The airport industry in the UK, thanks to the existence of local authority airports, enables us to examine how firms under the same ownership can change when their control mechanisms differ.

In Chapter 3 I use the basic model form that Vickers and Yarrow applied in their models, as they are most convenient for three different kinds of efficiency conditions. However, I use output as a manager's objective function to be maximised, which Rees originated[4] and Vickers and Yarrow developed. I explain the reason for this in chapter 3. Yet, before the application of the economic theory to the UK airport industry, I explain in the next chapter what policies were/are imposed on this industry both before and after the regulatory reform, as well as external changes to the industry structure, together with an examination of the various types of the constraints.

Appendix to Chapter 1

In the late 70's, Scott (1978), Loeb and Magat (1979) and Tam (1979) tried to design a mechanism through which the manager of a natural monopoly firm would have an incentive to produce the level of output which optimisation would require, regarding control constraints as an incentive structure. Their approach was to design a mechanism so that the manager could be given a whole or a portion of the consumers' surplus realised as a result of the production. With this method there is no way for the manager to maximise his/her profit other than by trying to maximise welfare, leading to the result of first best without the need for the regulator to know the cost level. However, setting aside the distribution problem ("Is it socially optimal to give all the welfare to the firm?"), there is the question of how to measure the consumers' welfare. Finsinger and Vogelsang(1981) developed the concept by solving this question. Their way of regulating this type of firm is to set several periods (t), in each of which the manager is allowed to get the portion of $Q_{t-1} \times [P_{t-1} - P_t]$ which is an approximation of each period's gain in consumers' surplus (Q is the output and P is the price). This mechanism does not require information of cost levels nor demand levels. This was an innovative departure point for information economists.

There is still a question regarding Finsinger and Vogelsang's method: how can the effort facilitated by the manager be compensated if the total cost level is reduced at period t compared with at period $t - 1$ as a result of his/her effort? Therefore in order to complete the design method which started from the condition 'without knowing the cost level' another condition 'without knowing the effort level' is required. There are two types of information asymmetry problems; adverse selection and moral hazard. The greatest contribution of information economists is in their construction of models in which cost has these two separate factors. In the case of the mechanism that Finsinger and Vogelsang created, if there is a case where the manager can expect to have the bonus from the regulator without making any effort, this bonus is a pure rent to the firm and this is the problem of adverse selection. It is to do with the fact that the firm knows the technology and cost structure better than the regulator. On the other hand, moral hazard is to do with some amount of action, i.e., 'effort', which influences the cost level. As the regulator cannot observe it, the manager has very little incentive to make this kind of effort, because there is no reward for the effort to the manager.

For example, Laffont and Tirole's models (1986) include a cost function of

$$C = (\beta - e)q$$

β is technology parameter and e is effort parameter. The regulator can observe the total cost of C, but he/she cannot see the level of both β and e. The effort e causes the manager the disutility $\varphi(e)$. Here $\varphi'(e) > 0$ and $\varphi''(e) > 0$ express the disincentive of the manager against e. The regulator gives the firm a net transfer T as well as recovering the cost. The assumption is that the manager is only interested in his/her income and disutility stemming from e. The objective function of the manager is

$$E(U) = E[U\{T, \varphi(e)\}] = ET - \varphi(e)$$

The regulator knows that β is in the range of $[\underline{\beta}, \overline{\beta}]$, but does not know the actual level of β. Their model analysed how a linear contract in terms of T, $T = a - bC$, can induce the manager to have the right incentive, facing a selection of $\{T(\underline{\beta}), C(\underline{\beta})\} or \{T(\overline{\beta}), C(\overline{\beta})\}$ (in the simplest case of only two types of β). The way this mechanism works is analogous to the way a consumer would select a combination of fixed tariff and price each time he/she has to pay when consuming the service, say of the telephone, when a two-part or multi-part tariff is introduced. The solution is to do with so-called mechanism design in game theory and uses incentive compatibility and participation constraint, i.e., it would give the firm no gain if an efficient firm (e.g., a firm that has $\underline{\beta}$) announces that its level of β is as if $\underline{\beta}$, (incentive compatibility) and also at least U should not be less than $\overline{U}$ which is the level of utility realised if the manager would not have carried out this project (participation constraint). In the case of a telephone company that designs a multi-part tariff, the objective is to maximise profit. In this Laffont and Tirole model, the regulator's objective is to maximise welfare derived from the project contract. As the result of their solution it was shown that the most efficient firm is required to input optimum effort level, but on the other hand, the rent it can obtain from its level $\underline{\beta}$ is guaranteed. Compared with this result, an inefficient firm is not given any rent, although its effort level is lower than the optimum level. This mechanism uses a trade-off between the rent the regulator has to allow a firm to keep and the effort level. Laffont and Tirole's model also showed that the more the transfer mechanism is closer to a fixed amount type, the more both the effort and the rent will be.

The 'optimal regulation' approaches mentioned here always share the same presumption. In order to devise the mechanisms the regulator has to know how much the disutility of the firm's manager is. Although the approaches treat both moral hazard and adverse selection, unlike the models in section 1-3 of Chapter 1, in which only the moral hazard aspect can be incorporated, 'optimal regulation' approaches are constructed on the presumption that the regulator knows the level of the manager's disutility, $\varphi(e)$. This is not realistic and far from being practical, and is a bottleneck with the 'optimal regulation' approaches. The difficulty of knowing the disutility of managers means that in reality monetary transfer from the consumers to the managers of the firm is not feasible. For instance, within the framework of the UK nationalised industries this kind of transfer was not possible. Thus it would be quite difficult to construct the framework for 'optimal regulation' models when analysing the UK's institutional arrangements.

Pint (1991) is one of the researchers who constructed a model which compared the performance between nationalised industry and private regulated industry using the framework I have explained in this Appendix without the money transfer concept but instead using different level of perks which the managers could obtain.

Notes to Chapter 1

1. After privatisation the organisation's name was changed into BAA plc which is *not* an abbreviation of the then nationalised British Airports Authority. In order to avoid any confusion I do not use an abbreviation when I mention the then nationalised British Airports Authority.

2. Vickers and Yarrow (1988) attached a cost reduction effort with negative weight in the government's objective function because this kind of action is better monitored by the workers (especially in the case of redundancy) than by the voters.

3. Because of this reason I excluded models where the manager's objective involves his/her income. However, note that the model that Gravelle (1982) considered, using the income as a parameter as well as an output and cost-reduction effort, is prominent (in the sense that he was successful in putting both allocative efficiency condition and X-efficiency condition). Also he proved that a lump sum financial target gives no instruction as to improvement of X-inefficiency. However, the key roles in this model are the share of the manager's own consumption of the output of the firm and the impact of the firm's profit increase on his tax burden, which are rather trivial in the real world.

4. In fact there was a case where output maximisation was explained as an explicit policy, which was seen in London Transport in the '70s. See Glaister and Collings (1978).

Chapter 2

History of UK Airport Regulation

2-1 Introduction

In this chapter I discuss actual changes in the economic regulation of the airport industry in the UK. I will confirm the kind of questions we should raise as to industry efficiency and the control and constraints from both inside and outside the airport companies, by means of viewing the past and current constraints imposed on the industry by the regulators or by government national policies.

It was the Airports Act 1986 that made the most significant impact on the parties involved in the UK airport industry. It involved privatisation of the British Airports Authority and legislative changes affecting other regional and local airports, essentially involving every airport in England, Wales and Scotland. As to Northern Ireland there exists The Airports (N.I) Order 1994, but this is almost the same as the Airports Act 1986. The current regulatory framework of the industry is based on the 1986 Act. In the next section we will look at the history of the regulations which have led to the current framework before moving on to describe the current regulatory framework in section 2-3.

2-2. Before the Airports Act 1986

(1) Constraints faced by the then nationalised British Airports Authority

The setting up of the British Airports Authority on April 1966 as a nationalised organisation was based upon the Airports Authority Act 1965. The process went back to a White Paper published in 1961 (Cmnd 1457 '*Civil Aerodromes and Air Navigational Services*')[1]. After the Second World War central government had acquired the major airports, because of the need for large scale capital investment (Manchester Airport was an exception which remained under the local authority). Therefore, at that time Heathrow, Gatwick, Stansted and Prestwick belonged to the Department of Aviation with all their employees Civil Servants. However, the parties involved including the airlines confirmed that the airport business was '*potentially a keenly commercial undertaking*' (a statement made by BEA: British European Airways) and that it would be more efficient for a self-contained and autonomous organisation to manage these airports, which was nominally the reason for setting up the British Airports Authority[2]. The establishment of the Authority was judged to be urgently required following an examination of the finances. At that time, the loss was £9 million in the operations of London's three airports during the period between 1957/58 and 1959/60.

Thus the British Airports Authority's constraints on management became subject to the policies imposed by the government on nationalised industries. Already at the period of set up, the British Airports Authority was a gigantic firm with passenger numbers of 60% of the UK total. Its constraints can be roughly categorised into six groups.

1) Revenue Constraint

The Authority was required to break even, taking one year with another. It was not allowed to have any revenue surplus. This was a statutory provision (the 1965 Act section 3(1) and (7)).

2) Investment Criteria

A White Paper in 1967 (Cmnd 3437 '*Nationalised Industries: A Review of the Economic and Financial Objectives*') introduced Test Discount Rate (hereafter TDR), recommending that investment decisions should be based upon discounted cash flow calculations (8%; later increased to 10%). The intention was to check if a planned investment could be justified in terms of the opportunity costs, and the rate was set in line with the estimated return to investment in the private sector. It was criticised, in another White Paper in 1978 (Cmnd 7131 '*The Nationalised Industries*'), as counting only new investment and not being practical in terms of the industry network, and TDR was replaced with Required Rate of Return (hereafter RRR) which looked at an industry's investment as a whole (5%; later 10% and 8% from 1993).

3) Pricing Constraint

Both the two White Papers mentioned above recommended the introduction of long-run marginal cost (hereafter LRMC) pricing into the nationalised industries. Theoretically industry prices would be based on the future internal rate of return of the capital to be invested, therefore the prices could be linked with the financial target and RRR. However, there had never been any discussions or linkages between the pricing principle and financial objective. Little and McLeod (1972), after criticising this rather vague linkage and the fact that the 1967 White Paper related LRMC with a tool for leading optimum use of existing capacity as well as with guidance on the best possible investment decisions, pointed out that it was highly questionable whether LRMC was a relevant concept in cases of extremely lumpy investments such as airports, commenting that '*airports are quite unlike electricity, for example, where each new generating station is marginal to the system*'. Little and McLeod set out the reasoning for the British Airports Authority's introduction of peak landing charges (morning peak hours at Heathrow was in question), and the logic was clearly based on the cost of delays in landing, i.e., short run marginal cost, not LRMC. There may have been a long debate within the British Airports Authority as to how to meet the government's pricing rule based on LRMC and financial objective ending with their peak-load landing charge policy.

4) Financial Targets for the British Airports Authority

In all of the three White Papers published in 1961 (Cmnd 1337 '*Financial and Economic Obligation of the Nationalised Industries*'), 1967 and 1978 respectively, the government had required the nationalised industries to meet financial targets which would be set for each industry individually. In theory these targets were supposed to express both the pricing constraints and investment criteria. However, the actual way of setting this target was by negotiation between the nationalised industry and the Minister in charge. In the case of the British Airports Authority, the period of negotiation with the Department of the Board of Trade was sometimes lengthy, during the first three years of its operation the target was never actually set. Also from 1976/77 to 1980/81 the Authority had not had a financial target due to the introduction of the 'cash limit' mentioned below. Table 2-1 (see at the end of this chapter) shows the financial targets and the figures actually achieved.

5) Borrowing Constraints

The British Airports Authority was able to borrow money only from the Minister (from 1966 the Board of Trade) (section 5 of the 1965 Act). However, in 1976/77 the government introduced 'cash limits' on the external borrowing of the nationalised industries. In the case of the British Airports Authority these were set on the basis of 100% self finance which meant that at least the profit including grants should exceed the total expenditure including debt repayment. In the early '80s the cash limit was very tight for the Authority and this constraint seems to have overruled the financial target. According to the Annual Report 79/80 of the British Airports Authority, this cash limit was the only binding constraint in that year.

6) Policy Constraint

It is by its nature that a nationalised industry is affected by a nation's macro economic policies. As to this aspect, the requirement of supplying 'cheap and adequate' services is a problem often discussed in relation to nationalised industries. Rail and bus services, and public utilities like gas and electricity need a relatively uniform provision throughout the country. Cross-subsidisation from profitable businesses to unprofitable ones is often required. The inefficiency of cross-subsidisation had always been a topic discussed in the White Papers. In the case of the British Airports Authority, however, uncertainty was the most serious problem[3]. With regard to allowing the Authority to develop particular investment programmes, the government had quite often changed its decisions. The timing of investment plays an important role in an airport needing large scale construction projects. Policy constraints were sometimes connected to borrowing constraints, as 'cash limits' were adopted when the government wanted to reduce its overall financial burden generated by the nationalised industries. Policy constraints are also often to do with environmental concerns. Airport development very often needs lengthy planning inquiries. Inquiries cause delay as well as uncertainty. Heath (1984) pointed out that, because of the uncertainties surrounding the result and length of the inquiry as to the Stansted project, the Authority had to include both the Stansted development and Heathrow's fifth terminal in its 1983 Corporate Plan, although the two plans had been considered as alternatives previously. The government's airline policy had also constrained the investment decision. The weighting placed on terminal development rather than runway development due to changes in aircraft technology was recently reduced, helped by airline deregulation policy.

(2) Constraints faced by the local authority airports

In a way, local authority airports before the 1986 Act can be seen as analogous to the government owned airports before they were acquired by the British Airports Authority under nationalisation. The constraints imposed on the management of local authority airports were even stronger than those imposed on the British Airports Authority. I categorise these into four groups.

1) Funding Constraint

Funding for airport services was allocated from the responsible authority's revenue via the local rates and grants from central government. Many of the airport services were loss-making. The accounting convention had not included a depreciation concept.

2) Price and Wage Constraints

The standard level of pricing for services throughout the country including landing fees had been set by the Joint Airport Charges Committee. As far as I know there was no benchmark or principle regarding how they set the price levels. Wage levels for their staff were set by the National Council for Airports.

3) System Constraint in the Case of the Airports Owned Jointly by Several Authorities

There were cases where airports were owned by several local authorities. As Povall (1994) noted, sometimes one function of an airport was controlled by one Council with other functions controlled by other Councils. The difficulties in communication between owners certainly formed a constraint on management.

4) Policy Constraint

'Airport' services, as part of the local authority's direct provision, seemed to have been treated in the same way as 'education' or 'health' services. It can be said that the existence of the voters in a local community itself was a constraint. Attracting voters has to be one of the main objectives of local politicians. This must have played a key role in deciding whether or not to invest in local authority airport facilities.

(3) Two national policies

Until 1978 when the Government published a White Paper '*Airports Policy*' (Cmnd 7084), central government had no national airports policy as such. Since the setting up of the Roskill Commission in 1967, many efforts and much time (almost 7 years) had been spent in the search for the location of the Third London Airport and discussion of its timing (Maplin project). In 1974, the Labour Government decided to abandon the project, which meant that the airport industry for the time being had to give up the idea of having a new airport in the UK. This government decision made the parties involved reconsider alternative means to expand capacity to meet the projected future demand in the London area. The focus of the 1978 Airports Policy was therefore 'the most effective use of existing airports'. The parties involved realised that the concentration of traffic demand in the South East area would be unavoidable, that the effect of diversion of traffic from the South East to the other regions would be limited and that there had been overcapacity in airports located in areas other than the South East. When this White Paper was published, the technology of the aircraft industry had improved in all the three aspects of size; noise reduction; and fuel efficiency. Because of this it was suggested that airport capacity would be gained more effectively by terminal development rather than the construction of further runways.

Two groups of decisions as to England and Wales were mentioned in the 1978 White Paper.

1) South East area:

- consideration of development possibilities at Stansted
- restriction/ban on the use of particular kinds of traffic at Heathrow
- willingness of the Government to let the British Airports Authority own and manage local authority airports

2) other areas:

- concentration of air services on a limited number of airports

The Government categorised all airports into the following four types:

(A) International Gateway Airports;

(B) Regional Airports;

(C) Local Airports;

(D) General Aviation Aerodromes.

It intended to use this categorisation as a tool for policy making, deciding that, outside the South East area, Manchester should be the only 'International Gateway Airport', and that Birmingham, East Midland, Newcastle, Leeds/Bradford and Cardiff should be 'Regional Airports'. As to the South East, Heathrow, Gatwick, Stansted and Luton were considered as a single 'International Gateway Airports system'. This kind of policy change was closely related to 'policy constraint' and 'funding constraint' for local authority airports. (e.g. Teeside Airport has been in decline after being categorised as a Local Airport, whereas Newcastle has grown in importance.)

We can see, in the 1978 Airports Policy White Paper, that the then government, which was very pro-co-ordination, wanted to ignore competition among airports.

In the case of Luton Airport, it said: if '*Luton Borough Council and the BAA were to agree to a transfer of ownership of Luton airport this would assist the BAA in exercising its major executive and co-ordinating role in the development of the London airports system*'('BAA' in this statement is the abbreviation of the then nationalised British Airports Authority). The neglect of competition among airports was inherited from the policy expressed in the 1978 White Paper by another policy expressed in the 1985 White Paper.

The White Paper, '*Airports Policy*' (Cmnd 9542) published in 1985, under the Conservative Government, followed broadly the recommendations of the Public Inquiries' report in which Stansted's new terminal project was approved and the fifth terminal project at Heathrow was turned down. In this White Paper the concept of the introduction of private capital was expressed. Discussion of the change in ownership of airports, together with the suggestion of introducing new economic regulation (see next section 2-3 (2)) and traffic distribution policy in the London area (see 2-3 (5)) were the main features of this White Paper. It mentioned the reasons why the Government believed that the privatisation of airports would bring benefits: it would

1) reduce the size of the public sector,
2) assist the Government's objective of creating wider share ownership,
3) increase employee participation,
4) provide for greater freedom for management (e.g., access to private capital),
5) encourage more innovative management and
6) lead to efficiency gains and greater responsiveness to customers.

There had been arguments over whether the British Airports Authority should be sold as seven separate companies or sold as a single body. The former argument advocated in terms of separation:

a) that there would be advantages from competition among airports and

b) that the incentive to increase efficiency through the potential threat from take-over would be advantageous.

The latter argument considered that if it would be left unseparated,

a) it would be easier to support the early development at Stansted and

b) the Government would quickly achieve its aim of privatisation.

(As to these argument, see Starkie and Thompson (1985).)

The Government was supporting the idea of privatising the British Airports Authority as a single entity. In the 1985 White Paper it believed that even in a totally deregulated airline market, effective competition between airports would be limited. The Government made it clear that the new regulator should be the Civil Aviation Authority (hereafter CAA). The Government tended to consider that it would be only through competition among airline companies that the airline industry would become competitive. This might have implied that the Government may have liked to see both the airport industry and the airline industry together under the same regulatory body.

The British Airports Authority was privatised in 1987 and the name was changed into BAA plc [not an abbreviation]. It seems that the Government's priority to maximise the sales value of the seven airports was put above the creation of competitive airports. At the beginning of April 1987, the seven airports under the ownership of this privatised monopolist BAA were Heathrow, Gatwick, Stansted (three London airports) and Edinburgh, Glasgow, Aberdeen and Prestwick (Scottish airports). After privatisation BAA sold Prestwick and bought Southampton.

The Government also said that local authority airports would be run more effectively if they were constituted as Companies Act companies. It was up to the owners, i.e., local authorities, to decide whether or not to use their power under the Act to dispose of their initial shares to introduce private capital. As far as the White Paper was concerned, the Government seems to have wanted them to privatise their airports. It said that although '*the Government will encourage them to introduce private capital, it has decided not to ask for powers to compel them to do so*'.

Following the 1985 policy, all major local authority airports became plc airports. Under the 1986 Act, any plc airport that had had an annual turnover of more than £1 million in two of the previous three financial years became subject to economic regulation (currently 28 airports in the UK at the end of 2000).

2-3. The framework within the Airports Act 1986

In this section I explain the current framework of economic regulation mainly based on the 1986 Act. The price control regulation of airports is only relevant to 'airport charges'. The purpose of subsection (1) below is to define which charges are regulated.

(1) Definitions in terms of airport business and airport charges

1) Operational Activities

'Operational activities' means 'any activities which are undertaken for the benefit of airport users'. Operational activities are subject to current economic regulations. However, 'non-operational activities' are regarded as businesses which are not directly relevant to airport users themselves, such as hotels, leisure facilities, industrial estates and supermarkets. Freedom for the management to go for 'non-operational' business constitutes one of the advantages under the 1986 Act regulatory change. However, it does not seem that the CAA had expected the plc airports to have extensive 'non-operational' business, as it stated that '*in most cases airports will be involved in non-operational activities only to a very limited extent if at all*'[4].

Operational activities consist of two kinds of activities. One is (a) 'air-side' activities which can be regarded as core services, and the other is (b)'commercial-side' activities which originally started as the by-products of 'air-side' operation.

(a) 'air-side'

Roughly the following services belong to 'air-side' business:

- aircraft taking off and landing
- aircraft parking
- taxiway management
- ground handling, i.e., passenger handling, baggage handling, cargo handling, flight catering and aircraft toeing

In the 1986 Act the businesses that belong to 'air-side' are strictly categorised under the name of 'relevant activities'. A complication is that not all of the services in the 'relevant activities' category are subject to price control regulation. Only the prices which belong to 'airport charges' defined below are regulated.

(b) 'commercial-side'

Services normally managed by the concessionaires, such as check-in desks operation, duty-free and tax-free shops, banks or restaurants, including car parks are all categorised as 'commercial-side' operation.

As to 'air-side' and 'commercial-side' operations, there is an important feature which is common to the airport business, called the 'single-till' approach, I will mention it later in this section (2-3 (4)).

2) Definition of Airport Charges

Airport charges, according to the definition in the 1986 Act (section 36(1)), are defined as charges levied on operators of aircraft

a) in connection with the landing, parking or taking off of aircraft at the airport.

b) They also include charges levied on aircraft passengers on arrival at, or departure from, the airport by air.

In the UK the following four categories are normally used:

- landing charge
- parking charge
- taking-off charge
- passenger charge (or passenger supplement fee[5])

Apart from airport tax which is levied by the government in its budget, these charges are normally imposed indirectly on the passengers through airline companies.

(2) Framework of the current economic regulation

The responsibility for the economic regulation of the airport industry was given to the CAA. The CAA had been an organisation which was solely in charge of the economic and safety regulation of the airline industry and management of air traffic control. This feature made the regulation of the airport industry very different from other newly privatised regulated industries such as telecommunication, gas, water and electricity. Independent regulators were introduced at the time of the privatisation of these industries, i.e., Oftel, Ofgas, Ofwat and Offer. The uniqueness of airport regulation is the fact that the regulator is also the regulator of the actual users of this industry.

The duties of the CAA as a regulator of the airport industry under the 1986 Act (section 39 (2)) are as follows:

(a) to further the reasonable interests of users of airports in the UK,

(b) to promote the efficient, economic and profitable operation of such airports,

(c) to encourage investment in new facilities at airports in time to satisfy demands by airport users,

(d) to impose the minimum restrictions that are consistent with the performance by the CAA of its functions and

(e) to take into account the international obligations of the UK.

The regulatory framework consists of two-fold regulations. There is a first level of regulation relevant to all plc airports and an upper level of regulation which is only to do with 'designated' airports.

1) The First Level of Regulation

Airports which are subject to economic regulation have to ask for permission to levy airport charges and are required to submit accounting information specified by the CAA. The only grounds on which a permission may be refused is where the airport fails to provide the information the CAA needs. However, the airport users can make complaints against the level of airport charges to the CAA. So far (up to the year 2000) there have been no cases where the application of airport charges was not permitted by the CAA, nor have there been any complaints against airport charges with regard to the airports which are not ‘designated’. However, there have been several official complaints against the level of airport charges set at BAA’s London airports, which I will mention later in Chapter 5.

2) The Upper Level of Regulation — ‘designated’ airports

The 1986 Act also provides the Secretary of State for Transport with certain powers, one of which is that he can designate particular airports for the purpose of economic regulation (section 40(10)). Although it is not known on what basis the Secretary of State designated them, four airports, Heathrow, Gatwick, Stansted and Manchester were designated. Two kinds of regulations are imposed on designated airports.

(1) regulation in terms of accounting information

Designated airports are required to submit accounting information specified by the CAA. Each of the designated airports is required to show (a) separately the revenue from and the costs of airport charge related activities, other ‘operational activities’ and ‘non-operational activities’, and (b) how much the revenue from the ‘non-operational activities’ exceeds the cost of these activities, only when there is a loss on ‘operational activities’. This accounting regulation gives the CAA information as to the degree of cross-subsidisation from ‘non-operational activities’ to ‘operational activities’. As I have mentioned (1)-1), the CAA did not seem to expect ‘non-operational activities’ to be extensive, the possibility that there might exist a cross-subsidisation from ‘operational activities’ to ‘non-operational activities’ was not presumed. These accounting conditions can by discretion be imposed on any regulated airports which are not ‘designated’. This is particularly the case where the non designated airport’s owner is a ‘designated’ airport, as in BAA’s Scottish airports. The CAA intended to impose these accounting conditions on these BAA Scottish airports, although currently it is a convention that all the regulated airports show separate accounts of airport charge related activities, other 'operational activities' and 'non-operational activities'.

(2) regulation of price controls

'Permission to levy airport charges' is not relevant to designated airports. The CAA imposes such conditions '*as the CAA considers appropriate for regulating the maximum amounts*' on designated airports. (section 40(3) of the Act) This is regarded as a form of price cap regulation. It was mentioned by the Government in the 1985 White Paper that price regulation should be in the form of RPI-X which means the annual rate of price increase may not go up more than the Retail Price Index, less an amount representing a targeted increase in productivity. This form was also recommended in the report published by the Department of Transport in consultation with NERA in 1986. Once the price limit is set, it is relevant to the following five years until the new price limit comes into force following the new review.

The most unusual feature concerning the economic regulation of 'designated airports' is that the Monopolies and Mergers Commission (hereafter MMC) is given a specific role. The MMC has its traditional role as the investigation of monopolies, mergers and anti-competitive practices. Also the MMC has additional roles under the principal Acts in relation to the privatised public utilities, where the MMC acts as an arbitrator between the regulated companies and the regulators. When a regulated company contests the regulator's decision the company can refer to the MMC, as can the regulator if it suspects the regulated company acts against the public interest. However, in the case of designated airports, the MMC is involved in the review process itself. The CAA has to refer to the MMC concerning what level of airport charges would be the maximum the designated airport can impose on its users, as well as whether there has been any conduct by the airport which is suspected of being against the public interest.

After the MMC investigates the airport company, the CAA publishes a report based on the MMC's recommendations. At the same time the CAA announces its own initial proposal regarding the conditions it proposes on the airport charges during the following quinquennium. When there are findings which the MMC considers are against the public interest, the CAA also has to include suggested remedies in the initial proposal. The MMC's report is not regarded as binding. The MMC is not a regulator as such and the report is treated as recommendation. Therefore it is totally open to the discretion of the CAA as to the extent that the CAA's initial proposal is based on the MMC's recommendation or reflects the CAA's different opinion.

After the announcement of the CAA's initial proposal, the parties involved can give their opinions in terms of the proposal within one month. The parties involved are: the airport in question; the airline companies; other airports; Department of Transport and other groups like organisations of tour operators and local authorities in the airport's surrounding area. After considering these opinions, the CAA publishes the final conditions. The designated airports cannot rely on the MMC as an arbitrator even if they are not satisfied by the CAA's final decision, because the MMC is the first mover.

This process where the regulation of designated airports starts from the MMC's involvement is rather unusual. Because there is single-till approach (which I describe later in subsection (4) in relation to international obligations), the regulation of airport charges requires investigation of the whole of the 'operational activities' as to profitability, cost of capital and business risks etc.. As mentioned before, 'operational activities' have both an 'air-side' and a 'commercial-side'. When the regulation was originally introduced it was considered that the CAA was not experienced in investigating the 'commercial-side' because the CAA was originally a regulatory body that specialised in the airline industry and aviation safety. However, the Department of Transport is trying to change the procedure, on the grounds that the current procedure and order set in the regulatory system is wasteful[6].

The process I have mentioned so far is relevant to the quinquennial regulatory reviews. Apart from the quinquennial review, if there is a complaint from any users to the CAA against an airport's particular conduct, the CAA would have to publish its decision on the complaint including complaints as to the airport charges as I mentioned above in (2)-1). There would have to be either measures to remedy the conduct or undertakings as to future conduct. The airport has a right to object to the imposition of conditions. If the airport does object, the CAA has to refer to the MMC. The MMC's conclusion based on its investigation is binding in this case. The CAA has to impose conditions to remedy the course of conduct subject to the MMC's conclusion.

(3) Licence for public use of aerodrome

Normally in the other regulated industries such as telecommunication, gas, water and electricity, public supply licences include conditions as to economic regulations. Thus sometimes the threat of deprivation of the licence can be used as a strategy by the regulators. However, in the airport industry, the 1986 Act does not include licensing as such. There is the Air Navigation Order 1985 which says that a principal condition of public use licences is for the airport to be open to all aircraft on equal terms and conditions. As an airport is important from a national defence viewpoint, regulations under this Order might be used in case of national emergency. Otherwise, the licence matter would never be an issue. The 'licence' matter is not tied up with economic regulation.

(4) International obligations

International obligations play a very important role in the regulatory mechanism. The Secretary of State has power (under the 1986 Act) to give general directions. A direction may override any condition, including a price condition. There are four international obligations which are particularly relevant to the economic regulation:

a) Article 15 of 'Chicago Convention (1944)',
b) Article 10 of 'Bermuda 2 (1977)',
c) 'Memorandum of Understanding between the Government of United States of America and the Government of the United Kingdom on Airport User Charges (1983)' (hereafter MOU) and
d) 'Exchange of Notes' (1994)'.

Article 15 of the 'Chicago Convention' mainly prohibits discriminatory charging against foreign airlines. Article 10 of 'Bermuda 2' has been a bottleneck for the British Airports Authority (and to BAA plc, too). It provides the key principle in setting airport charges. It says:

'User charges may reflect, but shall not exceed, the full cost to the competent charging authorities of providing appropriate airport and air navigation facilities and services, and may provide for a reasonable rate of return on assets, after depreciation.'* (*'User charges' defined in 'Bermuda 2' mean charges made to airlines for the provision for aircraft, their crews and passengers of airport or air navigation property or facilities, including related services and facilities)

Bermuda 2, agreed between UK and US Governments, contains the most detailed obligations in terms of the level of airport charges. However, there had been a dispute between the UK and US Government in the early '80s. In 1980 a group of international airlines brought an action against the British Airports Authority and the Government of the UK on the grounds that the level of charges was excessive. This action was brought under Bermuda 2. At the same time, two American airlines brought a separate action. They claimed that the peak pricing structure had discriminated against them. They were operating long-haul services in busy periods. The action was brought under the Chicago Convention. Both cases were settled out of Court between the UK Government and the US Government. The settlement agreement was expressed in the form of the MOU.

When this agreement was reached, the policy of privatising the British Airports Authority had already been under consideration. Therefore the MOU can be regarded as an important evolving constraint upon the future regulation of the British Airports Authority.

Firstly, the Bermuda 2 principle was confirmed that airport charges should be just and reasonable.

Secondly, the Secretary of State suggested that he might even have to seek external financing for future expenditure of the British Airports Authority:

'*If BAA* incurs major capital expenditure, there will be occasions when BAA's after-tax cash flow, including user charges, is insufficient to cover BAA's requirements for capital expenditure in a given year, and in such circumstances it would be necessary and appropriate for BAA to fund all or part of its capital expenditure programme from other sources .... as may be permitted by future legislation.*' (section 4(b)) (*'BAA' here stands for the then British Airports Authority, and not 'BAA plc'.)

The above paragraph implies that future capital investment would not necessarily be covered by airport charge revenue.

Thirdly, the MOU confirmed the single-till approach, defining the concept of 'a reasonable rate of return on assets' in Bermuda 2 as rate of return on total assets including the commercial-side:

'*In formulating financial targets with BAA, UK Government looks for no more than a reasonable rate of return on investment. In computing revenues that contribute to the rate of return on assets, no distinction will be made as to the sources of revenue, including duty-free sales and other commercial revenues.*' (section 4(c))

The following quotation from 'BAA: Offer for Sale' (prospectus of BAA at the time of floatation) shows the importance attached to international obligations:

'*The system of economic regulation .... was developed taking full account of the UK's international obligations. In particular, the RPI-*1 *formulae for SEAL were determined taking account of projected revenues from all operational activities, ..., and the projected costs of the provision of facilities and services at those airports over the next five years.*'

There is a question as to why privatised BAA should need price level limits via RPI-X. If we strictly follow what the MOU provides, it would lead an airport operator to fully rely on the monopolistic rent charged to its concessionaires on the 'commercial-side'. Normally the reason for the introduction of RPI-X into other privatised industries is to prevent the firms from cross-subsidising unprofitable or competitive markets from profitable monopolistic markets. International obligations in the airport industry require cross-subsidisation. Thus RPI-X regulation in terms of airport charges can be looked upon as a tool to enforce cross-subsidisation from 'commercial-side' operation to 'air-side' operation. However, most of the revenues from 'commercial-side' operation is the pure by-product of 'air-side' operation. The monopolistic rent of an airport charged to its concessionaires and tenants is the extreme external effect stemming from the 'air-side' operation. If there were no runways and taxiways no one would want to start his or her business in the terminal.

Regarding d) there was an end to the conflict between US government and BAA and the UK government in the form of 'Exchange of Notes' on October 1994. The main points are:

1) At Heathrow the differential between peak and off-peak international passenger charges should be phased out in four substantially proportionate instalments. Also a peak international passenger charge should not be re-introduced before either 2003 or the opening of Terminal 5, whichever is the earliest.
2) At Heathrow there should be no change in the balance of landing, parking and passenger charges, whilst the peak international passenger charge is being phased out.
3) At Heathrow a weight-related element in peak landing fees should not be re-introduced.
4) At Heathrow the level of parking charges relative to the level of total user charges should not be increased.
5) The 'single-till' approach was confirmed.

These points which were made clear in an 'Exchange of Notes' were only related to Heathrow. In the report MMC4, the MMC was concerned that the phasing out of the peak international charge at Heathrow would distort the effect of pricing in terms of allocative efficiency. As the Airports Act 1986 requires the CAA to take international obligations into account, there seems to be no option but to accept the principle set out in the 'Exchange of Notes'. However, neither the MMC nor the CAA mentioned anything about the differential between peak and off-peak charges at airports other than Heathrow. As described in Chapter 5 both Gatwick and Stansted have seemed to phase out the differential between peak and off-peak international passenger charges (and domestic, too). No description about this feature was found in MMC's reports or the CAA's final announcement of the current (1997-2002) formulae of airport charges.

(5) Capacity Constraints

It was since the 1978 White Paper that the government introduced regulations regarding the types of airline services at Heathrow. Through the physical banning of new international operators, new domestic services and charters from Heathrow, the government intended to maintain a balance with other UK airports.

When the 1985 Airport Policy was published the government's intention was based on a reluctance to leave the capacity problem to market forces, i.e., slot allocation through pricing such as auctioning. This was mainly because of the matter of fairness, as the government considered that the economic allocation of slots at Heathrow would make the incumbent airlines that already had 'grandfather's rights' even more dominant. Although in the White Paper's discussion the government did not intend to remove so-called 'Traffic Distribution Rules', the Secretary of State for Transport largely removed these rules in 1991. The problem of slot allocation still remains.

Table 2-1 Financial targets and actual rate of return on net assets achieved

year	financial target (%)	actual rate of return (%)	TDR/ RRR (%)	brief explanation of financial constraints
1966/67	-	10.3	8	• establishment of the British Airports Authority (financial target has not yet been settled)
1967/68	-	11.0	8	• financial target still under negotiation
1968/69	-	12.3	8	• last stage of the negotiation with regard to financial target
1969/70	14.0	13.4	10	• financial target still under negotiation
1970/71	14.0	12.3	10	• financial target for the three year period from 69/70 to 71/72 as 14% per year
1971/72	14.0	14.3	10	• the British Airport Authority acquired Edinburgh Airport
1972/73	14.0	17.4	10	• achieved rate of 17.4% was calculated as roughly equivalent to 6% under CCA
1973/74	15.5	16.2	10	• financial target for the three year period from 73/74 to 75/76 was set as 15.5% per year
1974/75	15.5	11.5	10	
1975/76	15.5	15.0	10	• yielding of 14.2% as average rate of return during the three year period from 73/74 to 75/76
1976/77	-	6.1 (HCA)/ 1.5 (CCA)	10	• assets were revaluated: 15% of rate of return calculated under pre-revaluation of the assets (from this year CCA had been introduced)
1977/78	-	8.9 (HCA)/ 2.5 (CCA)	10	• 'cash limits' was introduced: yet the British Airports Authority's capital was still within this year's limit

Continued to the next page

Table 2-1 (continued)

year	financial target (%)	actual rate of return (%)	TDR/ RRR (%)	brief explanation of financial constraints
1978/79	-	9.8 (HCA)/ 2.8 (CCA)	10	• its capital was still within the cash limits (maximum borrowable amount was £125 million)
1979/80	-	11.0 (HCA)/ 2.1 (CCA)	5	• its capital borrowed exceeded its cash limits by £0.8 million: Annual Report mentioned that in the absence of a rate of return target, the British Airports Authority's financial policy had been dictated by (primarily) cash limits
1980/81	6.0 (CCA)	5.9 (CCA)	5	• financial target was set at 6% per year for the three year period from 80/81 to 82/83 • the British Airports Authority was able to borrow £20 million
1981/82	6.0 (CCA)	5.6 (CCA)	5	
1982/83	6.0 (CCA)	3.8 (CCA)	5	• the actual rate of return was 5% on average during the period from 80/81 to 82/83 • discussion on privatisation was started
1983/84	4.1 (CCA)	5.4 (CCA)	5	• a formula for setting a financial target was introduced:[minimum of 3% + $\frac{1}{5}$ of traffic growth as total terminal passenger numbers (5.7% in this year)] was the target for this year • break-even target on the Scottish Airports as a whole was introduced for the three years from 83/84 to 85/86
1984/85	6.3 (CCA)	6.9 (CCA)	5	• [previous year's target (4.1%) as the minimum return + $\frac{1}{5}$ of the traffic growth (11% in this year)] was the target for this year • Scottish Airports turned into profit-making this year (£4 million of profit as a whole (previous year's profit was £0.7 million
1985/86	7.3 (CCA)	7.5 (CCA)	5	• [previous year's target of 6.3% + + $\frac{1}{5}$ of the traffic growth (4.8% in this year)] was the target for this year
1986/87	6.2 (CCA)	7.6 (CCA)	5	• the reason for the financial target of 6.2% is unknown

Notes to Chapter 2

1. '*London's Airports*' published in July 1961 *(The Fifth Report from the Select Committee on Estimates)* recommended that *'an Independent Authority should be established to manage the London Group of Airports'*. In August 1961 the Government announced (in Cmnd 1457 White Paper) that *'an Airports Authority should be set up to own and manage the main international airports now owned by the State'*.

2. British Airports Authority's Annual Report and Accounts 1966/67.

3. Unprofitable but socially needed airports, i.e., airports located in the Scottish Highland and Islands had been owned by the Civil Aviation Authority (CAA). The problem of cross-subsidisation from profitable business to unprofitable business was not an issue.

4. '*Economic Regulation of Airports - General Guidance*' by the CAA (it is the first guidance provided by the CAA for the airport operators just after the new economic regulation was introduced, although the precise publication date is unknown)

5. Manchester Airport uses this name. Also at Manchester a charging category called 'baggage and freight handling charge' is included in its airport charge schedule. However, this 'baggage and freight handling charge' is irrelevant to 'relevant activities' defined by the 1986 Act, which means that 'ground handling charge' at Manchester should not be looked upon as 'airport charge' in the defined meaning.

6. The president of the Board of Trade, 'A Fair Deal for Consumers: Modernising the Framework for Utility Regulation (Green Paper)' 1998. See Annex D.

Chapter 3

UK Airport Industry: Regulatory Models

3-1. Introduction

Here I examine how we can predict the performance of the UK airport industry, using the economic theories of regulation I outlined in Chapter 1. We have seen in Chapter 2 the industry's changing structure and what kinds of policies have been/are imposed on the industry. I use the information described in Chapter 2 to construct models for this industry and analyse their implications.

3-2. Before the 1986 Act: The British Airports Authority

As mentioned in Chapter 1, the formulation of the constraints in the models which Vickers and Yarrow (1988) established allows us to derive respective predictions about each of the three efficiency criteria which I analyse further in later chapters, allocative efficiency in pricing (Chapter 4) and internal efficiency and investment efficiency (Chapter 6). The model style straightfowardly encapsulates a public corporation manager's objectives and constraints. The basic settings of the model which are repeated from Chapter 1 are as follows:

$V(q)$: consumers' willingness to pay

q : product output

r : opportunity cost of capital

k : capital stock level

x : the level of expense for cost reduction (level of internal efficiency enhancing activity)

b : marginal cost to the public corporation's manager incurred by inputting x

$c(q, k, x)$: non-capital cost

θ : financial target (target rate of return)

Assumptions:

$b > 1$: disutility of managerial effort

$\frac{\partial c}{\partial q} > 0$: increase of the output would increase non-capital cost (hereafter expressed as c_q)

$\frac{\partial c}{\partial k} < 0$: increase in capital stock level would reduce non-capital cost level (hereafter expressed as c_k)

$\frac{\partial c}{\partial x} < 0$: increase in the level of efficiency enhancing activity would reduce non-capital cost (hereafter expressed as c_x)

θ is a function of k; Vickers and Yarrow's assumption is $\frac{\partial \theta}{\partial k} < 0$ (hereafter θ_k)

The objective of the public corporation's manager is to maximise:

$V(q) - c(q, x, k) - bx - rk$

and the constraint is:

s.t. $\quad p(q)q - c(q, x, k) - x - \theta \cdot k \geq 0$

(the rate of return per capital stock should be at least the target rate of return)

The reason for Vickers and Yarrow to make the assumption $\theta_k < 0$ is based on the following sentences expressed in the White Paper published in 1967:

'Where and when there is spare capacity, as there may be at some points in the business cycle, or excess demand, short run marginal costs are relevant; the object is to persuade customers to make use of spare capacity or to curtail excess demand.' (paragraph 21 *in 'Nationalised Industries: A Review of*

Economic and Financial Objectives' Cmnd 3437)

The idea of setting the financial target as a function of k is prominent, but in fact, as seen later, the financial target had been also used explicitly as a function of q, during the period from 1983/84 to 1986/87 as the policy for setting the British Airports Authority's financial targets. Since the process of setting the financial target was mainly by negotiation between the government and the industry, and the capital stock level is directly related to capacity level which the White Paper above mentioned, the assumption on $\theta(k)$ is in theory convincing.

The objective function of the managers of the British Airports Authority seemed to be to maximise their size (output). Whitbread (1971) made comments regarding the British Airports Authority's incentive toward production and investment. He suggested the following three points:

a) It would have been possible for the British Airports Authority, because it has been monopolist in the growing aviation industry, not to invest, yet still meet the financial targets imposed on it. However, it has extensively invested in facilities.

b) Thus, in terms of financial obligation, 'that constraint suggests rather that Government is suspicious of some over-enthusiastic willingness to invest by the Authority'.(p.124)

c) The British Airports Authority showed a marked preference for Cublington as the choice of location for the Third London Airport, rather than Foulness. At Foulness the expected passenger numbers would be less than at Cublington, though both locations were expected to satisfy the Authority's financial target return.

Whitbread suggested that '*incentives to invest are the result of a conscious desire to see the Authority grow in terms of the physical size and quantity of assets*'.

Very soon after the Third London Airport project was turned down, Sir Peter

Masefield (the former manager of the British Airports Authority), in 1974, tried to emphasise that the British Airports Authority should be allowed to invest in both Stansted and Terminal 5 at Heathrow, as a form of 'criticism' of the Roskill proposal[1] .

As described in Chapter 2, one of the suggestions which the government made in its White Paper, 'Airports Policy' 1978, was an intention to allow the British Airports Authority to own other airports. In responding to this, the British Airports Authority itself said, in its Annual Report of 1978/79, that:

'*The British Airports Authority is willing in principle to acquire those five regional airports identified in the Government White Paper.........A growth in international services at such airports is highly desirable to lessen the need for passengers from these regions to use airports in the South East. The British Airports Authority opposes, however, suggestion that passengers from the South East should be forced to use airports in other regions*' (p.69).

It is likely that the objective of the managers of the British Airports Authority had been to maximise their airports' size. The representative for 'size' can be either their outputs or revenue.

Vickers and Yarrow also developed their model using Rees's suggestion, in which the managers' objective is set to maximise $q - (b - 1)x$. The second term encapsulates the managers' disincentive for cost-reduction effort. This implies the following model for the British Airports Authority's managers:

$$\text{Max. } q - (b - 1)x$$
$$\text{s.t. } p(q)q - c(q,k,x) - x - \theta(k)k \geq 0 \qquad (3\text{-}1)$$

The first order conditions with regard to q, x and k are respectively:

$$\frac{p-c_q}{p} = \epsilon - \frac{1}{\lambda p} \qquad (3\text{-}2)$$

$$-c_x = \frac{b-1}{\lambda} + 1 \qquad (3\text{-}3)$$

$$-c_k = \theta(k)\{1 - \eta(k)\} \qquad (3\text{-}4)$$

where λ is the multiplier's value in the constrained maximisation problem of (3-1). ϵ is the inverse elasticity of demand and $\eta(k)$ is the elasticity of financial target with respect to capital input (expressed as an absolute term) $(\eta(k) = -\frac{\partial\theta}{\partial k}\frac{k}{\theta})$.

For reference purposes, where the managers' aim is to maximise the total welfare, i.e., to maximise $V(q) - c(q,k,x) - x - rk$, the first order conditions would be written as follows as benchmarks:

$$p = c_q \qquad (3\text{-}5)$$

$$-c_x = 1 \qquad (3\text{-}6)$$

$$-c_k = r \qquad (3\text{-}7)$$

Intuitively from the constraint in (3-1) the higher the value of θ is set, the stronger the pressure would be either in the direction of raising the revenue or in the direction of reducing the cost or both. When the constraint is not binding, the price mark-up shown by (3-2) can be negative because the size of the absolute value of $\frac{1}{\lambda p}$ is very large. (3-2) is rearranged as follows:

$$p = \frac{c_q}{1-\epsilon} - \frac{1}{\lambda(1-\epsilon)} \qquad (3\text{-}8)$$

When the constraint is binding (λ>0), tightening of θ, through raising λ, means that the range of p can be either set below the marginal cost, or above the marginal cost c_q. The level of p depends on how large λ would be. In the case of the welfare maximisation objective model, the price is always set as the marginal cost level (from the benchmark equation (3-5)).

Where the constraint is not binding, the value of the right-hand side of (3-3) would become much larger than 1 and very little amount of x is expected to be input. In the binding constraint's case, however, the greater the λ's value becomes, the closer $-c_x$ becomes to b. However, as long as $b > 1$ is the assumption, the internal efficiency would never be at the optimum level.

(3-4) implies that if the capital is employed more than at the level where efficiency is achieved, the tightening of θ would work as a device for reducing over-investment, as long as $\theta_k < 0$. However, the degree of this effect depends on the $\eta(k)$ or the negotiation between the government and the managers.

Since 1983/84, the way the government imposed its financial target on the British Airports Authority has changed. In 1983/84 the financial target was set as:

[minimum 3% + $\frac{1}{5}$ × traffic growth rate compared to the previous year],

where traffic means total terminal passenger numbers. This fact is not well known, nor have I been able to locate any written documents where the reasoning for this 3% or the proportion of $\frac{1}{5}$ came from. Merely the description of this financial target formula is shown on the British Airports Authority's annual reports.

This method of determining the financial target continued until the British Airports Authority was privatised. Although during the year 1986/87 how the financial target in this year was determined as 6.2% is not known (See Table 2-1), it seems to have been based on this formula (See Table 2-1). Therefore, during the period between 1983/84 and 1986/87, assuming that the managers' objective was to maximise the output, the appropriate model is:

$$\text{Max. } q^t - (b-1)x^t$$
$$\text{s.t. } p^t(q^t)q^t - c(q^t, k^t, x^t) - x^t - \theta^t(q^t)k^t \geq 0$$
$$\theta^t(q^t) = \theta^{t-1} + \frac{1}{5} \times \frac{q^t - q^{t-1}}{q^{t-1}} \qquad (3\text{-}9)$$

The superscript t denotes current period t. The first order conditions with regard to q^t, x^t and k^t are:

$$\frac{p^t - c_q^t}{p^t} = \epsilon^t - \frac{1}{\lambda p^t} + \frac{k^t}{5p^t q^{t-1}} \qquad (3\text{-}10)$$
$$-c_x^t = \frac{b-1}{\lambda} + 1 \qquad (3\text{-}11)$$
$$-c_k^t = \theta^t(q^t) \qquad (3\text{-}12)$$

When (3-10) is compared with (3-2), pricing is more directly linked to the capital employed, because of the third term of the right-hand side of (3-10). There is a trade-off between the value of k^t and λ. The larger the capital employed, the higher the price becomes, though this link is also related to the output in the previous year. The effect of $+\frac{k^t}{5p^t q^{t-1}}$ is to adjust the price level if the price was set below the marginal non-capital cost, compared to the case of (3-2) [2].

In terms of (3-12), the investment condition is directly determined by the financial target and indirectly determined by the output. In actuality, as the passenger numbers were growing more and more throughout the period (3-12) implies that the British Airports Authority was forced to move toward under-investment.

As the aviation industry has been continuously growing, the value of $\theta(q)$ is assumed to be increasing year by year during the period between 1983/84 and 1986/87. (3-11) means that via raising λ, the pressure for cost reduction during this period became much stronger than before.

Predictions derived from the conditions (3-10) and (3-12) are not surprising when we consider the fact that at the beginning of this period the government began its preparations for privatising the British Airports Authority. In June 1983, in the Queen's Speech the government declared its intention of privatising as many airports as possible.

There is another interesting fact; the British Airports Authority introduced flat rate landing fees for aircraft in excess of 50 metric tonnes at Heathrow from 1985/86 instead of weight-related landing fees. The reason for this is given by Toms (1994) as '*the opportunity cost of any landing could be represented as the value of the access denied to another potential user who could not use the same slot*' The recognition of the real (short run) opportunity cost of the capital by the British Airports Authority may be regarded as confirmation of the predictions from (3-10) and (3-12).

3-3. Before the 1986 Act: local authority airports

The institutional arrangements for local authority airports before the legislation change in 1986 were more straightforward. The airports were directly owned and managed by the local authorities, as explained in Chapter 2. The direct principals of those airports' managers were the relevant local authorities, i.e. politicians. The managers were local authority officers. Above this level of the hierarchy there were the local voters. We see the relationship between the voters and the local politicians as another principal-agent relationship. A unique feature of this principal-agent relationship is that the monitoring power constraining the agent is stronger in the case of local authorities, compared to the relationship between the general public and the Minister of the governmental department that is in charge of a particular nationalised firm . The effect of any action which the local Council decides to take tends to be more visible because of their closeness to the local electorate. An airport has positive externalities in a community by attracting other industries, so the total scale of the operation of the airport is related to the overall local tax burden. Also the externality comes from the availability of the airport itself to the community residents, which is an additional value attached by that community.

On the other hand, the closer link between the local politicians and the local voters affects employment policy at the airport, which might affect its internal efficiency.

In the case where a local authority airport faced financial loss, it was met both by the local taxpayers' money and by the grants and loans which the local authority received from central government, which meant that the airport management was not independent of the motives of the local politicians. Thus, whilst there were no financial targets such as those imposed on the British Airports Authority, pressure from the local politicians seemed to be the main constraint on the managers of those airports. Therefore, the objectives of those airports managers are not easy to identify. However, considering the scale of positive externality contributing to the community itself, which also means the managers' non-pecuniary benefit from the operation such as prestige, the motives of the managers seem to have been similar to those of the local politicians. Furthermore, the Local Government Officers who were in charge of the airport service had to compete against others who were in charge of other local public services, in terms of their budgets, which could lead the airport managers to a typical 'empire-building' bureaucratic attitude.

I mentioned, in Chapter 2, one of the most important decisions by the government in the White Paper '*Airports Policy*' (1978: cmnd 7084), i.e. classification of all airports into four groups. The basic concept of the government's decision at that time was:

'*that rationalisation of the facilities outside the South East of England, and concentration of air services at a limited number of airports, are likely to be among the most effective ways of seeking to redress the balance in air transport between the South East and the rest of Great Britain*'. (paragraph 115 of '*Airports Policy*' (1978))

Before reaching its decision on the classification, the government consulted with local authorities, and stated that:

'*many local authorities drew attention to the need to avoid in the future the 'creeping expansion' of airports which they have contended has been a characteristic of the past and to establish 'ceilings' on the growth of particular airports*'. (paragraph 26, ibid)

This meant that the local authorities admitted their "*unco-ordinated*" investment competition (which is the word Whitbread (1971) used) through rivalry among themselves, and this admission is evidence of the objective of the managers of the airports.

The more interesting point of this classification, i.e., the influence of local authorities over the central government, is explained by Barnes (1983). He used an example of Teesside and Newcastle. Teesside, after being classified as (C) category (i.e., 'Local Airports'), had declined while Newcastle which was only 40 miles away from Teesside, after classification as (B) category (i.e., 'Regional

Airports'), had continued to develop[3]. He pointed out that the reason why the government categorised Newcastle as (B) and Teesside as (C) was because the former had possessed more facilities. Therefore he maintained that a local authority with ambition for its airport expansion was able to influence the classification by initiating a measure of early capital investment.

From the discussion so far it seems appropriate, in making a model of a typical local authority airport, to assume that the objective of the airport's managers is to maximise the output. One constraint is a break-even financial obligation taking into account the grant from central government and the other is a ceiling on the capital borrowable. I assume that the grant is a function of capital employed. The managers of the airport solve the following problem:

$$\begin{aligned} \text{Max} \quad & q - (d-1)x \\ \text{s.t.} \quad & c(q,k,x) - p(q)q + x + rk \geq G(k) \\ & K \geq k \end{aligned} \tag{3-13}$$

where d is the marginal cost to the local authority airport's managers incurred by inputting x, and thus dx is an expression of the managers' disutility for reducing the total cost by x. $d > 1$ is assumed as $b > 1$ as in (3-1). λ is the multiplier to the first constraint and ρ is the multiplier to the second constraint, $G(k)$ denotes the grant ($G_k = \frac{\partial G}{\partial k}$) and K is the limit to borrowing capital from central government. The first-order conditions derived from (3-13) are:

$$\frac{p-c_q}{p} = \frac{1}{\lambda p} - \epsilon \tag{3-14}$$

$$-c_x = 1 - \frac{d-1}{\lambda} \tag{3-15}$$

$$-c_k = r - G_k - \frac{\rho}{\lambda} \tag{3-16}$$

In this model, note that the first constraint in (3-13) is set in a different direction compared to the British Airports Authority's case. This is because I took into consideration that the loss is always met by the local taxpayers' money in the case where the constraint is not satisfied, i.e. this constraint means that the minimisation of the local tax that would be put into the airport operation has already been incorporated.

In terms of pricing, (3-14) tells us that if the first constraint is not binding (λ=0) p is always set below the marginal cost, (when we assume that we can eliminate the case of $\epsilon > c_q$). When the first constraint is binding, the larger λ becomes, the smaller the price becomes.

An implication from (3-15) is that in the case where the first constraint is not binding, i.e. the tax paid by the local residents has to be used to recover the loss ($\lambda \div 0$), the cost reduction effort x is converged to zero as $-c_x = +\infty$. However, if the first constraint is binding, the larger the grant from the central government, the closer the total cost reduction level becomes to the optimum, whose speed depends on the size of $(d-1)$. However, as I assumed $d > 1$, $-c_x > 1$ always holds and the level of x is always smaller than the optimal amount.

(3-16) means that only if we assume G_k=0 (capital employed is nothing to do with the amount of the grant), and ρ=0 (the second constraint is non-binding), $-c_k = r$ holds and the airport is at its optimal capacity level. However, when $G_k > 0$, which can be reasonably assumed from what I have discussed above and from note 3 in this Chapter, particularly after 1978's Airports Policy, (even where the condition that the constraint on the borrowing limit is not binding,) the airport is led to over-invest. When the borrowing limit is binding, the degree of over-investment depends on the change in the capital ceiling K. The more generously K is set, the smaller the change in K makes ρ. However, if K is reduced, it would raise ρ and the effect of the borrowing limit change makes the problem of over-investment more serious.

These predictions seem to be consistent with how the airports' managers actually behaved. Particularly, the problem of over-investment seems to explain the situation that is described as 'creeping expansion' in the 'Airports Policy' (1978). Regarding local authority airports price setting, there had been no published standard airport charges such as the British Airports Authority's '*Condition of Use: including aircraft charges*' which is normally published each year. It is because the airport charges at a local authority airport were (and still are at non-designated local authority airports) on the basis of private, normally secret negotiations between the airport and airlines. As I mentioned in Chapter 2, there was a Joint Airport Charges Committee which set national standards for airport charges. However, the local authority airports' managers are said to have had wide discretion with regard to their decision making and pricing policies, therefore it is quite possible that the structure of airport charges was different from airport to airport. The local authority airport managers tried to create a structure which would make the airport as attractive as possible to the airlines using the airport, from which we can assume that some categories of airport charges might have been below the marginal cost.

There is one thing which the model cannot explicitly incorporate. It is the preference and priorities of the majority members of the local authorities owning a local authority airport. For instance there remains the following two issues:

1) the local authority politicians preference with regard to employment of workers and
2) priority the local authority politicians attached to externality considerations.

The first issue seems to have been linked to the policy of the political party which the majority of the local authority members belonged to. Particularly, in the case of Labour party dominated local authorities, there seems to have been greater scope for the workers to improve their employment conditions because of their unions' relationship with the politicians. The workers were able to have stronger bargaining power with the managers in terms of their cost reduction efforts. We could argue that the managers disutility parameter of cost reduction effort, d, in the condition (3-15) has already been reflected by the degree of the workers bargaining power.

The second issue brings about the following question: which kind of externality did the local authority politicians put the greater emphasis on, increasing positive externality or decreasing negative externality? Although I have discussed the incentive to the local politicians for mainly gaining the externality through which a community having an airport can become wealthier, we cannot ignore the very important environmental problem caused by the pollution and noise from an airport operation. The most important consideration the politicians in the community around a local authority airport have to take into account whenever they decide a particular investment programme is how to strike a balance between the effect of the positive externality and of the negative externality. Each local authority airport has had different priorities attached to this balance. For instance, Luton Borough Council has always put greater weight on minimising environmental problems, whilst Manchester City Council/the Greater Manchester Council (the local authorities have been different from time to time in terms of ownership of Manchester Airport) have seemed to consider that the regional development arising from the airport investment is of greater importance than reducing the environmental problems. We could argue that this externality aspect of the operation of a local authority airport has been implicitly expressed through the effect of raising/reducing λ as increasing/decreasing the total revenue in the model.

3-4. After the 1986 Act: London airports of BAA plc

The Airports Act 1986 established a function within the CAA to impose pricing controls on the 'designated' airports which are Heathrow, Gatwick, Stansted and Manchester. Of these airports the first three are now owned and managed by the privatised BAA plc. As described in Chapter 2, all the airports which are owned by public liability companies (whether they are still in the public sector or not) are subject to economic regulation in the form of being granted a permission to levy airport charges. As well as this kind of regulation, 'designated' airports are subject to a specific form of pricing regulation which determines the maximum revenue that the airport can earn by way of airport charges. The economic regulator, the CAA, through each airport operator's review, sets the pricing formula in a period for five years ahead. Regarding the three London airports of BAA the first quinquennium began on 1st of April 1987.

The prices which are subject to economic regulation are airport charges as defined and explained in Chapter 2. Therefore there needs to be a distinction between the model that I explore in the next chapter and the model I showed in section 3-2 of this chapter, which is, that the model after the regulatory reform needs a separation of the revenue which is related to the 'air-side' operation from the revenue which is related to the 'commercial-side' operation.

The maximum revenue has been constrained at BAA's London airports by price regulation. The 'maximum revenue' was defined by the Secretary of State for Transport to be the maximum average revenue yield per passenger using each airport[4]. There was a discussion about the form of maximum revenue regulation, i.e., whether it should be in the form of the so-called 'Tariff Basket Approach' where the average revenue is calculated using the weight of the previous year's sum of each product of quantity and price of a group of services, or alternatively, it should be in the form of so-called 'Average Revenue Approach' where the average revenue is calculated using the weight of the previous year's total revenue divided by the total quantity. The detailed analysis on the allocative efficiency thorough price setting I have carried out in Chapter

4. In this chapter I use a descriptive way of expressing the price cap constraint:

$$\text{maximum level} \geq \frac{TR_{airside}}{q_{passengers}}.$$

The managers of each airport will try to solve the following problem:

$$\text{Max} \qquad TR(q) - c(q,x,k) - ax - rk$$

$$\text{s.t.} \qquad \text{maximum level} \geq \frac{TR_{airside}}{q_{passengers}} \qquad (3\text{-}17)$$

The two other aspects, i.e., the managerial effort and investment efficiency, are expected to improve to the monopolistic level so that the marginal conditions can be satisfied. Instead of (3-3) and (3-4) or (3-11) and (3-12), the level of managerial effort and the investment level are respectively:

$$-c_x = a \qquad (3\text{-}18)$$

$$-c_k = r \qquad (3\text{-}7)$$

where a denotes the marginal cost to the managers for cost reduction at each privatised BAA airport. I assume $a > 1$. It can be assumed that the value a is smaller than b, and is closer to 1 ($b > a > 1$). This is because of the stronger pressure on the managers after privatisation. The existence of the shareholders and the threat of takeover were the main impacts of privatising the then British Airports Authority. Unlike some public utilities such as gas and electricity which were privatised, efficiency gain through increased competition in the product market was not expected to be realised to a great extent in the case of the UK airports. In fact it was not even included in the Government's belief in the benefits of privatising the UK airports when it published the White Paper '*Airports Policy*' in 1985, as mentioned in Chapter 2. Gaining access to private capital means that the monitoring of the managers in their managerial effort was strengthened compared to the period of nationalisation, because of which the assumption $a < b$ can be reasonably justified.

The price cap regulation in the form of RPI-X is not only imposed on all of BAA's three London airports' average revenue, but is also imposed on Heathrow and Gatwick separately. Thus there had been three price caps, (1) for the system, (2) for Heathrow and (3) for Gatwick. The idea was that whilst fixing the maximum price level for both Heathrow and Gatwick, the system cap allowed Stansted to set the airport charges in a less restricted manner.

There were some changes in the 1996 review. The CAA decided to have Stansted's airport charge level also separately capped which was RPI+1 for the period between 1997 and 2002 (the third quinquennium). During the review the MMC stated that if there was an overall system cap on all three London airports, it might be possible for BAA to have an incentive to set charges at Stansted which would be lower than the level that would minimise the loss at Stansted. There were complaints by Luton and Norwich against Stansted's price setting. According to Luton, the charges at Stansted were lower than the level at which Stansted alone would minimise its loss. At the same time when the new terminal was opened, Stansted had introduced a policy by which any airlines that started new international routes had off-peak passenger charges applied to them. Though the CAA admitted that the pricing at Stansted was harmful to other regional airports, it did not feel the need for any remedy. In its view, the policy of developing Stansted was 'immature' as there still existed Traffic Distribution Rules (See Chapter 2) when the government decided to develop Stansted. After Traffic Distribution Rules were removed, there was not so much traffic as expected. Thus the problem is whether to totally abandon Stansted or to maintain Stansted while recovering just the variable costs. It is not certain if the total revenue of Stansted covers its total variable costs. In the MMC's view, because the previous price capping system required both Heathrow and Gatwick to be capped separately, the low price of Stansted did not necessarily mean that the level of charges at either Heathrow or Gatwick were raised. Yet the fact that the MMC recommended the separate cap on Stansted and that the CAA followed the recommendation means that they had felt some fear of distorting the competition among the regional airports and Stansted.

Also a combined price cap was newly established for Heathrow and Gatwick which was RPI–3, instead of separately capping each of the two airports. However, there was a regulation as to the differential between Heathrow's price level and Gatwick's price level. Within this combined cap the real reduction in charges each year at Heathrow should be 1% less than Gatwick's level. Thus we can look upon the effect as two separate caps. The values of *X* given to BAA's three London airports are shown below including Manchester:

Table 3-1 The values of X at BAA's airports and Manchester

	87	88	89	90	91	92	93	94	95	96	97
BAA	1*	1*	1*	1*	1*	8*	8*	4*	1*	1*	3(-1)†
MA	-	1	1	1	1	1	3	3	3	3	3

	98	99	00	01	02
BAA	3(-1)†	3(-1)†	3(-1)†	3(-1)†	-
MA	5	5	5	5	5

MA denotes Manchester International Airport

* Two separate caps for both Heathrow and Gatwick, plus a system cap for all the three airports

† A combined cap RPI-3 for Heathrow and Gatwick, with a differential limit, and Stansted's RPI+1

The existence of the system price cap applied to the whole London system makes the prediction as to the first and second quinquennium complicated. Therefore I do not include the predictions regarding the conditions of the airport charges in this chapter. Instead, I focus on the effect of the price cap imposed on a 'designated' private airport in Chapter 4.

3-5. After the 1986 Act: Scottish airports of BAA plc

The airports owned by public liability companies, other than the 'designated' airports, are not subject to the price cap regulation regarding airport charges. Yet, as I explained in Chapter 2, there is a lesser degree of economic regulation. This means that the CAA grants 'permission to levy airport charges' to the non-designated plc airports. The airports submit their proposals for airport charges or any changes in their airport charges to the CAA who gives the operators permission. Section 41 of the Airports Act 1986 mentions the cases where the CAA should intervene with their airport charges, such as in the case of undue discrimination against particular users or in the case where there seems to be anti-competitive conduct against other airport operators. However, there is no written information published as to what grounds or on what basis the CAA should judge whether the airport charges plans submitted by the operators are permissible. This means that a non-designated airport can charge whatever it likes and only in the case of complaint against its charges by the users or other airports, does the CAA investigate the matter. Therefore the emphasis of the regulation regarding the airport charges of the non-designated airports is not 'pro-active', but rather 're-active'. Regarding the non-designated airports, there seem to be no specific constraints, at least in the sense of airport charges. Behind the decision by the Secretary of State for Transport in not designating the airports other than the three London airports and Manchester, there seems to have been a government view that the non-designated airports would behave in a market orientated manner. It can be thought that the government, when it designated the four airports, suspected that at those airports both the 'air-side' services and 'commercial-side' services could be monopolistic, while the government had a perspective that there would be room for competition among the non-designated airports. Price efficiency will be discussed in the next chapter. The conditions as to managerial effort and investment efficiency are expected to be improved after the regulatory reform as was the case with the three London airports. The marginal conditions of (3-18) and (3-7) are predicted. As to internal efficiency I include Scottish airports in an empirical analysis in Chapter 6.

Since 1993/94 Edinburgh and Glasgow have introduced so-called 'voluntary price-capping' of their airport charges. This is based on consultation between the airports and the user airline companies and there are no written documents about the 'voluntary price-capping'. The 'voluntary price-capping' on each airport is in the form of the 'Average Revenue Approach'. I will mention this later in Chapter 5.

3-6. After the 1986 Act: local authority airports other than Manchester

The local authority airports which became plcs due to the Airports Act 1986 are unconstrained with regard to their airport charges, as in the case of the Scottish Airports of BAA plc. However, there is a significant difference between the local authority airports and Scottish Airports. The local authority airports are all (including Manchester) subject to capital constraints because they chose to remain in the public sector. As seen in Chapter 2, the government expressed, in the 1985 White Paper 'Airports Policy', its wish to encourage the local authorities to privatise their airports, though the government did not force them. However, the reason for privatising the British Airports Authority, and for changing the status of the local authority airports which had turnover of more than a given amount into plcs was to reduce the government's financial burden. Though most of the local authority airports still remain in the public sector, central government influences the airports' incentive for gaining access to private capital, by reducing the capital amount which they can borrow from central government.

The model for the objective of the managers of these local authority airports can be expressed as:

$$\text{Max} \quad TR(q) - c(q,x,k) - \beta x - rk$$
$$\text{s.t.} \quad K \geq k \qquad (3\text{-}19)$$

The first order conditions are:

$$\frac{p-c_q}{p} = \epsilon \qquad (3\text{-}20)$$
$$-c_X = \beta \qquad (3\text{-}21)$$
$$-c_k = r + \delta \qquad (3\text{-}22)$$

where δ is the multiplier of the constraint on capital. β denotes the marginal cost to the managers for cost reduction at an airport. I assume $\beta > 1$.

(3-20) implies that the price structure is set at a monopolistic level. Compared to (3-14) the possibility of prices being set below the marginal non-capital cost is non-exisitent. However, as this is a simple model, I have not made any distinction between the airport charges and the prices for the 'commercial-side' services. One would need a specification for the total revenue function of the 'commercial-side' service in order to predict price structure in both airport charges and 'commercial-side' prices.

As far as the cost reduction effort is concerned, the same predictions can be applied as in the case of Scottish Airports. The difference between (3-15) and (3-21) is clear. (3-15) means the closeness to the optimum effort level, i.e. 1, can be changed not only by the disutility level of the manager for cost reduction, but also by the amount of the central government grant. However, (3-21) means that cost reduction effort level is only related to the managers' disutility for cost reduction effort.

The main difference as to the capital constraint is shown in condition (3-22). When the constraint is binding, as δ is positive, the capital investment is not efficient and under-investment is the case because $-c_k > r$. When the constraint is tightened, due to the reduction of the borrowing limit from the central government, the degree of under-investment becomes larger. The airports which had been struggling within tight borrowing limits either chose to sell their airports to the private sector or tried to find ways to implement their investment programmes by other means than by relying totally on borrowing from central government. Airports such as East Midlands, Cardiff, Bournemouth and Belfast City, Prestwick, Southend and Birmingham have chosen to be privatised. An example of funding a part of the investment programme was seen at Birmingham before privatisation. It created a joint venture with several private companies including airlines. Currently Luton is using the joint venture approach. However, in 1999 the option of borrowing money on the open market was given to Manchester, Newcastle, Leeds-Bradford and Norwich by the Minister of Transport.

3-7. After the 1986 Act: Manchester Airport

Manchester Airport is in a unique position in the UK airport industry. Although it chose to remain in the public sector, it was picked as one of the 'designated' airports by the Secretary of State. This means that not only is there a constraint on the airport charges, but also a capital constraint on borrowing from central government.

The manner in which the airport charges are controlled is that of the RPI-X price-cap regulation which is the same as in the case of the three London airports of BAA plc. Manchester's price-cap formula is also set by the 'Average Revenue Approach'. The regulatory review is at five year intervals, which is exactly the same as in the case of BAA's London airports.

The managers of Manchester have to solve the following problem:

$$\text{Max} \qquad TR(q) - c(q,x,k) - \alpha x - rk$$

$$\text{s.t.} \quad \text{maximum level} \geq \frac{TR_{airside}}{q_{passengers}}$$

$$K \geq k \qquad (3\text{-}23)$$

Regarding the price condition, the same complication arises as in the case of each of the BAA's airports, because in this simple model the proper distinction between the 'air-side' revenue and the 'commercial-side' revenue cannot be made. The advantage of the model style in this chapter is however, that one can distinguish the conditions of managerial efficiency and investment efficiency. The conditions for managerial efficiency and capital input efficiency are as follows:

$$-c_x = \alpha \qquad (3\text{-}24)$$

$$-c_k = r + \gamma \qquad (3\text{-}25)$$

where α denotes the marginal cost to the managers for cost reduction at Manchester Airport. I assume $\alpha > 1$. γ is the multiplier of the second constraint. Therefore, although the managerial efficiency seems to improve compared with the period before the regulatory reform, as γ is positive, the same capital under-investment problem can be the case as with the other local authority airports.

So far I have explained the four different kinds of constraint categories which have appeared after the regulatory reform. I analyse in Chapter 4 the price conditions regarding the current price cap regulation imposed on the designated airports after the reform, and the effects of the rebalancing of airport charges followed by an empirical analysis in Chapter 5. In Chapter 6, I focus on their productive efficiency (as a combination of cost reduction effort and investment level) in order to see whether any difference in production efficiency can be observed under different constraints.

Notes to Chapter 3

1. However, Stansted by 1968 was about to be chosen as the Third London Airport, which was much earlier than the establishment of the Roskill Committee.

2. When Bös's term is used, the 'under-estimation of marginal cost' is adjusted by (3-10), i.e., both (3-2) and (3-10) can be rearranged as:

$$\frac{p-(c_q-\frac{1}{\lambda})}{p} = \epsilon \qquad (3\text{-}2)'$$

$$\frac{p-(c_q-\frac{1}{\lambda}+\frac{k^t}{5q^{t-1}})}{p} = \epsilon \qquad (3\text{-}10)'$$

(3-2)' means that the firm sets price as though it were a monopolist, but the firm under-estimates its real marginal cost c_q as $[c_q - \frac{1}{\lambda}]$. (3-10)' shows that this under-estimation of marginal cost is corrected by the degree of $\frac{k^t}{5q^{t-1}}$, which might introduce, in turn, 'over-estimation of marginal cost', depending on q^{t-1}. The allocative efficiency in price structure will be analysed in Chapter 4 in greater detail.

3. The reasons why Teeside has declined after being categorised as (C), whilst Newcastle after being categorised as (B) has continued to develop were:

a) the government varied the grant size and amount that an airport could borrow from the government depending upon the category attached to the airport and

b) the government influenced the policy on route licensing reflecting the category of an airport indirectly through the Civil Aviation Authority, e.g., renewal or permission for a particular route,

according to Barnes (1985).

4. The actual price controls imposed on BAA plc's three London airports are as follows:

$$M^t = \left(1 + \frac{RPI^t - X}{100}\right) Y^{t-1} - K^t \qquad \text{(3-A)}$$

where M^t is maximum average revenue yield per passenger using *all* three London airports of BAA and RPI^t is the percentage change in the Retail Price Index between that published with respect to September in year t and that with respect to September in year $t + 1$. Y^{t-1} is the actual average revenue yield in the year $t - 1$ per passenger who using all three London airports in the year $t - 1$. K^t is the correction factor which is to do with the difference between M^{t-2} (the maximum average revenue yield per passenger applied to the year $t - 2$) and the actual average revenue yield per passenger in the year $t - 2$. The formula for determining Y^{t-1} and K^t are respectively as follows:

$$Y^{t-1} = Y^{t-2}\left(1 + \frac{RPI^{t-1} - X}{100}\right) + S^{t-2} \qquad \text{(3-B)}$$

and

$$K^t = \frac{T^{t-2} - \{Q^{t-2} \times M^{t-2}\}}{Q^{t-2}}\left(1 + \frac{r}{100}\right)^2. \qquad \text{(3-C)}$$

Y^{t-2} is the actual total revenue in the year $t - 2$ divided by the actual total passenger numbers in the year $t - 2$. S^{t-2} is an allowed percentage of the change in total security costs in the year $t - 2$ divided by the actual passenger numbers in the year $t - 2$. The allowed percentage was initially set as 75% (also initially 75% at Manchester, however, since the second quinquennium 95% for both BAA's airports and Manchester). T^{t-2} is the actual revenue in the year$t$ –2 and Q^{t-2} is the actual passenger numbers in the year $t - 2$. Where K^t has a positive value, r is 3% plus the interest rate for the year $t - 2$, that is the Treasury Bill Discount Rate, and where K^t has a negative value, r is equal to the Treasury Bill Discount Rate.

Chapter 4

Price Rebalancing and Airport Charges

4-1. Introduction

This chapter addresses some of the resource allocation problems of the regulation of airport charges from the point of view of microeconomics theory. As explained already in the previous chapters, the regulatory reform of the U.K. airport industry under the 1986 Airports Act mandates the CAA to impose conditions on the 'designated' airports. The conditions as to airport charges are the ones that "*the CAA considers appropriate for regulating the maximum amounts that may be levied by the airport operator by way of airport charges at the airport during the period of five years*" (The Airports Act 1986; clause 40 (3)). The main interest in this chapter lies in the prediction of outcomes of airport charges which the airport operators might set under this regulatory constraint, i.e., under the 'maximum amounts' of airport charges.

In this chapter, I focus on the static context. I explain in section 4-2 the forms of two types of price cap regulation implemented in the UK with a brief summary of what economists have predicted might be the outcome difference between them. In section 4-3, I explain the specific features regarding the 'Average Revenue Approach' price cap constraint imposed on the 'designated' UK airports, including the nature of 'operational activities', as a preparation for the models in the rest of this chapter. Section 4-4 shows several comparisons between the predicted outcomes of ordinary 'Average Revenue Approach' and those of 'Airport Average Revenue Approach' using a simple model. In section 4-5 I analyse the price ratio changes under different regulatory constraints in terms of BAA. I focus on both the difference among airport charges and the difference between the airport charges and the unregulated prices. (A more complicated model with demand interdependency is shown in Appendix (1) and (2)).

4-2. 'Tariff Basket Approach' and 'Average Revenue Approach'

In the UK, virtually all of the privatised utility industries are now subject to 'price regulation' which is different in principle from so-called 'rate of return regulation'. Price regulation is often called 'price cap regulation' because price regulation in the UK determines the maximum allowable price level through a price cap which is in the form of the Retail Price Index less X%. There are roughly two kinds of price cap regulation. One is called the 'Tariff Basket Approach' and the other is called the 'Average Revenue Approach'[1] or 'Revenue Yield Approach'[2]. The difference lies in the form of the constraint. Under Tariff Basket constraint the regulated firm would choose p_i^t which is the price of the service i in the period t subject to the following constraint:

$$\sum p_i^t q_i^{t-1} \leq (RPI - X) \sum p_i^{t-1} q_i^{t-1} \qquad \text{(4-1)}$$

where superscript indicates period and subscript indicates service i. RPI is the rate of increase of the price index between the period t and $t-1$ and X is determined by the industry regulator. Average Revenue Approach is different in that the firm faces the following type of constraint:

$$\frac{\sum p_i^t q_i^t}{\sum q_i^t} \leq (RPI - X)\frac{\sum p_i^{t-1} q_i^{t-1}}{\sum q_i^{t-1}} . \qquad (4\text{-}2)$$

In the UK, of the newly privatised regulated industries, BT and the water industry are subject to the constraints that belong to the Tariff Basket 'family', whilst BG, BAA, Manchester Airport and the Regional Electricity Companies were initially subject to the constraints which are categorised as Average Revenue constraints. (4-1) and (4-2) can be shown in simplified forms as follows:

$$\sum p_i^t q_i^{t-1} \leq \overline{p} \qquad (4\text{-}1)'$$

$$\frac{\sum p_i^t q_i^t}{\sum q_i^t} \leq \overline{p} \qquad (4\text{-}2)'$$

where $\overline{p}$ represents the level of price cap. The main difference between the two formulae is that the firm under the Tariff Basket constraint cannot control the output which weights current prices in the current term. The variables determining the range of p_i^t are all externally given. However, there is room for the firm under the Average Revenue constraint to manipulate q_i^t as the current output is inside the constraint.

Some literature was produced recently which focused on the differences between the outcome under the Tariff Basket Approach and the outcome under the Average Revenue Approach, most of which included simulations. Bradley and Price (1988) show that if a monopolist firm is regulated under Average Revenue constraint as compared to Ramsey pricing, marginal cost pricing would never be an outcome and the price of the service whose marginal cost is expensive might be even higher than the price that an unregulated monopolist would set. Bradley and Price (1991) used a linear relationship between the marginal cost and the size of the market in order to show that a monopolist who is subject to Average Revenue constraint would choose to sell the product only where the marginal cost is within a certain level, whilst an unconstrained monopolist would continue to supply in the markets where the marginal cost gets higher as long as marginal revenue is positive[3]. Vickers and Yarrow (1988) expressed this concept using price mark-up ratios. Under constraint (4-2)' the constrained monopolist would set the price of service j and service k such that the price mark-up of service j, $\frac{p_j}{mc_j}$, is higher than the price mark-up of service k, $\frac{p_k}{mc_k}$, when $mc_j > mc_k$. Both Bradley and Price (1988 and 1991) and Vickers and Yarrow (1988) showed that a price structure would be different from that under a Ramsey pricing solution. Law (1995) and Cowan (1997b) made simulations in order to show that under Average Revenue constraint a tightening of the price cap could cause the welfare to be reduced.

Waterson (1992) generalised the findings of Vickers and Yarrow (1988) and Bradley and Price (1988). Given the assumptions that both demand and marginal costs of two services are independent and that marginal costs are constant, Waterson analysed the price structure of a monopolist who supplies service 1 and 2, subject to the constraint (4-2)'. The profit to be maximised is $\sum R_i - \sum C_i$; $i = 1,2$. R_i is total revenue from service i and C_i is total cost from service so that $\sum C_i = mc_1 q_1 + mc_2 q_2$ where mc_i is service i's marginal cost. The first order conditions of the Lagrangean can be arranged as:

$$\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})\,\{1-b(\overline{m}_1-1)\}}{(1-\frac{1}{e_1})\,\{1-b(\overline{m}_2-1)\}}, \qquad (4\text{-}3)$$

where $e_i = -\frac{\partial p_i}{\partial q_i}\frac{q_i}{p_i}$ which is the elasticity of service i's demand (expressed as the absolute term), $m_i = \frac{p_i}{mc_i}$, $\overline{m}_i = \frac{\overline{p}}{mc_i}$ and $b = \frac{\lambda}{1-\lambda}$. λ is the Lagrange multiplier and it is proved that $0 < \lambda < 1$ from the second order condition, which implies that $b > 0$.

Waterson compared (4-3) both with the result of an unconstrained monopolist's price structure and with the price structure which would result under Ramsey pricing rule. When there is no constraint the monopolist would set the prices of service 1 and 2 so that the ratio of the two services' price mark-ups will be:

$$\frac{m_1}{m_2} = \frac{1-\frac{1}{e_2}}{1-\frac{1}{e_1}} . \qquad (4\text{-}4)$$

Under Ramsey pricing rule, i.e., when the monopolist maximises the welfare subject to a break-even constraint, the price mark-up ratio will be:

$$\frac{m_1}{m_2} = \frac{1-a\frac{1}{e_2}}{1-a\frac{1}{e_1}} , \qquad (4\text{-}5)$$

where $a = \frac{\mu}{1+\mu}$ and μ is the multiplier of the Lagrangean for the Ramsey optimal problem. $\mu > 0$ and therefore $0 < a < 1$, which means that $\frac{m_1}{m_2}$ under Ramsey rule will be always smaller than $\frac{m_1}{m_2}$ under the unregulated monopolistic price setting.

Under Average Revenue constraint, it is clear that when $mc_1 = mc_2$, condition (4-3) will become identical to condition (4-4). However, when $mc_1 > mc_2$, and $e_1 = e_2$, as $\overline{m}_1 < \overline{m}_2$, the result will be $m_1 > m_2$. This means that when the demand elasticities of two services are the same, the market that is more costly will always have a higher price mark-up. When $mc_1 > mc_2$ and $e_1 < e_2$, this tendency will be boosted and Waterson suggested that Average Revenue constraint might increase '*the peakiness of peak load pricing, for example*'. This is a different way of showing the same findings that Bradley and Price (1988) demonstrated using the distance between p_1 and p_2.

Waterson also showed a condition which would result from the case where Average Revenue constraint is imposed on a subset of the monopolist's services. In this case the relevant Lagrangean will be:

$$L = \sum_{i=1}^{3} R_i - \sum_{i=1}^{3} C_i + \lambda\left[\overline{p}(q_1 + q_2) - \sum_{j=1,2} R_j\right] \qquad (4\text{-}6)$$

where total revenue from service 3 is not affected by the constraint. The price mark-up ratio of service 1 and service 3 will be:

$$\frac{m_1}{m_3} = \frac{1-\frac{1}{e_3}}{1-\frac{1}{e_1}}\{1 - b(\overline{m}_1 - 1)\}\ , \qquad (4\text{-}7)$$

which implies that, if $e_1 = e_2 = e_3$, and if $\overline{p} > mc_1$, i.e., $\overline{m}_1 > 1$, then $\frac{m_1}{m_2} > \frac{m_1}{m_3}$. This means that the price mark-up of service 1 is lower when compared with the unregulated service than when compared with that of service 2, whilst under the same assumption, both the Ramsey condition and the unconstrained monopolist condition would be $\frac{m_1}{m_2} = \frac{m_1}{m_3} = 1$.

There is one difference between the general form of Average Revenue Approach and the price constraint imposed on airport charges at 'designated' airports, i.e., the denominator of the constraint as to the left-hand term of the form (4-2)'. Airport charges consist of (a) passenger charge per passenger, (b) aircraft landing charge per landing and (c) aircraft parking charge. The maximum average revenue, i.e., $\overline{p}$, is formally described as '*the maximum average revenue yield per passenger in the relevant year t*' in the CAA's announcements and expressed as:

$$M^t = \left(1 + \frac{RPI^{t-1} - X}{100}\right) Y^{t-1} - K^t$$

where M^t is the maximum average revenue yield per passenger and Y^{t-1} is the previous year's average revenue yield per passenger after being adjusted by the cost pass through factors such as a part of the security cost which the Government imposes on the airport . K^t is the correction factor to adjust either over- or under-charging due to the difference between the forecast revenue and actual revenue[4]. As to the simplified constraint form of (4-2)', the numerator of the left hand side is the sum of the revenues from (a), (b) and (c), whereas, the denominator is the total passenger numbers. We will see, in the rest of this chapter, how this slightly different version of Average Revenue regulation would produce a different outcome from the general outcome predicted by the literature I have mentioned.

4-3. Features of Airport Charge Regulations

The revenue of an airport comes from (1) 'air-side' operation, (2) commercial-side' operation and (3) 'non-operational activity'. (1) and (2) are the components of 'operational activities' defined in the 1986 Act. The term 'air-side' operation is synonymous with the term 'traffic' operation as used in the accounts of the British

Airports Authority, and also this term is synonymous with the revenue from airport charges. This category 'air-side' operation is made up of (a), (b) and (c) described above.

The revenue relevant to the economic regulation of the UK airports is the revenue from (1) and (2). The revenue that is directly regulated by the price cap regulation is the one from airport charges, i.e., revenue from (1) only. However, the level of revenue from (2) is no less important, because of the 'single-till' approach which I described in chapter 2. The term 'commercial-side activities' is synonymous with the term 'other operational activities' in the regulatory account.

The 'single-till' approach officially enables the airport operator to cross-subsidise any loss of its 'air-side' operation by using the revenue of its 'commercial-side' operation. This approach means that as long as the total cost of the 'operational activities' is covered by the sum of the revenues from (1) and (2), the level of profits from the 'commercial-side' that is used to offset the loss from the 'air-side' operation is irrelevant. In theory this could then lead to a negative airport charge.

As described above, the airport charge composed of (a) passenger charge (per passenger arriving or departing), (b) landing charge (per landing or taking-off) and (c) aircraft parking charge are all subject to the Average Revenue price cap regulation. On the other hand, there are many categories of 'commercial-side' activities, as shown in Table 4-1. One can classify the 'commercial-side activities' roughly into three categories as shown in Table 4-1. The classification is according to the 'MMC2' report.

As far as the hearings into BAA's commercial activities, which have been documented in the reports of MMC2 and MMC4, are concerned, it can be noted that there are several types of payment that are received by BAA for the right to use its facilities or spaces that are either located inside the airports or facilitated in off-airport sites, by either concessionaires, air-side licensees or tenants. The categorisation I have made is shown in Table 4-2.

Table 4-1 Categories of 'commercial activities'

(1) concessions	(2) trading licences	(3) rents, 'occupation licences' and other property related revenue
retailing catering banking car hire car parking flight insurance hotel bookings advertising etc.	ground handling passenger baggage cargo handling etc. air-side licences in-flight catering aircraft cleaning supply of duty/tax-free goods etc. crew transport disabled passenger services aircraft security passenger coaching etc.	check-in desks fuel rents transit shed operation off-airport car parking leases offices VIP lounges etc

Table 4-2 Methods of payments: examples

percentage of turnover	retailing & catering, air-side licences (6% × turnover since the late '70s not being changed until 1996)
fixed fee as economic rent based on the value of the space	check-in desks, on-airport office rents
hybrid rents (ground rent with an element linked to turnovers)	ground handling companies, transit shed operators, off-airport car parking leases
based on a formula linked to passenger numbers and the RPI	fuel rents
voluntarily set ceilings such as RPI	car parks
allocated cost related	buses and coaches

We can write the profit of a designated airport, Π, as the sum of the airport charge revenue, TR_R, and the unregulated 'commercial-side' revenue, TR_U, minus the total cost, TC.

$$\Pi = TR_R + TR_U - TC \qquad (4\text{-}8)$$

I assume that a privatised airport maximises Π as its objective. I set aside the other profit coming from 'non-operational' activities. The income and the cost from the 'non-operational' activities is independent and not relevant to the economic regulation of the UK airport industry. As described in Chapter 2, this group of activities is strictly ring fenced from the airport users by the 1986 Act, although it has been an important addition to income resource since the industry reform. Therefore Π means the profit from the total 'operational activities'. One could add the profit from these 'non-operational activities' to the right hand term of (4-8), but it would not affect the results of the analysis, as the profit from 'non-operational activities' is totally unregulated and not relevant to any of the economic constraints.

TR_R, which is the revenue from airport charges can be expressed as the following:

$$TR_R = TR_P + TR_L + TR_K$$

$$= TR_P(q_P) + TR_L(q_L) + TR_K(q_K) \qquad (4\text{-}9)$$

where the notations are as follows:

TR_P : total revenue obtained from passenger charge
q_P : total passenger numbers
TR_L : total revenue obtained from landing charge
q_L : total landing numbers
TR_K : total revenue obtained from aircraft parking charge
q_K : number of parkings made by all aircraft

The revenue from 'commercial-side' which is not directly regulated, TR_U, can be expressed as:

$$TR_U = TR_U(p_U, q_P) = p_U q_U(p_U, q_P) \qquad (4\text{-}10)$$

There is no single unit measurement for q_U which represents either a unit of space or a unit of a facility that is hired by concessionaires, trading licensees or tenants. p_U is the unit price that the third party who uses the space or facility pays to the airport operator depending on which facility they are using. Although the payment methods for the 'commercial-side' services are varied, they are in effect closely related to the passenger numbers (apart from the bottom two rows in Table 4-2 – those two categories' charges are determined as the results of interventions by either the Office of Fair Trading or local communities, on the grounds of fairness). This is the reason why I justify TR_U as the function of passenger numbers[5].

As to the costs, there are many facilities and spaces which are commonly used by both 'air-side' and 'commercial-side' operations. I will use the following notations to denote common costs and attributable costs:

- attributable unit cost of passenger service: c_P
- attributable unit cost of landing or taking-off: c_L
- attributable unit cost of parking space: c_K
- opportunity cost per unit of output measured differently for each category of 'commercial-side' operation: c_{Uh} $(h = 1,\ldots,m)$
- volume of the output of 'commercial-side' operation which is hired or rented (or leased out) by either concessionaires, trade licensees or tenants: Q_h $(h = 1,\ldots,m)$
- common cost (non-attributable cost): F

c_{Uh} is the value of space per square metre if the measured unit Q_h is the size of the space (such as check-in desk) rented by the tenants or trade licensees, whilst it is the maintenance cost per facility (such as a baggage conveyor) if the measured unit is the number of the facilities. Thus the total cost function can be expressed as:

$$TC = c_P q_P + c_L q_L + c_k q_K + \sum_h c_{Uh} Q_h + F \qquad (4\text{-}11)$$

The constraint which is imposed by the airport charge regulation can be written as:

$$\frac{TR_P+TR_L+TR_K}{q_P} \leq \overline{p} \qquad (4\text{-}12)$$

It is worth stressing again here that the denominator of the equation (4-12) is passenger numbers not including landing numbers nor parking volume. This constraint is different to the generally known style of Average Revenue Approach price capping. Let us now call this price cap constraint the 'Airport Average Revenue' (AAR) constraint.

4-4. Simple model of 'Airport Average Revenue Approach'

In order to make the rest of the analysis simpler, I use only two types of demand categories relating to airport charges, i.e., passengers and other air-side output. One can regard the latter category either as a mixture of landing numbers and the time and space used in aircraft parking, or, more practically, as just landing numbers. The determinant of the numbers and/or capacity of the facilities located outside terminals (e.g., the numbers and the size of runways, taxiways and aprons etc.) are in fact landing numbers. It is more convenient to put airport charges from both landing and parking together into one category. Normally an aircraft parking charge is imposed on the airline based on the time spent in parking and the weight of each aircraft, which complicates the modelling in terms of analysing the price structure. Let us call this combined category 'runway' output[6]. Another reason for putting aside aircraft parking is that the share of the aircraft parking charge in the total of airport charges at an airport is normally quite small[7]. For these reasons I make the model structure simpler than the one explained in the previous section. Instead of (4-9) the total revenue from airport charge is, from now on, expressed as:

$$TR_R = TR_P + TR_W \tag{4-13}$$

where suffix P denotes passenger charge and suffix W denotes charge from 'runway' output.

Likewise, the total cost and the price cap constraint can be simplified. Instead of the expression (4-11), I use the following expression of total cost:

$$TC = c_P q_P + c_W q_W + c_U q_U + F \tag{4-14}$$

This simplification does not affect the results of the analysis. c_W means the unit cost of runway related output. c_U means the unit cost of commercial-side activity.

The price cap constraint AAR can be reduced to the following form:

$$\frac{TR_P + TR_W}{q_P} \leq \overline{p} \tag{4-15}$$

One can see how this AAR constraint would result in a different set of outcomes from the outcomes predicted by an ordinary Average Revenue price cap constraint. In order to see the difference, I use the following outputs:

q_{P1} : peak passenger numbers

q_{P2} : off-peak passenger numbers

q_{W1} : peak runway output numbers (or simply peak landing numbers)

q_{W2} : off-peak runway output numbers (or simply off-peak landing numbers)

q_U : amount of 'outputs' (either volume or space) in unregulated commercial activities

The regulated airport aims to maximise its profit subject to this AAR constraint. The airport maximises:

$$\Pi = TR_P + TR_W + TR_U - TC$$

$$= \sum_i p_{Pi} q_{Pi} + \sum_i p_{Wi} q_{Wi} + p_U q_U - (\sum_i c_{Pi} q_{Pi} + \sum_i c_{Wi} q_{Wi} + c_U q_U + F)$$

$$;i = 1,2$$

(4-16)

The constraint (4-15) can be rewritten as the following:

$$\frac{\sum_i p_{Pi} q_{Pi} + \sum_i p_{Wi} q_{Wi}}{\sum_i q_{Pi}} \le \overline{p} \qquad ;i = 1,2 \qquad (4\text{-}17)$$

Each demand is set as independent here. $p_{P1}, p_{P2}, p_{W1}, p_{W2}, p_U$ are peak passenger charge, off-peak passenger charge, peak runway charge, off-peak runway charge and commercial activity's 'price', respectively. The Lagrange function is as follows:

$$\mathcal{L} = \Pi + \lambda\{\overline{p}(q_{P1} + q_{P2}) - (TR_P + TR_W)\} \tag{4-18}$$

The first order conditions of the Lagrangean $\mathcal{L}$ can be expressed as:

$$p_{P1}(1 - \frac{1}{e_{P1}})(1 - \lambda) = c_{P1} - \lambda\overline{p} \tag{4-19}$$

$$p_{P2}(1 - \frac{1}{e_{P2}})(1 - \lambda) = c_{P2} - \lambda\overline{p} \tag{4-20}$$

$$p_{W1}(1 - \frac{1}{e_{W1}})(1 - \lambda) = c_{W1} \tag{4-21}$$

$$p_{W2}(1 - \frac{1}{e_{W2}})(1 - \lambda) = c_{W2} \tag{4-22}$$

$$p_U(1 - \frac{1}{e_U}) = c_U \tag{4-23}$$

These results can be arranged in the form of prices as follows:

$$p_{P1} = \frac{c_{P1}-\lambda\overline{p}}{(1-\frac{1}{e_{P1}})(1-\lambda)} \tag{4-19)'$$

$$p_{P2} = \frac{c_{P2}-\lambda\overline{p}}{(1-\frac{1}{e_{P2}})(1-\lambda)} \tag{4-20)'$$

$$p_{W1} = \frac{c_{W1}}{(1-\frac{1}{e_{W1}})(1-\lambda)} \tag{4-21)'$$

$$p_{W2} = \frac{c_{W2}}{(1-\frac{1}{e_{W2}})(1-\lambda)} \tag{4-22)'$$

$$p_U = \frac{c_U}{(1-\frac{1}{e_U})} \tag{4-23)'$$

λ is the Lagrange multiplier. The second order condition holds and deduces that $0 < \lambda < 1$. Using the same style of expression in the section 4-2, i.e., $m_{Pi} = \frac{p_{Pi}}{c_{Pi}}$, $m_{Wi} = \frac{p_{Wi}}{c_{Wi}}$, $m_U = \frac{p_U}{c_U}$, $\overline{m}_{Pi} = \frac{\overline{p}}{c_{Pi}}$, $\overline{m}_{Wi} = \frac{\overline{p}}{c_{Wi}}$, and $b = \frac{\lambda}{1-\lambda}$, we can rewrite (4-19) to (4-23) as the following:

$$m_{P1} = \frac{1}{1-\frac{1}{e_{P1}}}\{1 - b(\overline{m}_{P1} - 1)\} \tag{4-24}$$

$$m_{P2} = \frac{1}{1-\frac{1}{e_{P2}}}\{1 - b(\overline{m}_{P2} - 1)\} \tag{4-25}$$

$$m_{W1} = \frac{1}{1-\frac{1}{e_{W1}}}(1+b) \qquad (4\text{-}26)$$

$$m_{W2} = \frac{1}{1-\frac{1}{e_{W2}}}(1+b) \qquad (4\text{-}27)$$

$$m_U = \frac{1}{1-\frac{1}{e_U}} \qquad (4\text{-}28)$$

Comparisons between the results of this AAR constraint setting and the result of an ordinary average Revenue constraint setting are summarised in Table 4-3. As it is clear from Table 4-3 in which I used Waterson's expression (from section 4-2), the most interesting difference between the outcome predicted from the ordinary Average Revenue constraint and the one from AAR can be seen in the price marginal cost ratios of (2), (3) and (5).

Table 4-3 Price marginal cost mark-up ratios

	(1) between regulated services both inside the constraint's denominator
ordinary Average Revenue	$\frac{m_1}{m_2}=\frac{(1-\frac{1}{e_2})}{(1-\frac{1}{e_1})}\frac{\{1-b(\overline{m}_1-1)\}}{\{1-b(\overline{m}_2-1)\}}$
AAR	$\frac{m_{P1}}{m_{P2}}=\frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})}\frac{\{1-b(\overline{m}_{P1}-1)\}}{\{1-b(\overline{m}_{P2}-1)\}}$
	(2) between regulated services, one included in the constraint's denominator, the other not in the denominator
ordinary Average Revenue	–
AAR	$\frac{m_{P1}}{m_{W1}}=\frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{\{1-b(\overline{m}_{P1}-1)\}}{(1+b)}$
	(3) between regulated services both not included in the constraint's denominator
ordinary Average Revenue	–
AAR	$\frac{m_{W1}}{m_{W2}}=\frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}$
	(4) between service regulated and included in the denominator and unregulated service
ordinary Average Revenue	$\frac{m_1}{m_3}=\frac{1-\frac{1}{e_3}}{1-\frac{1}{e_1}}\{1-b(\overline{m}_1-1)\}$
AAR	$\frac{m_{P1}}{m_U}=\frac{1-\frac{1}{e_U}}{1-\frac{1}{e_{P1}}}\{1-b(\overline{m}_{P1}-1)\}$
	(5) between service regulated but not included in the denominator and unregulated service
ordinary Average Revenue	–
AAR	$\frac{m_{W1}}{m_U}=\frac{1-\frac{1}{e_U}}{1-\frac{1}{e_{W1}}}(1+b)$

As to (2), by considering the term inside the large bracket of the outcome from AAR, the following cases can be examined:

$$1)\ if\ \overline{m}_{P1} \leq 0,\quad \frac{m_{P1}}{m_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{\{1-b(\overline{m}_{P1}-1)\}}{(1+b)} \geq \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}$$

$$2)\ if\ \overline{m}_{P1} > 0,\quad \frac{m_{P1}}{m_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{\{1-b(\overline{m}_{P1}-1)\}}{(1+b)} < \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}$$

As defined, $\overline{m}_{P1} = \frac{\overline{p}}{c_{P1}}$ and both $\overline{p}$ and $\overline{c}_{P1}$ are positive, the case 1) is impossible and the case 2) always holds. This means that the ratio of the price marginal cost mark-up of the landing charge, relative to the mark-up ratio of the passenger charge, would be always larger than would be realised under the unregulated monopolist price setting.

Regarding (3), i.e., the mark-up ratio of peak and off-peak landing charges, the ratio predicted by AAR constraint shows that it is exactly the same as in the case of the ratio that would be realised under an unregulated monopolist. (4-21) and (4-22) can be rearranged as:

$$MR_{W1} = p_{W1}(1 - \frac{1}{e_{W1}}) = \frac{1}{1-\lambda} c_{W1}$$

$$MR_{W2} = p_{W2}(1 - \frac{1}{e_{W2}}) = \frac{1}{1-\lambda} c_{W2}$$

where the left hand side of each equation is the relevant marginal revenue. This means that the marginal revenue from the landing charge is equal to the related marginal cost multiplied by $\frac{\lambda}{1-\lambda}$ which is larger than 1. Therefore, the marginal revenue from landing charge always exceeds the marginal cost. There would be fewer landings than with an unregulated monopolist.

As to (5), the ratio of the mark-up of landing charge to unregulated service shows that it is larger than the ratio of the mark-up of passenger charge to unregulated service.

It is convenient to show the same findings in the form of price ratios, not price marginal cost mark-up ratios. This is because (a) it makes the expression simpler and (b) I can use the expression directly in Chapter 5. There is a problem in terms of carrying out the empirical analysis due to the lack of information that would be required to deduce an estimation of marginal costs. I use only price data in the empirical analysis in Chapter 5, and I re-arrange the summary of this simple model's outcome into the price ratio forms shown in Table 4-4. I also rearranged the two base benchmark settings, i.e., a simple unregulated monopolist setting and Ramsey pricing rule setting, from the form of the price marginal cost mark-up ratios ((4-4) and (4-5) in section 4-2) to the price ratio form. This is shown in Table 4-5.

Table 4-4 Price ratios: difference between Average Revenue constraint and AAR

	(1) between regulated services both inside the constraint's denominator
ordinary Average Revenue	$\frac{p_1}{p_2} = \frac{(1-\frac{1}{e_2})}{(1-\frac{1}{e_1})}\frac{c_1-\lambda\overline{p}}{c_2-\lambda\overline{p}}$
AAR	$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-\lambda\overline{p}}{c_{P2}-\lambda\overline{p}}$
	(2) between regulated services, one included in the constraint's denominator, the other not in the denominator
ordinary Average Revenue	—
AAR	$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-\lambda\overline{p}}{c_{W1}}$
	(3) between regulated services both not included in the constraint's denominator
ordinary Average Revenue	—
AAR	$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_{W2}}$
	(4) between service regulated and included in the denominator and unregulated service
ordinary Average Revenue	$\frac{p_1}{p_3} = \frac{1-\frac{1}{e_3}}{1-\frac{1}{e_1}}\frac{c_1-\lambda\overline{p}}{(1-\lambda)c_3}$
AAR	$\frac{p_{P1}}{p_U} = \frac{1-\frac{1}{e_U}}{1-\frac{1}{e_{P1}}}\frac{c_{P1}-\lambda\overline{p}}{(1-\lambda)c_U}$
	(5) between service regulated but not included in the denominator and unregulated service
ordinary Average Revenue	—
AAR	$\frac{p_{W1}}{p_U} = \frac{1-\frac{1}{e_U}}{1-\frac{1}{e_{W1}}}\frac{c_{W1}}{(1-\lambda)c_U}$

Table 4-5 Price ratios in two Benchmark cases: Unregulated monopolist's setting and Ramsey setting

(M) Unregulated Monopolist	$\frac{p_j}{p_k} = \frac{(1-\frac{1}{e_k})}{(1-\frac{1}{e_j})}\frac{c_j}{c_k}$
(R) Ramsey rule	$\frac{p_j}{p_k} = \frac{(1-a\frac{1}{e_k})}{(1-a\frac{1}{e_j})}\frac{c_j}{c_k}$

In order to be able to compare the price ratios, there is a need to make several assumptions regarding the elasticities and marginal costs of the relevant services. Throughout the chapter I assume each demand function is downward sloping. Each output is assumed to be supplied only within the range where the marginal revenue is positive. Therefore the value of price elasticity of each service, expressed in the absolute term (i.e., $e_i \equiv -\frac{\partial q_i}{\partial p_i}\frac{p_i}{q_i}$), is assumed to be larger than 1.

It is arguable that one can detect the independent elasticity of airport charge distinguished from the elasticity of the airline tickets' price. Airport charge is regarded by airlines as a part of the total cost of flights. The cost of operating a flight by an airline consists of lots of cost categories, such as fuel cost, aircraft capital cost (or leasing cost), crew cost, in-flight-catering cost, overhead cost etc., apart from airport charge. One can detect 'elasticity of airport charge to the supply' of total capacity (such as the total number of landing and total seats) to an airline company. The problem is that the airlines don't reflect the cost of operating a flight averaged by passenger numbers to the ticket's price, let alone the marginal cost. There exists a 'yield management' technique which airlines employ in order to maximise the load factor, which means that most of the indirect and even direct costs incurred by flying a commercial aircraft are passed on to an individual passenger in a different way. Not only the technique of yield management, but there are many kinds of manipulations that airlines can conduct in order to make their operations more profitable through raising the number of passengers, e.g., they can change the size of the aircraft and the destination or route distance. The way the airlines pass a part of the total cost of a flight on to each passenger depends on these controllable elements. Intuitively one can assume that the 'elasticity of airport charge of the supply' would be smaller when the airline uses a larger aircraft and a longer route, as the proportion of airport charge to the total cost of a flight is smaller where it uses a larger aircraft and longer haul route. This is because of the 'runway' charge which is fixed per aircraft, becoming a smaller amount per passenger on average if the airline uses a larger aircraft on a longer haul route compared to using a smaller aircraft and shorter route. The recent practice of the airlines is to impose the passenger charge on a passenger as an addition to the ticket price. In a way one can regard the mix of passenger charge and 'runway charge' (i.e.,landing charge plus parking charge) as a kind of 'two-part tariff' system. Here I assume that (a) one can identify elasticity of airport charge from the airline demand and (b) each elasticity of passenger charge and 'runway' charge can be detectable separately. All assumptions as to the price elasticities are as follows:

(1) $e_i > 1$: the value of price elasticity of each service, expressed in the absolute term (i.e., $e_i \equiv -\frac{\partial q_i}{\partial p_i}\frac{p_i}{q_i}$), is always larger than 1

(2) $e_{P1} < e_{P2}$: elasticity of peak passenger charge is smaller than that of off-peak passenger charge

(3) $e_{P1} > e_{W1}$ and $e_{P2} > e_{W2}$: elasticity of runway charge is smaller than that of passenger charge in both peak and off-peak period

(4) $e_{W1} < e_{W2}$: elasticity of peak runway charge is smaller than that of off-peak runway charge

(5) $e_{P1} < e_U$ and $e_{P2} < e_U$: elasticity of passenger charge (in both peak and off-peak) is smaller than that of commercial service 'price'.

(6) $e_{W1} < e_U$ and $e_{W2} < e_U$: elasticity of runway charge (in both peak and off-peak) is smaller than that of commercial service 'price'

Assumptions (2) and (4) are based on the nature of the derived demand of transport. The passengers who would like to use the airline service during the peak hours are more likely to have their trips based on business demand than on leisure demand. Assumption (3) is less convincing. As suggested above, it is difficult to separate landing charge elasticity from passenger charge elasticity. However, there exists a physical constraint, i.e., the slot limit when it comes to landing and taking-off. Although in this thesis the issues regarding slots are not explored, slot problems have concerned transport economists particularly the property rights issue. 'Grandfather's rights' are quite often looked upon as an asset by airlines and the level of landing charge would be likely to have significantly less importance than a decision to give up a slot. In terms of landing time, there is another restriction, i.e., availability of take-off and landing slots at other network departure or destination airports. Also, as described above, whilst the recent custom is to show the passenger charge separately to the airline ticket purchasers, there are many ways of distributing landing charges among different passengers per flight which is 'hidden' inside the ticket price. I presume that the assumption (3) is justified. As to assumptions (5) and (6), one can assume that the air-side services are less price elastic than the commercial services. The commercial 'output' is a mixture of goods from many kinds of industries with different degrees of competitiveness as shown in Table 4-1. Some goods or services sold inside an airport terminal (such as medicines, foods, banking and all kinds of consumable goods, etc.) are pure by-products exploiting the externality that the airport produces, but they are quite competitive. Other goods which are directly related to the airline operations (such as fuel, check-in desk space and ground-handling services, etc.) are less competitive, but under inspection by the MMC regarding their competitiveness. However, the air-side services are the 'goods' which the airlines cannot dispense with if they are to operate in the airport.

Assumptions regarding marginal costs are as follows:

(1) $c_{P1} > c_{P2}$: the marginal cost related to each peak passenger is larger than the marginal cost related to each off-peak passenger.

(2) $c_{W1} > c_{W2}$: the marginal cost (short-run) incurred by the landing, taking-off and aircraft parking of each aircraft during peak period is larger than that during the off-peak period.

(3) $c_{W1} > c_{P1}$ and $c_{W2} > c_{P2}$: the marginal cost (short-run) of landing, taking-off or aircraft parking incurred by each aircraft is larger than the

marginal cost per passenger (in both peak period and off-peak period).

In so far as I have been able to determine there has been no marginal cost estimation actually carried out except in the case where the British Airports Authority once published its two internal documents in 1983. It calculated the peak and off-peak marginal costs at Heathrow and Gatwick in order to justify their peak passenger charges on the basis of their costs. This investigation of the costs came about because of the conflict between the Authority and the airlines which had led to 'the Memorandum of Understanding 1983' mentioned in Chapter 2. As these documents are unfortunately 'classified' inside BAA, I can only refer to the MMC2 report in which there is some description of the results of the estimation. According to MMC2, if the peak passenger charge had been set at the marginal cost level, the peak charge would have had to be roughly 10 times more expensive than the off-peak passenger charge. Therefore assumption (1) is clearly justified. As to the 'runway' marginal costs' assumption (2), not only the opportunity cost such as the 'congestion cost' during the peak hours incurred by each aircraft, which is one of the bases for the BAA's introduction of peak landing charge[8], but also the larger physical unit cost related to peak 'runway' operations, such as maintenance costs or fire security costs, justify that the marginal short-run cost of peak 'runway' service is larger than during off-peak hours. Assumption (3) comes from the matter of unit measurement. The marginal cost per passenger is related to each passenger, whereas the marginal 'runway' cost is measured by each aircraft movement, which justifies the marginal cost of 'runway' being larger than the marginal cost per passenger.

An additional assumption as to the value of $\lambda \overline{p}$ can be deduced from the elasticities' assumption (1) above, i.e., $e_i > 1$. Under this assumption the value of $1 - \frac{1}{e_{Pi}}$ is always positive. As p_{Pi} is positive, from the equations (4-19)' and (4-20)', it is automatically deduced that:

$c_{P1} > \lambda \overline{p}$ and

$$c_{P2} > \lambda \overline{p}.$$

As to the level of price cap level, $\overline{p}$, if the AAR constraint is binding, the price cap level can be expressed as:

$$\overline{p} = \frac{p_{P1}q_{P1}+p_{P2}q_{P2}+p_{W1}q_{W1}+p_{W2}q_{W2}}{q_{P1}+q_{P2}}$$

and this must be larger than the 'weighted average price of passenger charges', let's call it $\widetilde{p}$, that can be expressed as:

$$\widetilde{p} = \frac{p_{P1}q_{P1}+p_{P2}q_{P2}}{q_{P1}+q_{P2}}.$$

Therefore,

$$\overline{p} = \frac{p_{P1}q_{P1}+p_{P2}q_{P2}+p_{W1}q_{W1}+p_{W2}q_{W2}}{q_{P1}+q_{P2}} > \frac{p_{P1}q_{P1}+p_{P2}q_{P2}}{q_{P1}+q_{P2}} = \widetilde{p}.$$

It is likely that $\widetilde{p}$ is larger than both c_{P1} and c_{P2}, and therefore it is not too unrealistic to assume that $\overline{p} > c_{P1} > c_{P2}$.

Based on the all assumptions I have made above, we can compare each price ratio from (1) to (5) in Table 4-4, with (M) and (R) in Table 4-5 which are set as benchmarks.

(1) Between regulated services both inside the constraint's denominator

(1) peak passenger charge to off-peak passenger charge under AAR (and ordinary Average Revenue):

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-\lambda\overline{p}}{c_{P2}-\lambda\overline{p}}$$

(M1) peak passenger charge to off-peak passenger charge under unregulated monopolistic setting:

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}}{c_{P2}}$$

(R1) peak passenger charge to off-peak passenger charge under Ramsey rule:

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{a}{e_{P2}})}{(1-\frac{a}{e_{P1}})}\frac{c_{P1}}{c_{P2}}$$

The results are summarised in Table 4-6-(1).

(2) Between regulated services, one included in the constraint's denominator, the other not in the denominator

(2) peak (off-peak) passenger charge to peak (off-peak) runway charge under AAR:

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-\lambda\overline{p}}{c_{W1}}$$

(M2) peak (off-peak) passenger charge to peak (off-peak) runway charge under unregulated monopolistic setting:

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}}{c_{W1}}$$

(R2) peak (off-peak) passenger charge to peak (off-peak) runway charge under Ramsey rule:

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{a}{e_{W1}})}{(1-\frac{a}{e_{P1}})}\frac{c_{P1}}{c_{W1}}$$

The result is summarised in Table 4-6-(2).

(3) Between regulated services both not included in the constraint's denominator

(3) peak runway charge to off-peak runway charge under AAR:

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_{W2}}$$

(M3) peak runway charge to off-peak runway charge under unregulated monopolistic setting:

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_{W2}}$$

(R3) peak runway charge to off-peak runway charge under Ramsey rule:

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{a}{e_{W2}})}{(1-\frac{a}{e_{W1}})}\frac{c_{W1}}{c_{W2}}$$

The result is summarised in Table 4-6-(3).

(4) Between a service regulated and included in the denominator and an unregulated service

(4) peak (off-peak) passenger charge to commercial 'price' under AAR (and ordinary Average Revenue):

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-\lambda\overline{p}}{(1-\lambda)c_U}$$

(M4) peak (off-peak) passenger charge to commercial 'price' under unregulated monopolistic setting:

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}}{c_U}$$

(R4) peak (off-peak) passenger charge to commercial 'price' under Ramsey rule:

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{a}{e_U})}{(1-\frac{a}{e_{P1}})}\frac{c_{P1}}{c_U}$$

The results are summarised in Table 4-6-(4).

(5) Between a service regulated but not included in the denominator and an unregulated service

(5) peak (off-peak) runway charge to commercial 'price' under AAR:

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})} \frac{c_{W1}}{(1-\lambda)c_U}$$

(M5) peak (off-peak) runway charge to commercial 'price' under unregulated monopolistic setting:

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})} \frac{c_{W1}}{c_U}$$

(R5) peak (off-peak) runway charge to commercial 'price' under Ramsey rule:

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{a}{e_U})}{(1-\frac{a}{e_{W1}})} \frac{c_{W1}}{c_U}$$

The result is summarised in Table 4-6-(5).

Table 4-6-(1) Price ratio comparison: peak passenger charge to off-peak passenger charge

$\frac{p_{P1}}{p_{P2}}$	comparison among (1), (M1) and (R1)
	$(R1) < (M1) < (1)$

Table 4-6-(2) Price ratio comparison: peak passenger charge to peak runway charge

$\frac{p_{P1}}{p_{W1}}$	comparison among (2), (M2) and (R2)
	$(2) < (M2) < (R2)$

Table 4-6-(3) Price ratio comparison: peak runway charge to off-peak runway charge

$\frac{p_{W1}}{p_{W2}}$	comparison among (3), (M3) and (R3)
	$(R3) < (M3) = (3)$

Table 4-6-(4) Price ratio comparison: peak passenger charge to commercial 'price'

$\frac{p_{P1}}{p_U}$	comparison among (4), (M4) and (R4)
$if\ c_{P1} > \overline{p}$	$(R4) < (M4) < (4)$
$if\ c_{P1} \leq \overline{p}$	inconclusive: $(4) < (R4) < (M4)$ *or* $(R4) < (4) < (M4)$

Table 4-6-(5) Price ratio comparison: peak runway charge to commercial 'price'

$\frac{p_{W1}}{p_U}$	comparison among (5), (M5) and (R5)
	$(R5) < (M5) < (5)$

Regarding the result of (1), Table 4-6-(1) shows that the price ratio of peak passenger charge to off-peak passenger charge is higher than the ratio which would be realised under an unregulated monopolist.

As to the ratio between runway charge and passenger charge, it is clear from the result shown in Table 4-6-(2) that runway charge would be set inefficiently higher than passenger charge by more than the degree that would be achieved under an unregulated monopolistic situation.

There is a suggestion made by MMC that is very directly linked to this context. In the case of Manchester Airport, MMC concluded in their first report MMC1 that the use of the Tariff Basket Approach was preferable to using the AAR (although MMC called it 'Revenue Yield Approach', at the time of the investigation it had already been established that the 'Revenue Yield Approach' imposed on the 'designated' UK airports was meant to be in the form of AAR) because MMC was concerned with the potential incentive for Manchester to try to inflate the demand placed on the terminal capacity under AAR. MMC said that '*just as rate of return control may provide an artificial incentive to maximise the rate base, so the revenue yield approach may* *provide an artificial incentive for a regulated airport to increase passenger numbers without due regard to cost*'. At the time of this investigation, Manchester's terminal capacity was rather tight but the runway capacity had surplus, in contrast to BAA's London airports. MMC was therefore concerned that AAR constraint would give Manchester an incentive to inflate the demand for airport terminal capacity which is directly related to passenger charge. MMC was concerned that '*in some circumstances the airport might seek this otherwise unprofitable traffic because the associated losses can be more than compensated by increases in other airport charges*'. This can be looked upon as another way of predicting the outcome of the price ratio (2) shown in Table 4-6-(2). However, CAA did not take into account this conclusion. As to the BAA's case, the recommendation regarding the constraint type was made by NERA in a report commissioned by the Department of Transport. NERA's report didn't discuss the possible drawback with the Average Revenue constraint which MMC1 was concerned with. What may seem even more outlandish is that NERA's suggestion *against* the Tariff Basket Approach was based on the notion that the price structure under a Tariff Basket price cap constraint would give an incentive to a profit-maximising airport to concentrate price increases where the demand was increasing most strongly. NERA's concern was that the runway capacity (which is related to 'runway charge') was limited at BAA's 3 London airports, i.e., the apprehension that BAA would have a potential incentive to increase passenger charges relative to peak landing charges. However, apart from the capacity limit, this particular notion of the predicted outcome under a Tariff Basket Approach is rather more of an efficiency oriented outcome, and close to the Ramsey outcome. Yet, NERA recommended that the price cap constraint on BAA should be a Tariff Basket Approach, mainly because of the simplicity of calculation.

Regarding the result of (3), i.e., the ratio between peak runway charge and off-peak runway charge, (shown in Table 4-6-(3)) the ratio realised under AAR is exactly the same as the ratio which would be realised under an unregulated monopolistic situation. However, the actual runway charge itself, regardless whether at peak or off-peak, is always higher than the monopolistic level as I have explained before.

As for the price ratios between airport charge and unregulated commercial 'price', the one between passenger charge and commercial 'price' is very different from the one between runway charge and commercial 'price'. Regarding the former ratio, it always holds that the ratio under AAR is lower than the ratio under a monopolistic situation as shown in Table 4-6-(4). As to the comparison between the ratio under AAR and the ratio under Ramsey setting, it is inconclusive. In the two cases shown in Table 4-6-(4), i.e., as to the relationship between c_{P1} and $\overline{p}$, the likely relationship is $c_{P1} \leq \overline{p}$, which I have already presumed, and in this case the price ratio of passenger charge to commercial 'price' under AAR is either higher or lower than with Ramsey rule setting. Regarding the latter ratio, i.e., the ratio of landing charge to commercial 'price', the result shown in Table 4-6-(5) means that the ratio under AAR is always higher than the degree of the equivalent ratio which an unregulated monopolist would set.

4-5. Rebalancing predictions of BAA's airport charges

The purpose of this section is to try to predict the effect of changes of constraints on relative prices in the case of BAA (and of course the then nationalised British Airports Authority). Because the purpose of this section is to examine the effect of changes of constraints, I analyse the predicted outcomes under the different constraints which the then nationalised British Airports Authority had faced and BAA is now facing. As mentioned in Chapter 3, one suspects that the British Airports Authority had tried to maximise its output, the main financial constraint being the financial target. During the period between 1983/84 and 1986/87 which is just before privatisation, a formula to set each year's financial target was established so that the financial target was directly linked to the growth rate in passenger numbers. As described in Chapter 3, the financial target constraint applied to the year t's activities was expected to be:

$$TR^t - TC^t \geq \theta^t \cdot I^t \qquad (4\text{-}29)$$

where superscript t denotes the year t, and θ^t is the financial target for the year t and I^t is the investment during the year t. (4-29) is the constraint relevant to the period before 1983/84. However, during the period between 1983/84 and 1986/87, the financial target's form was changed so that the financial target itself became the function of the passenger numbers, as the result of the incorporation of the passenger numbers growth rate into the financial target. This constraint can be expressed in a simple form as:

$$TR^t - TC^t \geq \left[\theta^{t-1} + \frac{1}{5} \times \frac{q_P^t - q_P^{t-1}}{q_P^{t-1}}\right] \cdot I^t \qquad (4\text{-}30)$$

The following five types of constraints are considered in this section (and also in Appendix (1) and Appendix (2)):

(M): Unconstrained monopolist's pricing

(R): Ramsey pricing rule

(Q): Output maximisation

(QG): Output maximisation with passenger growth

(AAR): Airport Average Revenue constraint

The first two settings are for benchmarks. The constraints that the then nationalised British Airports Authority had been subject to and BAA is now subject to have been changed in the order of (Q), (QG) and (AAR). I have also carried out the price ratio calculations based on an assumed alternative objective of the British Airports Authority, i.e., that of maximising its revenue. Although I have made a model for the British Airports Authority's management maximising its output as its objective in Chapter 3, nothing is certain concerning the objectives of nationalised industries. It is still a grey area. The most likely alternative to output maximisation of this organisation as the objective under the nationalisation era was probably revenue maximisation. In Appendix (4), I show the results of the price ratios using the combination of this objective and the corresponding constraints, instead of (Q) and (QG) categories above.

Each combination of the objective and the constraint in a simplified form under each category (R), (M), (Q), (QG) and (AAR) can be expressed as the following (See Appendix (3) for the full Lagrangean form under each category):

(R): the firm maximises $CS(\boldsymbol{P})+\Pi$

s.t. $\Pi \geq z$

where $CS(\boldsymbol{P})$ denotes consumers' surplus, Π is the profit of the firm, and z is a constant number (required minimum profit or zero).

$$CS(\boldsymbol{P}) = CS(p_{Pi}, p_{Wi}, p_U)$$

$$= \sum_i \int_{p_{Pi}}^{p_{Pi}^0} q_{Pi}(p_{Pi})dp_{Pi} + \sum_i \int_{p_{Wi}}^{p_{Wi}^0} q_{Wi}(p_{Wi})dp_{Wi} + \sum_i \int_{p_{Pi}}^{p_{Pi}^0} q_{Wi}(p_{Wi})dp_{Pi} + \int_{p_U}^{p_U^0} q_U(p_U)dp_U \quad (4\text{-}31)$$

$$\Pi = \sum_i p_{Pi}q_{Pi}(p_{Pi}) + \sum_i p_{Wi}q_{Wi}(p_{Wi}) + p_U q_U(p_U) - \sum_i c_{Pi}q_{Pi}(p_{Pi}) - \sum_i c_{Wi}q_{Wi}(p_{Wi}) - c_U q_U(p_U) - F \quad (4\text{-}32)$$

Π here means the profit from 'operational activities' as explained in section 4-3.

(M): the firm maximises Π (same as (4-32)) without any constraint.

(Q): the firm maximises total output $\boldsymbol{q}$

s.t. $TR - TC \geq \theta \cdot I$

$$\boldsymbol{q} = \sum_i q_{Pi}(p_{Pi}) + \sum_i q_{Wi}(p_{Wi}) + q_U(p_U)$$

The period which is relevant to each p and q, and the financial target θ

and I in the constraint $TR - TC \geq \theta \cdot I$ is the same period, i.e., this constraint is the same as (4-29) which means:

$$\sum_i p_{Pi} q_{Pi}(p_{Pi}) + \sum_i p_{Wi} q_{Wi}(p_{Wi}) + p_U q_U(p_U)$$
$$- \sum_i c_{Pi} q_{Pi}(p_{Pi}) - \sum_i c_{Wi} q_{Wi}(p_{Wi}) - c_U q_U(p_U) - F \geq \theta \cdot I$$

(QG): the firm maximises total output ***q***

$$\text{s.t. } TR^t - TC^t \geq \left[\theta^{t-1} + \frac{1}{5} \times \frac{q_P^t - q_P^{t-1}}{q_P^{t-1}}\right] \cdot I^t$$

where ***q*** is the same as (4-33) and the constraint is the same as (4-30) which means:

$$\sum_i p_{Pi} q_{Pi}(p_{Pi}) + \sum_i p_{Wi} q_{Wi}(p_{Wi}) + p_U q_U(p_U)$$
$$- \sum_i c_{Pi} q_{Pi}(p_{Pi}) - \sum_i c_{Wi} q_{Wi}(p_{Wi})$$
$$- c_U q_U(p_U) - F \geq \theta^{t-1} I^t + \frac{I^t}{5} \times \frac{(q_{P1}^t + q_{P2}^t) - (q_{P1}^{t-1} + q_{P2}^{t-1})}{q_{P1}^{t-1} + q_{P2}^{t-1}}$$

(AAR): the firm maximises Π

$$\text{s.t. } \frac{\sum_i p_{Pi} q_{Pi}(p_{Pi}) + \sum_i p_{Wi} q_{Wi}(p_{Wi})}{\sum_i q_{Pi}(p_{Pi})} \leq \overline{p}$$

(4-36)

where Π is the same as (4-32). The constraint (4-36) is the same as (4-17).

In order to show the calculation results in a less complicated form, I use the following notations:

λ_Q: Lagrange multiplier for the constraint applied to (Q)

λ_{QG}: Lagrange multiplier for the constraint applied to (QG)

λ: Lagrange multiplier for the price constraint applied to (AAR)

μ: Lagrange multiplier for Ramsey rule constraint (same as before)

$a = \frac{\mu}{1+\mu}$ (same as before)

$d = \frac{1}{\lambda_Q}$ $(d > 1)$

$v = \frac{1}{\lambda_{QG}}$ $(v > 1)$

e_i: own price elasticity of service i in the absolute term $(= -\frac{\partial q_i}{\partial p_i}\frac{p_i}{q_i})$
(same as before)

$A = q_{P1}^{t-1} + q_{P2}^{t-1}$ (this denotes the total passenger numbers in the previous year)

I: capital input in period t

Each passenger charge under (R), (M), (Q), (QG) and (AAR) can be expressed (after rearranging each first order condition of the constrained maximisation shown above) as the following:

(R) $p_{Pi} = \frac{c_{Pi}}{(1-\frac{a}{e_{Pi}})}$ (4-37)

(M) $p_{Pi} = \frac{c_{Pi}}{(1-\frac{1}{e_{Pi}})}$ (4-38)

(Q) $p_{Pi} = \frac{c_{Pi}-d}{(1-\frac{1}{e_{Pi}})}$ (4-39)

(QG) $p_{Pi} = \frac{c_{Pi}-v+\frac{I}{5A}}{(1-\frac{1}{e_{Pi}})}$ (4-40)

(AAR) $p_{Pi} = \frac{c_{Pi}-\lambda\overline{p}}{(1-\frac{1}{e_{Pi}})(1-\lambda)}$ (4-41)

Each runway charge under (R), (M), (Q), (QG) and (AAR) can be expressed (after rearranging each first order condition of the constrained maximisation shown above) as the following:

(R) $p_{Wi} = \frac{c_{Wi}}{(1-\frac{a}{e_{Wi}})}$ (4-42)

(M) $p_{Wi} = \frac{c_{Wi}}{(1-\frac{1}{e_{Wi}})}$ (4-43)

(Q) $p_{Wi} = \frac{c_{Wi}-d}{(1-\frac{1}{e_{Wi}})}$ (4-44)

(QG) $p_{Wi} = \frac{c_{Wi}-v}{(1-\frac{1}{e_{Wi}})}$ (4-45)

(AAR) $p_{Wi} = \frac{c_{Wi}}{(1-\frac{1}{e_{Wi}})(1-\lambda)}$ (4-46)

Each unregulated commercial 'price' under (R), (M), (Q), (QG) and (AAR) can be expressed (after rearranging each first order condition of the constrained maximisation shown above) as the following:

(R) $p_U = \frac{c_U}{(1-\frac{a}{e_U})}$ (4-47)

(M) $p_U = \frac{c_U}{(1-\frac{1}{e_U})}$ (4-48)

(Q) $p_U = \frac{c_U-d}{(1-\frac{1}{e_U})}$ (4-49)

(QG) $p_U = \frac{c_U-v}{(1-\frac{1}{e_U})}$ (4-50)

(AAR) $p_U = \frac{c_U}{(1-\frac{1}{e_U})}$ (4-51)

The results are shown below. I use the prices applied during peak period in the comparison case (2) where each price ratio is expressed as the ratio of passenger charge to runway charge, because of the focus of this section. (Each equation in (2) is interchangeable into off-peak version, when one changes the suffix (attached to each p) from 1 to 2.)

(1) Between regulated services both inside the constraint's denominator

(R1) peak passenger charge to off-peak passenger charge under Ramsey rule:

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{a}{e_{P2}})}{(1-\frac{a}{e_{P1}})}\frac{c_{P1}}{c_{P2}}$$

(M1): peak passenger charge to off-peak passenger charge under unconstrained monopolist's pricing

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}}{c_{P2}}$$

(Q1): peak passenger charge to off-peak passenger charge under output maximisation

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-d}{c_{P2}-d}$$

(QG1): peak passenger charge to off-peak passenger charge under output maximisation with passenger growth

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-v+\frac{I}{5A}}{c_{P2}-v+\frac{I}{5A}}$$

(AAR1): peak passenger charge to off-peak passenger charge under Airport Average Revenue constraint

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-\lambda\overline{p}}{c_{P2}-\lambda\overline{p}}$$

(2) Between regulated services, one included in the constraint's denominator, the other not in the denominator

(R2) peak (off-peak) passenger charge to peak (off-peak) runway charge under Ramsey rule:

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{a}{e_{W1}})}{(1-\frac{a}{e_{P1}})}\frac{c_{P1}}{c_{W1}}$$

(M2): peak (off-peak) passenger charge to peak (off-peak) runway charge under unconstrained monopolist's pricing

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}}{c_{W1}}$$

(Q2): peak (off-peak) passenger charge to peak (off-peak) runway charge under output maximisation

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-d}{c_{w1}-d}$$

(QG2): peak (off-peak) passenger charge to peak (off-peak) runway charge under output maximisation with passenger growth

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-v+\frac{I}{5A}}{c_{w1}-v}$$

(AAR2): peak (off-peak) passenger charge to peak (off-peak) runway charge under Airport Average Revenue constraint

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{eW1})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-\lambda\overline{p}}{c_{W1}}$$

(3) Between regulated services both not included in the constraint's denominator

(R3) peak runway charge to off-peak runway charge under Ramsey rule:

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{a}{e_{W2}})}{(1-\frac{a}{e_{W1}})}\frac{c_{W1}}{c_{W2}}$$

(M3): peak runway charge to off-peak runway charge under unconstrained monopolist's pricing

$$\frac{p_{W1}}{p_{w2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_{W2}}$$

(Q3): peak runway charge to off-peak runway charge under output maximisation

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}-d}{c_{W2}-d}$$

(QG3): peak runway charge to off-peak runway charge under output maximisation with passenger growth

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}-v}{c_{W2}-v}$$

(AAR3): peak runway charge to off-peak runway charge under Airport Average Revenue constraint

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_{W2}}$$

(4) Between service regulated and included in the denominator and unregulated service

(R4) peak (off-peak) passenger charge to commercial 'price' under Ramsey rule:

$$\frac{p_{P1}}{p_{U}} = \frac{(1-\frac{a}{e_{U}})}{(1-\frac{a}{e_{P1}})}\frac{c_{P1}}{c_{U}}$$

(M4): peak (off-peak) passenger charge to commercial 'price' under unconstrained monopolist's pricing

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}}{c_U}$$

(Q4): peak (off-peak) passenger charge to commercial 'price' under output maximisation

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-d}{c_U-d}$$

(QG4): peak (off-peak) passenger charge to commercial 'price' under output maximisation with passenger growth

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-v+\frac{I}{5A}}{c_U-v}$$

(AAR4): peak (off-peak) passenger charge to commercial 'price' under Airport Average Revenue constraint

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\frac{c_{P1}-\lambda\overline{p}}{c_U(1-\lambda)}$$

(5) Between service regulated but not included in the denominator and unregulated service

(R5) peak (off-peak) runway charge to commercial 'price' under Ramsey rule:

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{a}{e_U})}{(1-\frac{a}{e_{W1}})}\frac{c_{W1}}{c_U}$$

(M5): peak (off-peak) runway charge to commercial 'price' under unconstrained monopolist's pricing

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_U}$$

(Q5): peak (off-peak) runway charge to commercial 'price' under output maximisation

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}-d}{c_U-d}$$

(QG5): peak (off-peak) runway charge to commercial 'price' under output maximisation with passenger growth

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}-v}{c_U-v}$$

(AAR5): peak (off-peak) runway charge to commercial 'price' under Airport Average Revenue constraint

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_U(1-\lambda)}$$

In the price ratio comparison case of (1), the relationship between (R1), (M1) and (AAR1) was already shown in Table 4-6-(1), and (R1)<(M1)<(AAR1) was the result. Here the level of both (Q1) and (QG1) should be analysed in relation to the level of (AAR1). It is clear that (M1)<(Q1) always holds in terms of the price ratios, although each passenger charge under (Q1) constraint is always lower than each passenger charge under an unconstrained monopolistic situation. However, one needs to consider the effect of $\frac{I}{5A}$ in the case of the constraint (QG). It is worth noting that under (QG) if the value of $\frac{I}{5A}$ is higher than the value of v, each passenger charge is even higher than the charge which an unconstrained monopolist would set (it is clear from the equations (4-38) and (4-40)). The value of $\frac{I}{5A}$ is related to the effect of the passenger number growth rate incorporated in the constraint applied to (QG). Although my main interest lies in the price ratio, this particular case where the effect of $\frac{I}{5A}$ is overpowering the effect of v produces an interesting finding. Each passenger charge under (Q), (QG) and (AAR) is lower than the unregulated monopolistic level except in this particular situation of (QG1). In this particular case, the price ratio under (QG) is always lower than the price ratio which would be realised under (M1), which means that both peak passenger charge and off-peak passenger charge are higher than the equivalent monopolistic level of charge, and also the ratio of peak passenger charge to off-peak passenger charge is lower than the unconstrained monopolistic price ratio. This scenario implies that the (QG) constraint would have worked as a pressure for the then British Airports Authority to relatively suppress peak passenger charge and relatively escalate off-peak passenger charge. When the value $\frac{I}{5A}$ become larger, the value $v = (\frac{1}{\lambda_{QG}})$ becomes smaller, which enhances the effect of $\frac{I}{5A}$ on both the price ratio distortion and each price's increase. If this would be the case, the order of the price ratio level under each constraint would be (QG1)<(M1)<(Q1)<(AAR1), with either (R1)<(QG1)<(M1) or (QG1)<(R1)<(M1).

However, if one assumes that $v > \frac{I}{5A}$ is the case, the relationship between the price ratios under different constraint categories is inconclusive, depending on the scale of the Lagrangean multiplier that is relevant to each constraint. It is at least certain that all the price ratios under (Q), (QG) and (AAR) are higher than the ratio under (M). The relative scale of d, $v - \frac{I}{5A}$ and $\lambda\overline{p}$ should be considered. The results are summarised below:

<table>
<tr><td colspan="2">if $d > v - \frac{I}{5A}$
(Q1)>(QG1)</td><td colspan="2">if $d \leq v - \frac{I}{5A}$
(Q1)≤(QG1)</td></tr>
<tr><td>if $\lambda\overline{p} > v - \frac{I}{5A}$
(AAR1)>(QG1)</td><td>if $\lambda\overline{p} \leq v - \frac{I}{5A}$
(AAR1)≤(QG1)</td><td>if $\lambda\overline{p} > v - \frac{I}{5A}$
(AAR1)>(QG1)</td><td>if $\lambda\overline{p} \leq v - \frac{I}{5A}$
(AAR1)≤(QG1)</td></tr>
<tr><td>(Q1)>(QG1)
(AAR1)>(QG1)</td><td>(Q1)>(QG1)≥(AAR1)</td><td>(Q1)≤(QG1)<(AAR1)</td><td>(Q1)≤(QG1)
(AAR1)≤(QG1)</td></tr>
</table>

What generally one can predict from this summary is that the stronger the constraint effect, the larger the price ratio in question tends to be, e.g., if the constraint (QG) is relatively more effective than that of (Q), the price ratio (QG1) tends to be higher than (Q1), and if the constraint (AAR) is relatively more effective than that of (QG), the price ratio (AAR1) tends to be higher than (QG1). Therefore without the knowledge of the constraint's strength, the price ratio prediction cannot be made. As shown in the summary table above in the normal and likely case of $v > \frac{I}{5A}$, one cannot state how the price ratio might have been changed from (Q), (QG) to (AAR) because there exist all the possible orders of relative size in this case. However, as Table 2-1 suggests, in the past the constraint (Q) does not seem to have been effective and from this reason it is likely that $d > v - \frac{I}{5A}$ was the case. The constraint (QG) seems to have been met throughout the period before privatisation since 1983/84. This means that we can predict that firstly (QG1)<(Q1), implying that since 1983/84 the price ratio dropped during operation under the then nationalised British Airports Authority, and secondly, (QG1)<(AAR1) following the privatisation of this organisation. The relationship between (R1), (Q1) and (QG1) is inconclusive.

In the case of the price ratio comparison (2), it always holds that (AAR2)<(M2)<(R2) as shown in Table 4-6-(2). It also always holds that (AAR2)<(M2)<(Q2) and (AAR2)<(QG2). As to the relationship between (Q2) and (QG2), here again one needs to consider both the effect of $\frac{I}{5A}$ and the relative strength of d and $v - \frac{I}{5A}$. As in the comparison case of (1) if one assumes that $d > v - \frac{I}{5A}$ was the case, and that the constraint (QG) is relatively more effective than the constraint (Q), the result would be predicted as (AAR2)<(Q2)<(QG2). The relationship between (R2), (Q2) and (QG2) cannot be certain.

In the case of the price ratio comparison (3), the relationship between (R3), (M3) and (AAR3) is that (R3)<(M3)=(AAR3) as shown in Table 4-6-(3). It should be noted again that the price level (not the price ratio level) realised under (AAR) is actually higher than under an unconstrained monopolist's price setting, although the price ratio level is the same as under an unconstrained monopolist's setting, as I have mentioned in the previous section in the form of (4-21)' and (4-22)'. The term $(1 - \lambda)$ in the equation (4-46) is cancelled out when the price ratio form is expressed. p_{Wi} under (R) constraint is always smaller than p_{Wi} under an unconstrained monopolist's setting. The runway charges (for both peak and off-peak) under (Q) and (QG) are lower than the level of (AAR), and as to the price ratios, it always holds that (Q3)<(AAR3) and (QG3)<(AAR3). It is uncertain whether each runway charge under (R) constraint would be smaller than under the (Q) (and (QG)) constraint, and also whether the price ratio under (R) constraint would be smaller than under the (Q) (and (QG)) constraint. This is because that whilst the term $\frac{(1-\frac{a}{e_{W2}})}{(1-\frac{a}{e_{W1}})}$ is always smaller than the term $\frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}$, the term in (Q3) $\frac{c_{W1}-d}{c_{W2}-d}$ (in (QG3)'s case $\frac{c_{W1}-v}{c_{W2}-v}$) is always smaller than $\frac{c_{W1}}{c_{W2}}$ so that the relationship between (R3) and (Q3) (and (QG3)) is inconclusive. In terms of the comparison between (Q3) and (QG3), if one assumes that $d > v$ was the case, meaning that the constraint of (Q) was less effective than the constraint of (QG), (Q3)<(QG3) is the relationship between the two price ratios. However, if $d < v$ was the case, (QG3)<(Q3) holds. In the likely case where the constraint of (Q) was weak and the constraint (QG) was effective, the price ratios' degree order is such that (Q3)<(QG3)<(AAR3)=(M3). The difference between (QG3), (Q3) and (AAR3) depends on the tightness of the constraints during the nationalisation era. If the constraint under (QG) was weak, there might have been a sudden jump after privatisation, to the higher ratio under (AAR). However, if the (QG)'s constraint had been strong, the change of the price ratios from (QG3) to (AAR3) may have been marginal.

In the comparison case (4), the relationship between (R4), (M4) and (AAR4) was shown in Table 4-6-(4). Under the likely assumption of $c_{P1} \leq \overline{p}$, it always holds that (AAR4)<(M4), although it is not clear whether (R4)<(AAR4) or (AAR4)<(R4). Under an additional assumption that $c_{Pi} > c_U$, the relationship between (Q4) and (M4) is (M4)<(Q4), and it also holds that (M4)<(QG4). The commercial 'price' itself, however, is always lower under either (Q) or (QG) constraint than the price level under (M). If one assumes that the constraint of (Q) is less effective than that of (QG), as with the cases in the above other comparisons (1), (2) and (3), i.e., $d > v$, the relationship between (Q4) and (QG4) is concluded as (Q4)<(QG4). Thus, the price ratios relationship among (Q4), (QG4) and (AAR4) is predicted as (AAR4)<(Q4)<(QG4). The relationship between (R4), (Q4) and (QG4) is inconclusive.

As to the comparison category (5), i.e., the price ratio of runway charge to the unregulated commercial 'price', it is always the case that (R5)<(M5)<(AAR5) holds as in Table 4-6-(5). Regarding the relationship among (Q5), (QG5) and (M5), (M5)<(Q5)<(QG5) is deduced under an additional assumption of $c_{Wi} > c_U$ as well as with the assumption that $d > v$. In the comparison between (QG5) and (AAR5), the relationship depends on the tightness of the constraint of (AAR):

if $\frac{c_U - v}{(1-\lambda)c_U} > 1$: (AAR5)>(QG5) if $\frac{c_U - v}{(1-\lambda)c_U} \leq 1$ and also if $c_{W1} - c_U < \frac{\lambda c_{W1} c_U}{v}$, then (AAR5)<(QG5)

if $\frac{c_U - v}{(1-\lambda)c_U} \leq 1$ and also if $c_{W1} - c_U \geq \frac{\lambda c_{W1} c_U}{v}$, then (AAR5)≥(QG5)

The first case of the three conditions above implies that the constraint of (AAR) is at its tightest level. Where the constraint is not as strong as the first case, the relationship between (AAR5) and (QG5) rather depends on the difference between c_{W1} and c_U and is inconclusive. Therefore where $c_{W1} > c_U$, the relationship can be either (Q5)<(QG5)<(AAR5) or (Q5)<(AAR5)<(QG5) or (AAR5)<(Q5)<(QG5). The last case is rather unlikely considering that the effect of constraint (Q) should be assumed to be weak in relation to the effect of constraint (AAR). If one assumes that the difference between c_{W1} and c_U is quite large, it seems that one can predict that the relationship is (Q5)<(QG5)<(AAR5). The relationship between (R5), (Q5) and (QG5) is inconclusive.

As to the commercial 'price', there is a notion that the importance attached to the revenue produced from the unregulated commercial services has been increasing in the case of BAA's airports and that the relative standard of airport charge has been reduced partly because of the 'designated' airport charge regulation.(for example, Condie (2000)). The outcome of (AAR4) compared to (R4), (Q4) and (QG4) shows that the price ratio of $\frac{p_{P1}}{p_U}$ was predicted to be lower under (AAR4) than the ratio which might be realised under any other constraints. However, as to the outcome of (AAR5), i.e., the price ratio of runway charge to commercial 'price', the relative ratio under (AAR) was predicted to be the highest of all the outcomes under the constraints I considered. This is because of the effect of the peculiar (AAR) constraint in which runway charge related output is not included as its denominator.

If one wants to find out if and how BAA attempts to increase its revenue from their unregulated services, one must not just look at the airport charge price regulation, we should also look at the way this unusual 'single-till' policy works. Many economists would say that the 'single-till' is the problem and why should there be a price cap on airport charges? The incentive for the airport to increase their commercial revenue might be closely linked to the cost side of the commercial-side. So there is a very interesting issue here which is to do with how the 'single-till' approach combined with the way the regulator, i.e., the CAA sets the "X" in the price cap RPI-X might affect the airport operator's incentive to inflate the total cost. On the other hand, the pressure to increase their revenue from the unregulated commercial service might contribute to their internal cost efficiency. As I have mentioned in note 5 of this chapter, how BAA changed its management style of some unregulated services would also be another interesting issue for further research. The point as to the effect of a 'single-till' approach will be revisited as one of the implications in the next chapter.

So far I have analysed the effect of the price rebalancing in terms of BAA's airport charges and commercial 'price' caused by the change of constraint. The model did not include capacity constraint, which might limit the ability to predict the price structure changes. However, one of the purposes of this chapter is to focus on the effect due to the idiosyncrasy of 'Airport Average Revenue' constraint.

These predictions can be applied for empirical analysis using price data. However, unlike the comparison between airport charges, the data regarding the unregulated commercial 'price' is difficult to obtain. There are possibilities of testing the predictions regarding the price ratio between airport charge and some unregulated commercial service's 'price', only where one has specified a particular area of commercial service with data availability.

As a preparation to the next chapter's analysis, I summarise in Table 4-7 the level change of each price ratio from the concluding predictions in this section.

Table 4-7 Summary of the predictions from section 4-5

[meaning of the signs]

+: higher than before

−: lower than before

		(Q) → (QG)	(QG) → (AAR)
(1) $\frac{p_{P1}}{p_{P2}}$	$\frac{\textit{peak passenger charge}}{\textit{off peak passenger charge}}$	−	+
(2) $\frac{p_{P1}}{p_{W1}}$	$\frac{\textit{(off) peak passenger charge}}{\textit{(off) peak runway charge}}$	+	−
(3) $\frac{p_{W1}}{p_{W2}}$	$\frac{\textit{peak runway charge}}{\textit{off peak runway charge}}$	+	+
(4) $\frac{p_{P1}}{p_U}$	$\frac{\textit{(off) peak passenger charge}}{\textit{commercial 'price'}}$	+	−
(5) $\frac{p_{W1}}{p_U}$	$\frac{\textit{(off) peak runway charge}}{\textit{commercial 'price'}}$	+	+

In Table 4-7 the plus sign in the category (1) in the column (QG)→(AAR), for example, means that the level of the price ratio $\frac{p_{P1}}{p_{P2}}$ is predicted to be higher under (AAR) than under (QG). In (1) the price ratio level once dropped under (QG) and was raised again under (AAR). However, the level of price ratio level under (AAR) is predicted as higher than under (Q). Similarly, in the cases of (2) and (4) the level of price ratio under (QG) is predicted to be higher than under (Q) and after constraint by (AAR) it is predicted to become lower than (QG). However, in both cases (2) and (4), the level of price ratio under (AAR) is predicted to be even lower than under (Q). Therefore, as a rough guide to the next chapter's empirical study, price ratio level change after privatisation can be summarised in Table 4-8. Here again, the plus sign means the level is higher after privatisation and the minus sign means the level is lower after privatisation.

Table 4-8 Summary of the predicted price ratio level change after privatisation

		after privatisation
(1) $\frac{p_{P1}}{p_{P2}}$	$\frac{\textit{peak passenger charge}}{\textit{off peak passenger charge}}$	+
(2) $\frac{p_{P1}}{p_{W1}}$	$\frac{\textit{(off) peak passenger charge}}{\textit{(off) peak runway charge}}$	−
(3) $\frac{p_{W1}}{p_{W2}}$	$\frac{\textit{peak runway charge}}{\textit{off peak runway charge}}$	+
(4) $\frac{p_{P1}}{p_{U}}$	$\frac{\textit{(off) peak passenger charge}}{\textit{commercial 'price'}}$	−
(5) $\frac{p_{W1}}{p_{U}}$	$\frac{\textit{(off) peak runway charge}}{\textit{commercial 'price'}}$	+

Appendix (1) Outcome of the interdependency demand model: peak versus off-peak

In this Appendix I use demand interdependency between passenger service and 'runway' output, and I focus on the differences between peak and off-peak airport charges. The comparisons in terms of relevant price ratios in this Appendix correspond to Table 4-6-(1), 4-6-(2) and 4-6-(3) in section 4-4.

As I have explained before in the previous section in the context of 'elasticity of airport charge to the supply' of a flight, we can consider the airport charge as a part of the cost of operating a flight, and airport charge can be looked upon as a kind of 'two-part tariff'. Therefore how the increase of passenger charge would affect an airline is different to how the increase of runway charge would influence it in its decision as to whether or not it should operate a flight and/or the decision as to what kind of aircraft and slot it should use. More realistically, one needs to take the interdependent relationship between passenger charge and runway charge into consideration.

As I use interdependent demands, the demand functions set in this section are as follows:

$$q_{P1} = q_{P1}(p_{P1})$$
$$q_{P2} = q_{P2}(p_{P2})$$
$$q_{W1} = q_{W1}\{p_{W1}, q_{P1}(p_{P1})\}$$
$$q_{W2} = q_{W2}\{p_{W2}, q_{P2}(p_{P2})\}$$

The specification of q_U is so designed that the demand of the commercial service is a function of its own 'price', except in Appendix (2). This is only for simplicity, because it does not affect the results in the calculation as to peak and off-peak price ratios. As the main interest in this section is in the comparisons which include only passenger charges and runway charges, the simplified specification of q_U makes the analysis less complicated.

In order to show the calculation results in a less complicated form, I use the following notations:

λ_Q: Lagrange multiplier for the constraint applied to (Q)

λ_{QG}: Lagrange multiplier for the constraint applied to (QG)

λ: Lagrange multiplier for the price constraint applied to (AAR)

μ: Lagrange multiplier for Ramsey rule constraint (same as before)

$a = \frac{\mu}{1+\mu}$ (same as before)

$d = \frac{1}{\lambda_Q}$ $(d > 1)$

$v = \frac{1}{\lambda_{QG}}$ $(v > 1)$

e_i: own price elasticity of service i in the absolute term $(= -\frac{\partial q_i}{\partial p_i}\frac{p_i}{q_i})$ (same as before)

ε_1: cross-elasticity of price p_{P1} in relation to q_{W1}, i.e., $\varepsilon_1 = -\frac{\partial q_{W1}}{\partial p_{P1}}\frac{p_{P1}}{q_{W1}}$ (also expressed as the absolute term)

ε_2: cross-elasticity of price p_{P2} in relation to q_{W2}, i.e., $\varepsilon_2 = -\frac{\partial q_{W2}}{\partial p_{P2}}\frac{p_{P2}}{q_{W2}}$ (also expressed as the absolute term)

$B_i = \frac{\frac{1}{e_i}}{1-\frac{1}{e_i}}$ $(B_i > 1)$ also ($B_{W1} > B_{W2}$ because of the previous assumption $e_{W1} < e_{W2}$)

$\beta_i = \frac{\frac{a}{e_i}}{1-\frac{a}{e_i}}$ $(\beta_i > 1)$ also ($\beta_{W1} > \beta_{W2}$ because of the previous assumption $e_{W1} < e_{W2}$, and $\beta_{W1} < B_{W1}$, $\beta_{W2} < B_{W2}$ from the fact that $0 < a < 1$)

$k_1 = \frac{\partial q_{W1}}{\partial q_{P1}}$

$k_2 = \frac{\partial q_{W2}}{\partial q_{P2}}$

$A = q_{P1}^{t-1} + q_{P2}^{t-1}$ (this denotes the total passenger numbers in the previous year)

I: capital input in period t

I use several assumptions as to some of the notations above:

$k_1 > 0$: the increase of passenger numbers in peak period would not reduce the runway output

$k_2 > 0$: the increase of passenger numbers in off-peak period would not reduce the runway output

$k_1 < k_2$: the degree of the increase (decrease) of the runway output due to the increase (decrease) of the passenger numbers during the peak period will be smaller than the equivalent degree during the off-peak period. The reason for this is that the capacity required in the runways, aprons and taxiways, etc. is tighter during the peak period than during the off-peak period. In the BAA's London airports (whose change of outcomes under the effect of different constraints is the main interest in this section), this assumption seems to be justified because of the slot problems.

$\varepsilon_1 < \varepsilon_2$: whilst the peak hours' operations are more often related to scheduled flights (slots are rigid) or the flights that passengers are more likely to use for their business purposes, the flights that are operated during the off-peak hours are more likely to be charter flights or for leisure demand. Therefore, the degree of the reduction of the runway output caused by the increase of the passenger charge during off-peak hours is presumed to be larger than the degree of the reduction of the runway output affected by the increase of the peak passenger charge[8].

Each passenger charge under (R), (M), (Q), (QG) and (AAR) can be expressed (after rearranging each first order condition of the constrained maximisation shown above) as the following:

$$\text{(R)} \quad p_{Pi} = \frac{(c_{Pi} - k_i \beta_{Wi} c_{Wi})}{(1 - \frac{a}{e_{Pi}}) + (1 - a)\frac{k_i}{\varepsilon_i}} \qquad (4\text{-}52)$$

$$\text{(M)} \quad p_{Pi} = \frac{(c_{Pi} - k_i B_{Wi} c_{Wi})}{(1 - \frac{1}{e_{Pi}})} \qquad (4\text{-}53)$$

$$\text{(Q)} \quad p_{Pi} = \frac{[c_{Pi} - k_i B_{Wi} c_{Wi} - d(1 - k_i B_{Wi})]}{(1 - \frac{1}{e_{Pi}})} \qquad (4\text{-}54)$$

$$\text{(QG)} \quad p_{Pi} = \frac{[c_{Pi} - k_i B_{Wi} c_{Wi} - v(1 - k_i B_{Wi}) + \frac{I}{5A}]}{(1 - \frac{1}{e_{Pi}})} \qquad (4\text{-}55)$$

$$\text{(AAR)}\ p_{Pi} = \frac{(c_{Pi}-k_i B_{Wi} c_{Wi}-\lambda \overline{p})}{(1-\frac{1}{e_{Pi}})(1-\lambda)} \qquad (4\text{-}56)$$

Each runway charge under (R), (M), (Q), (QG) and (AAR) is the same as in section 4-5 (see the equations (4-42) to (4-46)).

It is less straightforward to compare the price ratios than when the simple model was used as in the previous section. This is because of the complication caused by the cross-effect due to the interdependency demand model I introduced here. The results are shown below. I use the prices applied during peak period in the comparison case (2) where each price ratio is expressed as the ratio of passenger charge to runway charge, because of the focus of this section. (Each equation in (2) is interchangeable into off-peak version, when one changes the suffix (attached to each p) from 1 to 2.)

(1) Between regulated services both inside the constraint's denominator

(R1) peak passenger charge to off-peak passenger charge under Ramsey rule:

$$\frac{p_{P1}}{p_{P2}} = \frac{\{(1-\frac{a}{e_{P2}})+\frac{k_2}{\varepsilon_2}(1-a)\}}{\{(1-\frac{a}{e_{P1}})+\frac{k_1}{\varepsilon_1}(1-a)\}} \frac{[c_{P1}-k_1\beta_{W1}c_{W1}]}{[c_{P2}-k_2\beta_{W2}c_{W2}]}$$

(M1): peak passenger charge to off-peak passenger charge under unconstrained monopolist's pricing

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})} \frac{[c_{P1}-k_1B_{W1}c_{W1}]}{[c_{P2}-k_2B_{W2}c_{W2}]}$$

(Q1): peak passenger charge to off-peak passenger charge under output maximisation

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})} \frac{[c_{P1}-d-k_1B_{W1}(c_{W1}-d)]}{[c_{P2}-d-k_2B_{W2}(c_{W2}-d)]}$$

(QG1): peak passenger charge to off-peak passenger charge under output maximisation with passenger growth

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})} \frac{[c_{P1}-v-k_1B_{W1}(c_{W1}-v)+\frac{I}{5A}]}{[c_{P2}-v-k_2B_{W2}(c_{W2}-v)+\frac{I}{5A}]}$$

(AAR1): peak passenger charge to off-peak passenger charge under Airport Average Revenue constraint

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})}\frac{[c_{P1}-k_1 B_{W1} c_{W1}-\lambda \overline{p})]}{[c_{P2}-k_2 B_{W2} c_{W2}-\lambda \overline{p}]}$$

(2) Between regulated services, one included in the constraint's denominator, the other not in the denominator

(R2) peak (off-peak) passenger charge to peak (off-peak) runway charge under Ramsey rule:

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{a}{e_{W1}})}{(1-\frac{b}{e_{P1}})}\left[\frac{c_{P1}}{c_{W1}} - \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{a}{e_{W1}})} \cdot k_1 B_{W1}\right] \quad \text{(where } b = a - (1-a)\frac{q_{W1}}{q_{P1}}\text{)}$$

(M2): peak (off-peak) passenger charge to peak (off-peak) runway charge under unconstrained monopolist's pricing

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\left[\frac{c_{P1}}{c_{W1}} - k_1 B_{W1}\right]$$

(Q2): peak (off-peak) passenger charge to peak (off-peak) runway charge under output maximisation

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{[c_{P1}-d-k_1 B_{W1}(c_{W1}-d)]}{[c_{W1}-d]}$$

(QG2): peak (off-peak) passenger charge to peak (off-peak) runway charge under output maximisation with passenger growth

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\frac{[c_{P1}-v-k_1 B_{W1}(c_{W1}-v)+\frac{I}{5A}]}{[c_{W1}-v]}$$

(AAR2): peak (off-peak) passenger charge to peak (off-peak) runway charge under Airport Average Revenue constraint

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})}\left[\frac{c_{P1}}{c_{W1}} - k_1 B_{W1} - \frac{\lambda \overline{p}}{c_{W1}}\right]$$

(3) Between regulated services both not included in the constraint's denominator

(R3) peak runway charge to off-peak runway charge under Ramsey rule:

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{a}{e_{W2}})}{(1-\frac{a}{e_{W1}})}\frac{c_{W1}}{c_{W2}}$$

(M3): peak runway charge to off-peak runway charge under unconstrained monopolist's pricing

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_{W2}}$$

(Q3): peak runway charge to off-peak runway charge under output maximisation

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}-d}{c_{W2}-d}$$

(QG3): peak runway charge to off-peak runway charge under output maximisation with passenger growth

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}-v}{c_{W2}-v}$$

(AAR3): peak runway charge to off-peak runway charge under Airport Average Revenue constraint

$$\frac{p_{W1}}{p_{W2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_{W2}}$$

Apart from comparison (3), it is unfortunate that the price ratio results under the Ramsey solution cannot be used as useful references to compare the results of (Q), (QG) and (AAR). In both (1) and (2), the ratios under Ramsey rule are not clear-cut. Although it is obvious by definition that each price under Ramsey rule is smaller than the equivalent price under the unconstrained monopolist's setting, the relationship between (R1) and (M1) and the relationship between (R2) and (M2) cannot be clearly generalised because of the cross-effect due to the interdependency demand model. In the case of (1), because of the inclusions of both k_i and ε_i, one cannot judge the degree of $\frac{p_{P1}}{p_{P2}}$. The first fraction depends on both the degree of the passenger demand's elasticity and the degree of average passenger numbers per runway output, between peak and off-peak period ($\frac{k_i}{\varepsilon_i} = -\frac{l_i}{e_{Pi}}$, where l_i denotes $\frac{q_{Wi}}{q_{Pi}}$ which is the inverse of the average passenger numbers per runway output). Though the first half of the right hand term of (R1) is always smaller than the value $\frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})}$ of (M1), the second half fraction of (R1) is either bigger or smaller than that of (M1), due to the complex relationship between k_i and β_{Wi} and also between k_i and B_{Wi}. In the case of (2), the first half fraction of (R2) is always smaller than the first half fraction of (M2). However, the value inside the second large bracket of (R2) is larger than that of (M2). therefore the result is not conclusive regarding the price ratios' values. Such being the case, I use (M), (Q), (QG) and (AAR) to compare the price ratios of (1), (2) and (3).

In the price ratio comparison case of (1), in order to carry out the comparison among

(M1), (Q1), (QG1) and (AAR1), one needs to look into several key factors in relation to the cross-effect, due to the interdependency in the demands. The summary of the cases clustered by each factor are shown in Table 4-9. In order to make the expression simpler let us call $c_{Pi} - k_i B_{Wi} c_{Wi}$ 'real' marginal cost of c_{Pi}, which means this is the marginal cost of passenger service in period i including the cross-effect caused by the interdependent runway demand. I use the notation $\hat{c}_{Pi}$ to denote $c_{Pi} - k_i B_{Wi} c_{Wi}$.

Table 4-9 comparison among (M1), (Q1), (QG1) and (AAR1)

<table>
<tr><td rowspan="4">(a):
if $\frac{\hat{c}_{P1}}{\hat{c}_{P2}} > \frac{1-k_1B_{W1}}{1-k_2B_{W2}}$
(Q1)>(M1)</td><td rowspan="2">(a)-1: if
$\frac{\hat{c}_{P1}-d(1-k_1B_{W1})}{\hat{c}_{P2}-d(1-k_2B_{W2})} > 1$
(Q1)>(QG1)</td><td>(a)-1-1 $\frac{I}{5A}$'s effect
$k_iB_{Wi}c_{Wi}+v(1 - k_iB_{Wi}) < \frac{I}{5A}$</td><td>(Q1)>(M1)>(AAR1)>(QG1)</td></tr>
<tr><td>(a)-1-2 $\frac{I}{5A}$'s effect
$k_iB_{Wi}c_{Wi}+v(1 - k_iB_{Wi}) \geq \frac{I}{5A}$</td><td>not possible situation</td></tr>
<tr><td rowspan="2">(a)-2: if
$\frac{\hat{c}_{P1}-d(1-k_1B_{W1})}{\hat{c}_{P2}-d(1-k_2B_{W2})} \leq 1$
(QG1)≥(Q1)</td><td>(a)-2-1 $\frac{I}{5A}$'s effect
$k_iB_{Wi}c_{Wi}+v(1 - k_iB_{Wi}) < \frac{I}{5A}$</td><td>not possible situation</td></tr>
<tr><td>(a)-2-2 $\frac{I}{5A}$'s effect
$k_iB_{Wi}c_{Wi}+v(1 - k_iB_{Wi}) \geq \frac{I}{5A}$</td><td>(AAR1)≥(QG1)>(Q1)>(M1)</td></tr>
<tr><td rowspan="5">(b):
if $\frac{\hat{c}_{P1}}{\hat{c}_{P2}} \leq \frac{1-k_1B_{W1}}{1-k_2B_{W2}}$
(M1)≤(Q1)</td><td rowspan="3">(b)-1: if
$\frac{\hat{c}_{P1}-d(1-k_1B_{W1})}{\hat{c}_{P2}-d(1-k_2B_{W2})} > 1$
(Q1)>(QG1)</td><td rowspan="2">(b)-1-1 $\frac{I}{5A}$'s effect
$k_iB_{Wi}c_{Wi}+v(1 - k_iB_{Wi}) < \frac{I}{5A}$</td><td>when $\frac{k_2}{k_1} > \frac{C_{W1}+d(1+B_{W1})}{C_{W2}+d(1+B_{W2})}$
(M1)>(Q1)>(AAR1)>(QG1)</td></tr>
<tr><td>when $\frac{k_2}{k_1} < \frac{C_{W1}+d(1+B_{W1})}{C_{W2}+d(1+B_{W2})}$
(M1)>(AAR1)>(Q1)>(QG1)</td></tr>
<tr><td>(b)-1-2 $\frac{I}{5A}$'s effect
$k_iB_{Wi}c_{Wi}+v(1 - k_iB_{Wi}) \geq \frac{I}{5A}$</td><td>not possible situation</td></tr>
<tr><td rowspan="2">(b)-2: if
$\frac{\hat{c}_{P1}-d(1-k_1B_{W1})}{\hat{c}_{P2}-d(1-k_2B_{W2})} \leq 1$
(QG1)≥(Q1)</td><td>(b)-2-1 $\frac{I}{5A}$'s effect
$k_iB_{Wi}c_{Wi}+v(1 - k_iB_{Wi}) < \frac{I}{5A}$</td><td>(M1)>(AAR1)>(QG1)>(Q1)</td></tr>
<tr><td>(b)-2-2 $\frac{I}{5A}$'s effect
$k_iB_{Wi}c_{Wi}+v(1 - k_iB_{Wi}) \geq \frac{I}{5A}$</td><td>(AAR1)≥(QG1)>(M1)>(Q1)</td></tr>
</table>

Because the numerator of p_{Pi}'s expression under (M) must be positive (and also $c_{Pi} < c_{Wi}$ as per our assumption), it must be that $k_i B_{Wi} < 1$ holds. As $d > 1$, the numerator of the right-hand side of (4-54) is always smaller than that of the numerator on the right-hand side of (4-53), which means that passenger charge under (Q) is always lower than under (M) in both peak and off-peak cases. As $\lambda\overline{p} > 0$, it always holds that p_{Pi} under (AAR) is lower than that under (M). However, under (QG) each passenger charge is even higher than the charge which an unconstrained monopolist would set in the case where the effect of the passenger numbers growth rate incorporated in the constraint applied to (QG), i.e., the value of $\frac{I}{5A}$, is higher than the value $v(1 - k_i B_{Wi})$. This particular case where the effect of $\frac{I}{5A}$ is overpowering the effect of $v(1 - k_i B_{Wi})$ was already mentioned in section 4-5 where I explained that the case where $v < \frac{I}{5A}$ holds produces an unusual outcome. Each passenger charge under (Q1), (QG1) and (AAR1) is lower than the unregulated monopolistic level except in this particular situation of (QG1). In this particular situation, the price ratio under (QG1) is always lower than the price ratio which would be realised under (M1), which means that both peak passenger charge and off-peak passenger charge are higher than the equivalent monopolistic level of charge, and also the ratio of peak passenger charge to off-peak passenger charge being lower than the unconstrained monopolistic price ratio implies that the (QG) constraint would have worked as a pressure for the then British Airports Authority to relatively suppress peak passenger charge and relatively escalate off-peak passenger charge. When the value $\frac{I}{5A}$ becomes larger, the value $v = (\frac{1}{\lambda_{QG}})$ becomes smaller, which enhances the effect of $\frac{I}{5A}$ on both the price ratio distortion and each price's increase.

In the case where condition (a)-2 or (b)-2 is held, the significance of the cross-effect is so large that the 'real' marginal cost of peak passenger service with the constraint's effect, i.e., $\hat{c}_{P1} - d(1 - k_1 B_{W1})$ is smaller than the 'real' marginal cost of off-peak passenger service plus the constraint's effect $\hat{c}_{P2} - d(1 - k_2 B_{W2})$. In this situation, it is possible that the actual price ratio of peak passenger charge to off-peak passenger charge would become less than 1. This situation seems unlikely. Therefore, after eliminating all possible situations under the category of (a)-2 or (b)-2, the likely scenarios one can deduce in terms of the price ratio order among (Q1), (QG1) and (AAR1) may have been either (Q1)>(AAR1)>(QG1) or (AAR1)>(Q1)>(QG1). In both cases throughout the operation of the then nationalised British Airports Authority the price ratio seems to have been continuously raised since 1983/84 and after privatisation it is assumed to have risen again, yet the price ratio level is now lower than that under an unconstrained monopolistic price setting. This means that we can predict that firstly (Q1)>(QG1), implying that since 1983/84 the price ratio dropped during operation under the then nationalised British Airports Authority, and secondly, (AAR1)>(QG1) following the privatisation of this organisation.

However, if one uses a simple model where all demands are independent (as in section 4-5) (in this case the notations k_i, ε_i, B_i, β_i, and c_{Wi} should be dropped from the summary (1) above), the result is as follows:

if (a) $v > \frac{I}{5A}$, (R1)<(M1), (M1)<(Q1), (M1)<(QG1), (M1)<(AAR1) and

if $d > v - \frac{I}{5A}$ (Q1)>(QG1)		if $d \leq v - \frac{I}{5A}$ (Q1)≤(QG1)	
if $\lambda\overline{p} > v - \frac{I}{5A}$ (AAR1)>(QG1)	if $\lambda\overline{p} \leq v - \frac{I}{5A}$ (AAR1)≤(QG1)	if $\lambda\overline{p} > v - \frac{I}{5A}$ (AAR1)>(QG1)	if $\lambda\overline{p} \leq v - \frac{I}{5A}$ (AAR1)≤(QG1)
(Q1)>(QG1) (AAR1)>(QG1)	(Q1)>(QG1)≥(AAR1)	(Q1)≤(QG1)<(AAR1)	(Q1)≤(QG1) (AAR1)≤(QG1)

if (b) $v \leq \frac{I}{5A}$, (R1)<(M1), (M1)<(Q1), (M1)≥(QG1), (M1)<(AAR1) and, (Q1)>(QG1) and (AAR1)>(QG1)

Thus clearly when interdependent demand specification is introduced, the rather abnormal case of (b) above where $\frac{I}{5A}$ is so effective that both passenger charges are higher than the unconstrained monopolist's setting seems to be realistic. It is because one cannot identify the size of k_i and B_i. What generally one can predict if the simple model is used is that the stronger the constraint effect, the larger the price ratio in question tends to be, e.g., if the constraint (QG) is relatively more effective than that of (Q), the price ratio (QG1) tends to be higher than (Q1), and if the constraint (AAR) is relatively more effective than that of (QG), the price ratio (AAR1) tends to be higher than (QG1). Therefore without the knowledge of the constraint's strength, the price ratio prediction cannot be made. As shown in the summary table above in the normal case ($v > \frac{I}{5A}$), one cannot state how the price ratio might have been changed from (Q), (QG) to (AAR) because in this case there exists all the possible orders.

In the case of the price ratio comparison (2), it always holds that (AAR2)<(M2). It also always holds that (AAR2)<(QG2). However, the relationships between (a) (Q2) and (M2), (b) (QG2) and (M2), (c) (Q2) and (QG2) and (d) (Q2) and (AAR2) depend on many conditions as follows.

(a)-1 if $\frac{\hat{c}_{P1}}{c_{W1}} < 1 - k_1 B_{W1}$: (Q2)<(M2)

(a)-2 if $\frac{\hat{c}_{P1}}{c_{W1}} \geq 1 - k_1 B_{W1}$: (Q2)≥(M2)

(b)-1 if the value of $\frac{I}{5A}$, is higher than the value $v(1 - k_1 B_{W1})$: (QG2)>(M2)

(b)-2 if $\frac{\hat{c}_{P1}}{c_{W1}} < 1 - k_1 B_{W1} - \frac{I}{5vA}$: (QG2)<(M2)

(b)-3 if $\frac{\hat{c}_{P1}}{c_{W1}} \geq 1 - k_1 B_{W1} - \frac{I}{5vA}$: (QG2)≥(M2)

(c)-1 if $\frac{\hat{c}_{P1} - d(1-k_1 B_{W1})}{c_{W1} - d} < 1 - k_1 B_{W1} + \frac{I}{5(d-v)A}$: (QG2)<(Q2)

(c)-2 if $\frac{\hat{c}_{P1} - d(1-k_1 B_{W1})}{c_{W1} - d} \geq 1 - k_1 B_{W1} + \frac{I}{5(d-v)A}$: (QG2)≥(Q2)

(d)-1 if $\lambda \overline{p} > d(1 - k_1 B_{W1})$: (Q2)>(AAR2)

(d)-2 if $\lambda \overline{p} \leq d(1 - k_1 B_{W1})$: (Q2)≤(AAR2)

Unlike the comparison (1), the use of the simple model (as in section 4-5) without any interdependency demands would not make the analysis less complicated. In order to make the analysis less complicated, I put aside the comparisons (a) and (b) above, and focus on the relationships (c) and (d) above. Regarding the relationship between (Q2) and (QG2) the condition depends on the strength of the constraint attached to (QG). When the constraint is strong the value v is smaller and at the same time the value $\frac{I}{5A}$ is larger than when the constraint is weak, which means that the stronger the constraint of (QG) is, the more likely that (QG2)<(Q2). In terms of the relationship between (Q2) and (AAR2), when the constraint of (AAR) becomes stronger, i.e., $\overline{p}$ is raised, then λ also becomes larger, where $\lambda \overline{p}$ becomes large enough to make the condition (d)-1 hold, it is likely that (Q2)>(AAR2). The then nationalised British Airports Authority always achieved its financial targets during the period between 1983/84 and 1986/87 where the financial target was set linked to the passenger numbers growth rate. Thus one can assume that (QG)'s constraint was tight, and presumably it can be justified to consider that (Q2)>(QG2) was the case. Therefore the relationship between (Q2), (QG2) and (AAR2) might have been in the order of (Q2)>(QG2)>(AAR2), which means that the price ratio of passenger charge to runway charge has been continuously lowered.

The comparison of price ratios in the category (3) is not affected by the introduction of demand interdependency. The result is exactly the same as in section 4-5.

Appendix (2) Outcome of the interdependency demand model: airport charges versus unregulated commercial 'price'

This section's purpose is to try to predict how the changes in the constraints might have affected the price ratios between airport charges and the unregulated commercial 'price', in both the then nationalised British Airports Authority and privatised current BAA. In this section, not only do I use demand interdependency between passenger service and 'runway' output (as in the previous section), but I also introduce the demand function of unregulated commercial output which is dependent on passenger numbers, as well as on its own unregulated output's 'price'. This is as I have explained in section 4-4, i.e., the payment method for commercial services is closely related to the passenger numbers. This fact is also linked to the explanation regarding the input selection of revenue used in the empirical analysis of productive efficiency given in Chapter 6 (where I assume that a part of the input to produce the total revenue from the 'operational activity' is, in effect, the passenger numbers at an airport). I focus on the comparison of the price ratio between passenger charge and commercial 'price' and the price ratio between runway charge and commercial 'price', under different constraints which are used in section 4-5, i.e., the following constraints:

(M): Unconstrained monopolist's pricing

(R): Ramsey pricing rule

(Q): Output maximisation

(QG): Output maximisation with passenger growth

(AAR): Airport Average Revenue constraint

The price ratio between passenger charge and commercial 'price' and the price ratio between runway charge and commercial 'price' correspond to Table 4-6-(4) and

4-6-(5) shown in section 4-4 respectively.

The demand functions set in this section considering the interdependency are as follows:

$$q_{P1} = q_{P1}(p_{P1})$$
$$q_{P2} = q_{P2}(p_{P2})$$
$$q_{W1} = q_{W1}\{p_{W1}, q_{P1}(p_{P1})\}$$
$$q_{W2} = q_{W2}\{p_{W2}, q_{P2}(p_{P2})\}$$
$$q_U = q_U\{p_U, q_{P1}(p_{P1}), q_{P2}(p_{P2})\}$$

In order to show the calculation results in a less complicated form, I add the following notations as well as the notations used in previous section:

ε_{1U}: cross-elasticity of price p_{P1} in relation to q_U, i.e., $\varepsilon_{1U} = -\frac{\partial q_U}{\partial p_{P1}}\frac{p_{P1}}{q_U}$ (expressed as the absolute term)

ε_{2U}: cross-elasticity of price p_{P2} in relation to q_U, i.e., $\varepsilon_{2U} = -\frac{\partial q_U}{\partial p_{P2}}\frac{p_{P2}}{q_U}$ (expressed as the absolute term)

$$s_1 = \frac{\partial q_U}{\partial q_{P1}}$$

$$s_2 = \frac{\partial q_U}{\partial q_{P2}}$$

Additional assumptions regarding the added notations in this Appendix are:

$$B_U \left(= \frac{\frac{1}{e_U}}{1-\frac{1}{e_U}}\right) > 1$$

$$\beta_U \left(= \frac{\frac{a}{e_U}}{1-\frac{a}{e_U}}\right) > 1$$

$B_U < B_{Pi}$, $B_U < B_{Wi}$ (from the assumption $e_U > e_{Pi}$ and $e_U > e_{Wi}$ as in the section 4-4)

$s_i > 0$ (passenger numbers' increase always increases the volume of total commercial output)

For convenience and because of the focus of this section I use peak passenger charge to represent passenger charge in the comparison between passenger charge and unregulated commercial 'price', and I also use peak runway charge for comparison purpose as a representative variable for runway charge.

Each unregulated commercial 'price' under (R), (M), (Q), (QG) and (AAR) is the same as shown in the equations from (4-47) to (4-51) in the main chapter.

Each passenger charge under (R), (M), (Q), (QG) and (AAR) (after rearranging each first order condition of the constrained maximisation problems) is different from the equivalent shown in section 4-5 (which are (4-37) - (4-41) because of the additional interdependency specification of q_U. They are expressed as follows:

$$\text{(R):}\ p_{Pi} = \frac{(c_{Pi} - k_i\beta_{Wi}c_{Wi} - s_i\beta_U c_U)}{(1-\frac{a}{e_{Pi}})+(1-a)(\frac{k_i}{\varepsilon_i}+\frac{s_i}{\varepsilon_{iU}})} \qquad (4\text{-}57)$$

$$\text{(M)}\ p_{Pi} = \frac{(c_{Pi} - k_iB_{Wi}c_{Wi} - s_iB_U c_U)}{(1-\frac{1}{e_{Pi}})} \qquad (4\text{-}58)$$

$$\text{(Q)}\ p_{Pi} = \frac{[c_{Pi} - k_iB_{Wi}c_{Wi} - s_iB_U c_U - d(1-k_iB_{Wi} - s_iB_U)]}{(1-\frac{1}{e_{Pi}})} \qquad (4\text{-}59)$$

$$\text{(QG)}\ p_{Pi} = \frac{[c_{Pi} - k_iB_{Wi}c_{Wi} - s_iB_U c_U - v(1-k_iB_{Wi} - s_iB_U)+\frac{I}{SA}]}{(1-\frac{1}{e_{Pi}})} \qquad (4\text{-}60)$$

$$\text{(AAR)}\ p_{Pi} = \frac{(c_{Pi} - k_iB_{Wi}c_{Wi} - s_iB_U c_U - \lambda\overline{p})}{(1-\frac{1}{e_{Pi}})(1-\lambda)} \qquad (4\text{-}61)$$

Each runway charge under (R), (M), (Q), (QG) and (AAR) (after rearranging each first order condition of the constrained maximisation problems) is exactly the same as (4-42) - (4-46).

The results are shown below.

(4) Between service regulated and included in the denominator and unregulated service

(R4) peak (off-peak) passenger charge to commercial 'price' under Ramsey rule:

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{a}{e_U})}{(1-\frac{a}{e_{P1}})\{1+(1-a)(1+\beta_{P1})(\frac{k_1}{\varepsilon_1}+\frac{s_1}{\varepsilon_{1U}})}\left\{\frac{c_{P1}}{c_U} - \frac{k_1\beta_{W1}c_{W1}}{c_U} - s_1\beta_U\right\}$$

(M4): peak (off-peak) passenger charge to commercial 'price' under unconstrained monopolist's pricing

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\{\frac{c_{P1}}{c_U} - \frac{k_1B_{W1}c_{W1}}{c_U} - s_1B_U\}$$

(Q4): peak (off-peak) passenger charge to commercial 'price' under output maximisation

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\frac{[c_{P1}-d-k_1B_{W1}(c_{W1}-d)-s_1B_U(c_U-d)]}{[c_U-\frac{1}{\lambda}]}$$

(QG4): peak (off-peak) passenger charge to commercial 'price' under output maximisation with passenger growth

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\frac{[c_{P1}-v-k_1B_{W1}(c_{W1}-v)-s_1B_U(c_U-v)+\frac{I}{5A}]}{[c_U-v]}$$

(AAR4): peak (off-peak) passenger charge to commercial 'price' under Airport Average Revenue constraint

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\lambda)(1-\frac{1}{e_{P1}})}\{\frac{c_{P1}}{c_U} - \frac{k_1B_{W1}c_{W1}}{c_U} - s_1B_U - \frac{\lambda\overline{p}}{c_U}\}$$

(5) Between service regulated but not included in the denominator and unregulated service

(R5) peak (off-peak) runway charge to commercial 'price' under Ramsey rule:

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{a}{e_U})}{(1-\frac{a}{e_{W1}})}\frac{c_{W1}}{c_U}$$

(M5): peak (off-peak) runway charge to commercial 'price' under unconstrained monopolist's pricing

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_U}$$

(Q5): peak (off-peak) runway charge to commercial 'price' under output maximisation

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})}\frac{[c_{W1}-\frac{1}{\lambda}]}{[c_U-\frac{1}{\lambda}]}$$

(QG5): peak (off-peak) runway charge to commercial 'price' under output maximisation with passenger growth

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})}\frac{[c_{W1}-\frac{1}{\lambda}]}{[c_U-\frac{1}{\lambda}]}$$

(AAR5): peak (off-peak) runway charge to commercial 'price' under Airport Average Revenue constraint

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\lambda)(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_U}$$

Regarding comparison (4), the relationship between (R4) and (M4) is inconclusive. The value inside the large bracket of (R4) is larger than the value inside the large bracket of (M4) though the first fraction of (R4) is smaller than the first fraction of (M4). Thus (R4) is not useful for the purpose of a reference benchmark, and I use (M4) as a main benchmark to compare (Q4), (QG4) and (AAR4).

In order to compare the price ratios for (4) among (M4), (Q4), (QG4) and (AAR4) in a less complicated way, and to avoid any confusion, I use an alternative set of price ratios in which the demand that is interdependent on passenger charge is only the commercial output demand. The above equation of each price ratio under (4) shows the results of the maximisation problems using the following demand specification as I have defined at the beginning of this section:

- $q_{P1} = q_{P1}(p_{P1})$
- $q_{P2} = q_{P2}(p_{P2})$
- $q_{W1} = q_{W1}\{p_{W1}, q_{P1}(p_{P1})\}$
- $q_{W2} = q_{W2}\{p_{W2}, q_{P2}(p_{P2})\}$
- $q_U = q_U\{p_U, q_{P1}(p_{P1}), q_{P2}(p_{P2})\}$

However, instead I use here the following simplified demand specification:

- $q_{P1} = q_{P1}(p_{P1})$
- $q_{P2} = q_{P2}(p_{P2})$
- $q_{W1} = q_{W1}(p_{W1})$
- $q_{W2} = q_{W2}(p_{W2})$
- $q_U = q_U\{p_U, q_{P1}(p_{P1}), q_{P2}(p_{P2})\}$

Then the result of each price ratio under comparison category (4) can be expressed as follows:

(4)' : Between service regulated and included in the denominator and unregulated service (simplified version)

(R4)' peak (off-peak) passenger charge to commercial 'price' under Ramsey rule:

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{a}{e_U})}{(1-\frac{a}{e_{P1}})+(1-a)\frac{s_1}{\varepsilon_{1U}}}\{\frac{c_{P1}-s_1\beta_U c_U}{c_U}\}$$

(M4)': peak (off-peak) passenger charge to commercial 'price' under unconstrained monopolist's pricing

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\{\frac{c_{P1}-s_1 B_U c_U}{c_U}\}$$

(Q4)': peak (off-peak) passenger charge to commercial 'price' under output maximisation

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\frac{[c_{P1}-d-s_1 B_U(c_U-d)]}{[c_U-d]}$$

(QG4)': peak (off-peak) passenger charge to commercial 'price' under output maximisation with passenger growth

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\frac{[c_{P1}-v-s_1 B_U(c_U-v)+\frac{I}{SA}]}{[c_U-v]}$$

(AAR4)': peak (off-peak) passenger charge to commercial 'price' under Airport Average Revenue constraint

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\lambda)(1-\frac{1}{e_{P1}})}\{\frac{c_{P1}-s_1 B_U c_U-\lambda\overline{p}}{c_U}\}$$

In order to make the comparisons less complex, I denote $\tilde{c}_{P1}$ as expressing $c_{P1} - s_1 B_U c_U$. However, unlike in the case where we can deduce a relationship that $1 - k_i B_{Wi} < 0$ which is related to the cross-effect as to runway demand, one cannot assume if $1 - s_i B_U < 0$ or not, because in order to deduce any definite size range of the term $s_i B_U$ one would need an assumption as to the relationship between the size of c_{P1} and c_U. I avoid making any assumption regarding the relationship between the size of c_{P1} and c_U as the 'price' of the unregulated commercial output varies depending on the type of the output.

The relationships between (a) (Q4)' and (M4)', (b) (QG4)' and (M4)', (c) (Q4)' and (QG4)', (d) (Q4)' and (AAR4)', (e) (AAR4)' and (M4)' and (f) (AAR4)' and (M4)' depend on each comparison's condition(s). The possible orders of the price ratios between (a), (b), (c), (d), (e) and (f) above are as follows.

(a)-1 if $\frac{\tilde{c}_{P1}}{c_U} > 1 - s_1 B_U$: (Q4)'>(M4)'

(a)-2 if $\frac{\tilde{c}_{P1}}{c_U} \leq 1 - s_1 B_U$: (Q4)'≤(M4)'

(b)-1 $\frac{\tilde{c}_{P1}}{c_U} > 1 - s_1 B_U - \frac{I}{5vA}$: (QG4)'>(M4)'

(b)-2 if $\frac{\tilde{c}_{P1}}{c_U} \leq 1 - s_1 B_U - \frac{I}{5vA}$: (QG4)'≤(M4)'

(c)-1 if $\frac{\tilde{c}_{P1}-d(1-s_1B_U)}{c_U-d} < 1 - s_1 B_U + \frac{I}{5(d-v)A}$: (QG4)'>(Q4)'

(c)-2 if $\frac{\tilde{c}_{P1}-d(1-s_1B_U)}{c_U-d} \geq 1 - s_1 B_U + \frac{I}{5(d-v)A}$: (QG4)'≤(Q4)'

(d)-1-1 if $d(1 - s_1 B_U) > \lambda \overline{p}$ and $\lambda c_U - d > 0$: (AAR4)'>(Q4)'

(d)-1-2 if $d(1 - s_1 B_U) > \lambda \overline{p}$ and $\lambda c_U - d \leq 0$, and

case(I): if $\frac{\tilde{c}_{P1}-d(1-s_1B_U)}{c_U-d} > \frac{\lambda\overline{p}-d(1-s_1B_U)}{\lambda c_U-d}$: (AAR4)'<(Q4)'

case (II): if $\frac{\tilde{c}_{P1}-d(1-s_1B_U)}{c_U-d} \leq \frac{\lambda\overline{p}-d(1-s_1B_U)}{\lambda c_U-d}$: (AAR4)'≥(Q4)'

(d)-2-1 if $d(1 - s_1 B_U) \leq \lambda \overline{p}$ and $\lambda c_U - d > 0$, and

case (I): if $\frac{\tilde{c}_{P1}-d(1-s_1B_U)}{c_U-d} > \frac{\lambda\overline{p}-d(1-s_1B_U)}{\lambda c_U-d}$: (AAR4)'>(Q4)'

case (II): if $\frac{\tilde{c}_{P1}-d(1-s_1B_U)}{c_U-d} \leq \frac{\lambda\overline{p}-d(1-s_1B_U)}{\lambda c_U-d}$: (AAR4)'≤(Q4)'

(d)-2-2 if $d(1 - s_1 B_U) \leq \lambda \overline{p}$ and $\lambda c_U - d \leq 0$: (AAR4)'<(Q4)'

(e)-1-1 if $v(1 - s_1 B_U) + \frac{I}{5A} > \lambda \overline{p}$ and $\lambda c_U - v > 0$: (AAR4)'>(QG4)'

(e)-1-2 if $v(1 - s_1 B_U) + \frac{I}{5A} > \lambda \overline{p}$ and $\lambda c_U - v \leq 0$, and

case(I): if $\frac{\tilde{c}_{P1}-v(1-s_1B_U)+\frac{I}{5A}}{c_U-v} > \frac{\lambda\overline{p}-v(1-s_1B_U)+\frac{I}{5A}}{\lambda c_U-v}$: (AAR4)'<(QG4)'

case (II): if $\frac{\tilde{c}_{P1}-v(1-s_1B_U)+\frac{I}{5A}}{c_U-v} \leq \frac{\lambda\overline{p}-v(1-s_1B_U)+\frac{I}{5A}}{\lambda c_U-v}$: (AAR4)'≥(QG4)'

(e)-2-1 if $v(1 - s_1 B_U) + \frac{I}{5A} \leq \lambda \overline{p}$ and $\lambda c_U - v > 0$, and case (I): if $\frac{\widetilde{c}_{P1}-v(1-s_1B_U)+\frac{I}{5A}}{c_U-v} > \frac{\lambda\overline{p}-v(1-s_1B_U)+\frac{I}{5A}}{\lambda c_U-v}$: (AAR4)'>(QG4)'

case (II): if $\frac{\widetilde{c}_{P1}-v(1-s_1B_U)+\frac{I}{5A}}{c_U-v} \leq \frac{\lambda\overline{p}-v(1-s_1B_U)+\frac{I}{5A}}{\lambda c_U-v}$: (AAR4)'≤(QG4)'

(e)-2-2 if $v(1-s_1B_U)+\frac{I}{5A} \leq \lambda\overline{p}$ and $\lambda c_U - v \leq 0$: (AAR4)'≤(QG4)'

(f)-1 if $\frac{\widetilde{c}_{P1}}{c_U} > \frac{\lambda\overline{p}}{c_U}$: (AAR4)'>(M4)'

(f)-2 if $\frac{\widetilde{c}_{P1}}{c_U} \leq \frac{\lambda\overline{p}}{c_U}$: (AAR4)'≤(M4)'

In terms of (f), the case (f)-2 is an impossible situation as $\widetilde{c}_{P1}$ is larger than $\lambda\overline{p}$, and it is proved that (AAR4)'>(M4)' always holds. However, the comparisons (a) and (b) involve the comparison between $\widetilde{c}_{P1}$ and c_U, therefore unless one can identify a particular unregulated commercial service, the relationships are inconclusive. The comparison (c) involves the degree of each constraint of (Q) and (QG). If the constraint of (QG) becomes tighter, as the distance between d and v becomes larger, one can justify that the case (c)-2 is more likely to be expected, which means that the price ratio under (QG4)' is lower than that under (Q4)'. The comparisons (e) and (f) are both inconclusive. as the tightness of the constraint of (AAR) can make (AAR4)' either smaller than (QG4)' (or (Q4)') or larger than (QG4)' (or (Q4)').

As to the comparison category (5), i.e., the price ratio of runway charge to the unregulated commercial 'price', it is clearly shown that the outcome is not affected by the introduction of demand interdependency. Thus the conclusion of the results in comparing the price ratios (5) is exactly the same as I have explained in the section 4-5 of Chapter 4.

Appendix (3) Lagrangean forms with regard to (M), (R), (Q), (QG) and (AAR)

Below I show the related Lagrangean form for each category of constraint that I have used in Appendix (1). The forms are all relevant to the simple models I have used in section 4-4 and 4-5. However, in terms of the calculations in section 4-4 and 4-5, the demands are all independent. Therefore the only difference between the forms used in section 4-4 and 4-5 and the forms used in Appendix (1) is the specification of q_{Wi}. In section 4-4 and 4-5 q_{Wi} is $q_{wi}(p_{Wi})$ rather than $q_{Wi}(p_{Wi}, p_{Pi})$.

(M): Unconstrained monopolist's pricing

The firm maximises Π under no constraints:

$$\begin{aligned}\Pi &= p_{P1}q_{P1}(p_{P1}) + p_{P2}q_{P2}(p_{P2}) \\ &+p_{W1}q_{W1}(p_{W1}, p_{P1}) + p_{W2}q_{W2}(p_{W2}, p_{P2}) + p_U q_U(p_U) \\ &-c_{P1}q_{P1}(p_{P1}) - c_{P2}q_{P2}(p_{P2}) \\ &-c_{W1}q_{W1}(p_{W1}, p_{P1}) - c_{W2}q_{W2}(p_{W2}, p_{P2}) - c_U q_U(p_U) - F\end{aligned}$$

(R): Ramsey pricing rule

The Lagrangean function $\mathcal{L}_{(R)}$ to be optimised is as follows:

$$\begin{aligned}\mathcal{L}_{(R)} &= \int_{p_{P1}}^{p_{P1}^0} q_{P1}(p_{P1})dp_{P1} + \int_{p_{P2}}^{p_{P2}^0} q_{P2}(p_{P2})dp_{P2} \\ &+ \int_{p_{W1}}^{p_{W1}^0} q_{W1}(p_{W1}, p_{P1})dp_{W1} + \int_{p_{W2}}^{p_{W2}^0} q_{W2}(p_{W2}, p_{P2})dp_{W2} \\ &+ \int_{p_{P1}}^{p_{P1}^0} q_{W1}(p_{W1}, p_{P1})dp_{P1} + \int_{p_{P2}}^{p_{P2}^0} q_{W2}(p_{W2}, p_{P2})dp_{P2}\end{aligned}$$

$$+\int_{p_U}^{p_U^0} q_U(p_U)dp_U$$

$$+p_{P1}q_{P1}(p_{P1}) + p_{P2}q_{P2}(p_{P2})$$

$$+p_{W1}q_{W1}(p_{W1},p_{P1}) + p_{W2}q_{W2}(p_{W2},p_{P2}) + p_Uq_U(p_U)$$

$$-c_{P1}q_{P1}(p_{P1}) - c_{P2}q_{P2}(p_{P2})$$

$$-c_{W1}q_{W1}(p_{W1},p_{P1}) - c_{W2}q_{W2}(p_{W2},p_{P2}) - c_Uq_U(p_U) - F$$

$$+\mu[p_{P1}q_{P1}(p_{P1}) + p_{P2}q_{P2}(p_{P2})$$

$$+p_{W1}q_{W1}(p_{W1},p_{P1}) + p_{W2}q_{W2}(p_{W2},p_{P2}) + p_Uq_U(p_U)$$

$$-c_{P1}q_{P1}(p_{P1}) - c_{P2}q_{P2}(p_{P2})$$

$$-c_{W1}q_{W1}(p_{W1},p_{P1}) - c_{W2}q_{W2}(p_{W2},p_{P2}) - c_Uq_U(p_U) - F - z]$$

(Q): Output maximisation

The Lagrangean function $\mathcal{L}_{(Q)}$ to be optimised is as follows:

$$\mathcal{L}_{(Q)} = q_{P1}(p_{P1}) + q_{P2}(p_{P2})$$

$$+q_{W1}(p_{W1},p_{P1}) + q_{W2}(p_{W2},p_{P2}) + q_U(p_U)$$

$$+\lambda_Q[p_{P1}q_{P1}(p_{P1}) + p_{P2}q_{P2}(p_{P2})$$

$$+p_{W1}q_{W1}(p_{W1},p_{P1}) + p_{W2}q_{W2}(p_{W2},p_{P2}) + p_Uq_U(p_U)$$

$$-c_{P1}q_{P1}(p_{P1}) - c_{P2}q_{P2}(p_{P2})$$

$$-c_{W1}q_{W1}(p_{W1},p_{P1}) - c_{W2}q_{W2}(p_{W2},p_{P2}) - c_Uq_U(p_U)$$

$$-F - \theta(I) \cdot I]$$

(QG): Output maximisation with passenger growth

The Lagrangean function $\mathcal{L}_{(QG)}$ to be optimised is as follows:

$$\mathcal{L}_{(QG)} = q_{P1}(p_{P1}) + q_{P2}(p_{P2})$$

$$+q_{W1}(p_{W1},p_{P1}) + q_{W2}(p_{W2},p_{P2}) + q_U(p_U)$$

$$+\lambda_{QG}[p_{P1}q_{P1}(p_{P1}) + p_{P2}q_{P2}(p_{P2})$$

$$+p_{W1}q_{W1}(p_{W1},p_{P1})+p_{W2}q_{W2}(p_{W2},p_{P2})+p_Uq_U(p_U)$$
$$-c_{P1}q_{P1}(p_{P1})-c_{P2}q_{P2}(p_{P2})$$
$$-c_{W1}q_{W1}(p_{W1},p_{P1})-c_{W2}q_{W2}(p_{W2},p_{P2})-c_Uq_U(p_U)$$
$$-F-\theta^{t-1}(I)\cdot I$$
$$-\frac{I}{5(q_{P1}^{t-1}+q_{P2}^{t-1})}\{q_{P1}(p_{P1})+q_{P2}(p_{P2})-(q_{P1}^{t-1}+q_{P2}^{t-1})\}]$$

(AAR): Airport Average Revenue constraint

The Lagrangean function $\mathcal{L}_{(AAR)}$ to be optimised is as follows:

$$\mathcal{L}_{(AAR)}=p_{P1}q_{P1}(p_{P1})+p_{P2}q_{P2}(p_{P2})$$
$$+p_{W1}q_{W1}(p_{W1},p_{P1})+p_{W2}q_{W2}(p_{W2},p_{P2})+p_Uq_U(p_U)$$
$$-c_{P1}q_{P1}(p_{P1})-c_{P2}q_{P2}(p_{P2})$$
$$-c_{W1}q_{W1}(p_{W1},p_{P1})-c_{W2}q_{W2}(p_{W2},p_{P2})-c_Uq_U(p_U)-F$$
$$+\lambda[\overline{p}\{q_{P1}(p_{P1})+q_{P2}(p_{P2})\}$$
$$-p_{P1}q_{P1}(p_{P1})-p_{P2}q_{P2}(p_{P2})$$
$$-p_{W1}q_{W1}(p_{W1},p_{P1})-p_{W2}q_{W2}(p_{W2},p_{P2})]$$

Appendix (4) Revenue maximisation (an alternative to the output maximisation model)

In Appendix (1) and Appendix (2) where I compared the price ratios under different constraints using demand interdependency, I used output maximisation as the objective of the then nationalised British Airports Authority. However, it is also possible to look upon the objective of this organisation as revenue maximisation. In this appendix I show the predicted outcomes of each price ratio considered in Appendix (1) and Appendix (2). I use the following terms for the constraints:

(RV): Revenue maximisation

(RG): Revenue maximisation with passenger growth

They correspond to (Q) and (QG) in section 4-5, Appendix (1) and Appendix (2), i.e., instead of (Q) and (QG) we could say that the then nationalised British Airports Authority's constraints were (RV) and (RG) of which (RG) was applied to the period between 1983/84 and 1986/87.

(RV): the firm maximises total revenue TR

$$\text{s.t. } TR - TC \geq \theta \cdot I$$

where $TR = \sum_i p_{Pi} q_{Pi}(p_{Pi}) + \sum_i p_{Wi} q_{Wi}(p_{Wi}, p_{Pi}) + p_U q_U$

and the constraint is

$$\sum_i p_{Pi} q_{Pi}(p_{Pi}) + \sum_i p_{Wi} q_{Wi}(p_{Wi}, p_{Pi}) + p_U q_U$$
$$- \sum_i c_{Pi} q_{Pi}(p_{Pi}) - \sum_i c_{Wi} q_{Wi}(p_{Wi}, p_{Pi}) - c_U q_U(p_U) - F \geq \theta \cdot I$$

(same as (4-34))

(RG): the firm maximises total revenue TR

$$\text{s.t. } TR^t - TC^t \geq \left[\theta^{t-1} + \frac{1}{5} \times \frac{q_P^t - q_P^{t-1}}{q_P^{t-1}}\right] \cdot I^t$$

where the constraint is

$$\sum_i p_{Pi} q_{Pi}(p_{Pi}) + \sum_i p_{Wi} q_{Wi}(p_{Wi}, p_{Pi}) + p_U q_U - \sum_i c_{Pi} q_{Pi}(p_{Pi})$$

$$-\sum_i c_{Wi} q_{Wi}(p_{Wi}, p_{Pi}) - c_U q_U(p_U) - F \geq \theta^{t-1} I^t + \frac{I^t}{5} \times \frac{(q_{P1}^t + q_{P2}^t) - (q_{P1}^{t-1} + q_{P2}^{t-1})}{q_{P1}^{t-1} + q_{P2}^{t-1}}$$

(same as (4-35))

The results are as follows:

(RV1): peak passenger charge to off-peak passenger charge under revenue maximisation

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})} \frac{[c_{P1} - k_1 B_{W1} c_{W1}]}{[c_{P2} - k_2 B_{W2} c_{W2}]}$$

(RG1): peak passenger charge to off-peak passenger charge under revenue maximisation with passenger growth

$$\frac{p_{P1}}{p_{P2}} = \frac{(1-\frac{1}{e_{P2}})}{(1-\frac{1}{e_{P1}})} \frac{[c_{P1} - k_1 B_{W1} c_{W1} + \frac{I}{5A}]}{[c_{P2} - k_2 B_{W2} c_{W2} + \frac{I}{5A}]}$$

(RV2): peak (off-peak) passenger charge to peak (off-peak) runway charge under revenue maximisation

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})} [\frac{c_{P1}}{c_{w1}} - k_1 B_{W1}]$$

(RG2): peak (off-peak) passenger charge to peak (off-peak) runway charge under revenue maximisation with passenger growth

$$\frac{p_{P1}}{p_{W1}} = \frac{(1-\frac{1}{e_{W1}})}{(1-\frac{1}{e_{P1}})} [\frac{c_{P1}}{c_{w1}} - k_1 B_{W1} + \frac{I}{5Ac_{W1}}]$$

(RV3): peak runway charge to off-peak runway charge under revenue maximisation

$$\frac{p_{W1}}{p_{w2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})} \frac{c_{W1}}{c_{W2}}$$

(RG3): peak runway charge to off-peak runway charge under revenue maximisation with passenger growth

$$\frac{p_{W1}}{p_{w2}} = \frac{(1-\frac{1}{e_{W2}})}{(1-\frac{1}{e_{W1}})} \frac{c_{W1}}{c_{W2}}$$

(RV4): peak (off-peak) passenger charge to commercial 'price' under revenue maximisation

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\left\{\frac{c_{P1}}{c_U} - \frac{k_1 B_{W1} c_{W1}}{c_U} - s_1 B_U\right\}$$

(RG4): peak (off-peak) passenger charge to commercial 'price' under revenue maximisation with passenger growth

$$\frac{p_{P1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{P1}})}\left\{\frac{c_{P1}}{c_U} - \frac{k_1 B_{W1} c_{W1}}{c_U} - s_1 B_U + \frac{I}{5Ac_U}\right\}$$

(RV5): peak (off-peak) runway charge to commercial 'price' under revenue maximisation

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_U}$$

(RG5): peak (off-peak) runway charge to commercial 'price' under revenue maximisation with passenger growth

$$\frac{p_{W1}}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_{W1}})}\frac{c_{W1}}{c_U}$$

It is interesting that the results of the price ratio under (RV) are always the same as the ratio under an unconstrained monopolist setting in any category of comparison. However, each price level is lower than the equivalent price under an unconstrained monopolist's level (as the term $\frac{\lambda_{RV}}{1+\lambda_{RV}}$ contained in each price $p_i (= \frac{\lambda_{RV}}{(1+\lambda_{RV})}\frac{c_i}{(1-\frac{1}{e_i})})$ is cancelled out when expressed as price ratios; where λ_{RV} denotes the Lagrange multiplier to the (RV)'s constraint and $0 < \lambda_{RV} < 1$.)

Appendix (5) International and Domestic Charge Differences

It is possible to compare the price ratios between the international passenger charge and the domestic passenger charge. Although it is normal that an airport does not set different charges for international flights' landings/parkings and domestic flights' landings/parkings, the charges imposed on international passengers are often different from the charges imposed on domestic passengers. This is due to the apparent cost difference in the terminal area's service between the two categories of passengers. For instance, passengers for international flights are required to get through customs and sometimes immigration, which imposes additional costs on the airport operator.

In this section I compare the following price ratios under different constraints which I have already considered in section 4-5 (and 4-6) in this chapter, i.e., (R), (M), (Q), (QG) and (AAR):

(A) price ratio of international passenger charge to domestic passenger charge

(B) price ratio of international passenger charge to runway charge

(C) price ratio of international passenger charge to unregulated commercial 'price'

In terms of (B) and (C) above, I use international passenger charge for convenience. The results are interchangeable; the subscript I in the expressions below can be changed into D in order to see the ratio of domestic passenger charge to runway charge and the ratio of domestic passenger charge to unregulated commercial 'price'.

The notations I use are as follows:

q_I: international passenger numbers

q_D: domestic passenger numbers

q_W: runway output numbers

c_I: marginal cost related to each international passenger

c_D: marginal cost related to each domestic passenger

c_W: marginal cost incurred by the landing, taking-off and aircraft parking of each aircraft

c_U: unit cost of commercial activity (same convention I used in section 4-3 to 4-6)

Specifications for the demand functions used here are as follows:

$$q_I = q_I(p_I)$$
$$q_D = q_D(p_D)$$
$$q_W = q_W(p_W, p_I, p_D)$$
$$q_U = q_U(p_U)$$

When the comparison categories (A) and (B) are examined, for simplicity and because of the focus of the analysis, the demand of the unregulated commercial service q_U is not dependent on p_I and p_D and is the function of p_U only (which is the same convention I used in section 4-5), because this simplification doesn't affect the result. However, where the comparison category (C) is examined, I use the following specification instead in order to avoid complexity, which follows the same convention I introduced in category (4)' in section 4-6:

$$q_I = q_I(p_I)$$
$$q_D = q_D(p_D)$$
$$q_W = q_W(p_W)$$
$$q_U = q_U(p_U, p_I, p_D)$$

I use this specification in order to focus on the price ratio of international passenger charge to the unregulated commercial service.

The notations to show the results are as follows:

λ_Q: Lagrange multiplier for the constraint applied to (Q) (same as before)

λ_{QG}: Lagrange multiplier for the constraint applied to (QG) (same as before)

λ: Lagrange multiplier for the price constraint applied to (AAR) (same as before)

μ: Lagrange multiplier for Ramsey rule constraint (same as before)

$a = \frac{\mu}{1+\mu}$ (same as before)

$d = \frac{1}{\lambda_Q}$ $(d > 1)$ (same as before)

$v = \frac{1}{\lambda_{QG}}$ $(v > 1)$ (same as before)

e_j: own price elasticity of service j $(j = I, D, W, U)$ in the absolute term $(= -\frac{\partial q_j}{\partial p_j}\frac{p_j}{q_j})$

ε_I: cross-elasticity of price p_I in relation to q_W, i.e., $\varepsilon_I = -\frac{\partial q_W}{\partial p_I}\frac{p_I}{q_W}$ (also expressed as the absolute term)

ε_D: cross-elasticity of price p_D in relation to q_W, i.e., $\varepsilon_D = -\frac{\partial q_W}{\partial p_D}\frac{p_D}{q_W}$ (also expressed as the absolute term)

ε_{IU}: cross-elasticity of price p_I in relation to q_U, i.e., $\varepsilon_{IU} = -\frac{\partial q_U}{\partial p_I}\frac{p_I}{q_U}$ (also expressed as the absolute term)

ε_{DU}: cross-elasticity of price p_D in relation to q_U, i.e., $\varepsilon_{DU} = -\frac{\partial q_U}{\partial p_D}\frac{p_D}{q_U}$ (also expressed as the absolute term)

$B_j = \frac{\frac{1}{e_j}}{1-\frac{1}{e_j}}$ $(B_j > 1)$

$\beta_j = \frac{\frac{a}{e_j}}{1-\frac{a}{e_j}}$ $(\beta_j > 1)$

$k_I = \frac{\partial q_W}{\partial q_I}$

$k_D = \frac{\partial q_W}{\partial q_D}$

$s_I = \frac{\partial q_U}{\partial q_I}$

$s_D = \frac{\partial q_U}{\partial q_D}$

$A = q_I^{t-1} + q_D^{t-1}$ $(= q_{P1}^{t-1} + q_{P2}^{t-1})$ (this denotes the total passenger numbers in the previous year)

I: capital input in period t

I use several assumptions as to some of the notations above:

$k_I > 0$: the increase in international passenger numbers would not reduce the runway output.

$k_D > 0$: the increase in domestic passenger numbers would not reduce the runway output.

$k_I \fallingdotseq k_D$: unlike k_1 and k_2, $\frac{\partial q_W}{\partial q_I}$ and $\frac{\partial q_W}{\partial q_D}$ do not have a time related factor and I assume these proportions are more likely to be relevant to aircraft manufacturing technology, whereas an ordinary airport is concerned with a mixture of both international and domestic flights. It seems reasonable to assume that k_I is roughly the same as k_D, unless a special airport, such as one specialising in domestic flights or cargo flights is in question.

$e_I < e_D$: elasticity of international passenger charge is smaller than that of domestic passenger charge. The passengers using domestic flights have many more competitive transport modes available than in the case of the international passengers who have less variety of transport modes to select.

Because of this assumption, also $B_I > B_D, \beta_I > \beta_D$ can be assumed.

$e_I > e_W$ and $e_D > e_W$: elasticity of runway charge is smaller than that of passenger charge in both international and domestic flights.

$e_I < e_U$ and $e_D < e_U$: elasticity of passenger charge (for both international and domestic) is smaller than that of commercial service 'price'.

$e_W < e_U$: elasticity of runway charge is smaller than that of commercial service 'price'

$s_I > s_D$: the degree of the increase (decrease) of unregulated commercial service output due to the increase (decrease) of international passenger numbers is larger than the equivalent degree due to the increase (decrease) of domestic passenger numbers, because of the existence of some unregulated services only available to international passengers such as duty/tax-free shops. International passengers on average also spend longer inside a terminal than domestic passengers, because international passengers use the airport for changing planes more often than domestic passengers.

$c_I > c_D$: the marginal cost related to each international passenger is larger than the marginal cost related to each domestic passenger. According to MMC2, BAA's internal cost calculation report published in 1983 (that I mentioned in the context of cost assumption in section 4-4) estimated the terminal cost related to the international flight per passenger to be at least double the cost related to the domestic flight per passenger.

$c_W > c_I$ and $c_W > c_D$: the marginal cost (short-run) of landing, taking-off or aircraft parking incurred by each aircraft is larger than the marginal cost related to each passenger (in both international and domestic).

Under each set of objective function and constraint from (R) to (AAR) that I described in section 4-5, I have arranged the first order conditions and made summaries of the price ratios.

(A) International passenger charge vs domestic passenger charge (similar to the result of (1) between regulated services both inside the constraint's denominator)

(R(A)) international passenger charge to domestic passenger charge under Ramsey rule:

$$\frac{p_I}{p_D} = \frac{\left\{(1-\frac{a}{e_I})+\frac{k_D}{\varepsilon_D}(1-a)\right\}}{\left\{(1-\frac{a}{e_D})+\frac{k_I}{\varepsilon_I}(1-a)\right\}} \frac{[c_I-k_I\beta_W c_W]}{[c_D-k_D\beta_W c_W]}$$

(M(A)): international passenger charge to domestic passenger charge under unconstrained monopolist's pricing

$$\frac{p_I}{p_D} = \frac{(1-\frac{1}{e_D})}{(1-\frac{1}{e_I})} \frac{[c_I-k_I B_W c_W]}{[c_D-k_D B_W c_W]}$$

(Q(A)): international passenger charge to domestic passenger charge under output maximisation

$$\frac{p_I}{p_D} = \frac{(1-\frac{1}{e_D})}{(1-\frac{1}{e_I})}\frac{[c_I-d-k_IB_W(c_W-d)]}{[c_D-d-k_DB_W(c_W-d)]}$$

(QG(A)): international passenger charge to domestic passenger charge under output maximisation with passenger growth

$$\frac{p_I}{p_D} = \frac{(1-\frac{1}{e_D})}{(1-\frac{1}{e_I})}\frac{[c_I-v-k_IB_W(c_W-v)+\frac{I}{5A}]}{[c_D-v-k_DB_W(c_W-v)+\frac{I}{5A}]}$$

(AAR(A)): international passenger charge to domestic passenger charge under Airport Average Revenue constraint

$$\frac{p_I}{p_D} = \frac{(1-\frac{1}{e_D})}{(1-\frac{1}{e_I})}\frac{[c_I-k_IB_Wc_W-\lambda\overline{p}]}{[c_D-k_DB_Wc_W-\lambda\overline{p}]}$$

(B) International passenger charge vs runway charge (similar to the result of (2) between regulated services, one included in the constraint's denominator, the other not in the denominator)

(R(B)) international (domestic) passenger charge to runway charge under Ramsey rule:

$$\frac{p_I}{p_W} = \frac{(1-\frac{a}{e_W})}{(1-\frac{\varsigma}{e_I})}\left[\frac{c_I}{c_W} - \frac{(1-\frac{1}{e_W})}{(1-\frac{a}{e_W})} \cdot k_I B_W\right] \quad \text{(where } \varsigma = a - (1-a)\frac{q_W}{q_I}\text{)}$$

(M(B)): international (domestic) passenger charge to runway charge under unconstrained monopolist's pricing

$$\frac{p_I}{p_W} = \frac{(1-\frac{1}{e_W})}{(1-\frac{1}{e_I})}\left[\frac{c_I}{c_W} - k_I B_W\right]$$

(Q(B)): international (domestic) passenger charge to runway charge under output maximisation

$$\frac{p_I}{p_W} = \frac{(1-\frac{1}{e_W})}{(1-\frac{1}{e_I})}\frac{[c_I-d-k_IB_W(c_W-d)]}{[c_w-d]}$$

(QG(B)): international (domestic) passenger charge to runway charge under output maximisation with passenger growth

$$\frac{p_I}{p_W} = \frac{(1-\frac{1}{e_W})}{(1-\frac{1}{e_I})}\frac{[c_I-v-k_IB_W(c_W-v)+\frac{I}{5A}]}{[c_w-v]}$$

(AAR(B)): international (domestic) passenger charge to runway charge under Airport Average Revenue constraint

$$\frac{p_I}{p_W} = \frac{(1-\frac{1}{e_W})}{(1-\frac{1}{e_I})}\left[\frac{c_I}{c_W} - k_I B_W - \frac{\lambda \overline{p}}{c_W}\right]$$

(C) International passenger charge vs unregulated commercial 'price':(similar to the result of (4)' between service regulated and included in the denominator and unregulated service (simplified version))

(R(C)) international passenger charge to commercial 'price' under Ramsey rule:

$$\frac{p_I}{p_U} = \frac{(1-\frac{a}{e_U})}{(1-\frac{a}{e_I})+(1-a)\frac{s_I}{e_{IU}}}\left\{\frac{c_I - s_I\beta_U c_U}{c_U}\right\}$$

(M(C)): international passenger charge to commercial 'price' under unconstrained monopolist's pricing

$$\frac{p_I}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_I})}\left\{\frac{c_I - s_I B_U c_U}{c_U}\right\}$$

(Q(C)): international passenger charge to commercial 'price' under output maximisation

$$\frac{p_I}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_I})}\frac{[c_I - d - s_I B_U(c_U - d)]}{[c_U - d]}$$

(QG(C)): international passenger charge to commercial 'price' under output maximisation with passenger growth

$$\frac{p_I}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\frac{1}{e_I})}\frac{[c_I - v - s_I B_U(c_U - v) + \frac{I}{5A}]}{[c_U - v]}$$

(AAR(C)): international passenger charge to commercial 'price' under Airport Average Revenue constraint

$$\frac{p_I}{p_U} = \frac{(1-\frac{1}{e_U})}{(1-\lambda)(1-\frac{1}{e_I})}\left\{\frac{c_I - s_I B_U c_U - \lambda \overline{p}}{c_U}\right\}$$

As to (A), (R(A)) is not useful for reference purposes for the same reason explained in section 4-5 and I focus on the comparison among (M(A)), (Q(A)), (QG(A)) and (AAR(A)). Where one can use a strong assumption that $k_I = k_D$, it can always be held that (M(A))<(Q(A)) and (M(A))<(AAR(A)). Also where I eliminate a special case (as I mentioned in section 4-5) where the effect of the passenger numbers growth rate is so large that $\frac{I}{5A} > v(1 - k_I B_W)$ holds, it is always the case that (Q(A))<(QG(A)) and that none of (Q(A)), (QG(A)) or (AAR(A)) are lower than (M(A)). Whether

(QG(A)) is larger than (AAR(A)) depends on the effect of (AAR)'s price cap constraint, i.e., (a) if $\lambda\overline{p} > v(1 - k_I B_W) - \frac{I}{5A}$, then (AAR(A))>(QG(A)) holds, but (b) if $\lambda\overline{p} \leq v(1 - k_I B_W) - \frac{I}{5A}$, then (AAR(A))≤(QG(A)) holds. Being summarised, the order of the price ratios will be (Q(A))<(QG(A)), and (QG(A))≥(AAR(A)) where $\lambda\overline{p}$'s effect is not strong, whereas the order will be (Q(A))<(QG(A))<(AAR(A)) where $\lambda\overline{p}$'s effect is strong. In this latter case, if $\lambda\overline{p} \lesseqgtr d(1 - k_I B_W)$, then (Q(A))⋛(AAR(A)), depending on the relative strength of the constraints of (Q) and (AAR). Therefore where (AAR) constraint was effective, as under the then nationalised British Airports Authority, the price ratio may have been raised since 1983/84 and after privatisation the ratio may have dropped. However, where the effect of $\frac{I}{5A}$ is so high that both international passenger charges and domestic passenger charges are even higher than the level which an unconstrained monopolist would set, it would be the case (a) that the price ratio (QG(A)) is lower than (M(A)), (b) that (Q(A))>(QG(A)) holds and (c) that (QG(A))<(AAR(A)), whether (Q(A)) is larger than (AAR(A)) depending on the effect of (AAR) constraint, i.e., if $\lambda\overline{p} \lesseqgtr d(1 - k_I B_W)$, then (Q(A))⋛(AAR(A)).

Regarding (B), exactly the same analogy applies as in the comparison category (2). The relative price ratios are expected to be in the order of (Q(B))>(QG(B))>(AAR(B)) if all the constraints are binding.

The comparison (C) is also analogous to comparison (4)' and therefore the examination involves many conditions related to the comparison of each constraint's strength and is inconclusive.

Appendix (6) Summary of price mark-ups under different constraints

In section 4-5 of this chapter, I used price ratios in order to carry out comparisons of airport charge structures under different constraints (the unregulated commercial services are not an issue here). In this appendix I show the calculation results in the form of price mark-ups by the simple modelling used in section 4-5. In the summary table below the service types are expressed as $i = 1, 2$. i denotes airport charge which is either peak passenger charge, off-peak passenger charge, peak runway charge or off-peak runway charge (or as in Appendix (5) either international passenger charge or domestic passenger charge). Two simple cases in the table are shown so that the results can be comparable with the examination Waterson used (in section 4-2) in relation to the equation (4-3) as the predicted outcome under ordinary Average Revenue constraint.

Table 4-10 Summary of price mark-ups under different constraints

	m_i general rule	$\frac{m_1}{m_2}$ case 1: $e_1 < e_2, c_1 = c_2$	$\frac{m_1}{m_2}$ case 2: $e_1 = e_2, c_1 < c_2$
(R)	$\frac{p_i}{c_i} = \frac{1}{1-\frac{a}{e_i}}$ mark-up is proportional to the inverse elasticity, but a smaller mark-up than (M)	$\frac{m_1}{m_2} = \frac{(1-\frac{a}{e_2})}{(1-\frac{a}{e_1})}$ price mark-up for p_1 is higher than p_2, however, both mark-ups are smaller than (M)	$\frac{m_1}{m_2} = 1$
(M)	$\frac{p_i}{c_i} = \frac{1}{1-\frac{1}{e_i}}$ mark-up is proportional to the inverse elasticity	$\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})}{(1-\frac{1}{e_1})}$ price mark-up for p_1 is higher than p_2	$\frac{m_1}{m_2} = 1$
(Q)	$\frac{p_i}{c_i} = \frac{1}{1-\frac{1}{e_i}}(1 - \frac{d}{c_i})$	$\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})(1-\frac{d}{c_1})}{(1-\frac{1}{e_1})(1-\frac{d}{c_2})}$	$\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})(1-\frac{d}{c_1})}{(1-\frac{1}{e_1})(1-\frac{d}{c_2})}$ $> \frac{(1-\frac{1}{e_2})}{(1-\frac{1}{e_1})} = 1$: the ratio of the mark-ups is higher than what would be realised under (M)
(QG)	$\frac{p_i}{c_i} = \frac{1}{1-\frac{1}{e_i}}(1 - \frac{v}{c_i} + \frac{I}{5Ac_i})$ where i is passenger charge $\frac{p_i}{c_i} = \frac{1}{1-\frac{1}{e_i}}(1 - \frac{v}{c_i})$ where i is runway charge (service that is not directly related to passenger numbers)	(i) between passenger charges: $\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})(1-\frac{v}{c_1}+\frac{I}{5Ac_1})}{(1-\frac{1}{e_1})(1-\frac{v}{c_2}+\frac{I}{5Ac_2})}$ (ii) between runway charge p_1 and passenger charge p_2 $\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})(1-\frac{v}{c_2})}{(1-\frac{1}{e_1})(1-\frac{v}{c_1}+\frac{I}{5Ac_1})}$ higher than (M)	(i) if v $< \frac{I}{5A}$, $\frac{m_1}{m_2} > \frac{(1-\frac{1}{e_2})(1-\frac{v}{c_1})}{(1-\frac{1}{e_1})(1-\frac{v}{c_2})}$ the ratio is higher than (M) and (Q) (ii) the ratio is higher than under (M) and also higher than (Q)

Continued to the next page

Table 4-10 (continued)

	general rule	case 1: $e_1 < e_2, c_1 = c_2$	case 2: $e_1 = e_2, c_1 > c_2$
(AR)*	$\frac{p_i}{c_i}=\frac{1}{(1-\frac{1}{e_i})}[1 - b(\overline{m}_i-1)]$	as $\overline{m}_1 = \overline{m}_2$, $\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})}{(1-\frac{1}{e_1})}$ same as (M)	as $\overline{m}_1 < \overline{m}_2$, $m_1 > m_2$
(AAR)	(i) passenger charge: $\frac{p_i}{c_i}=\frac{1}{(1-\frac{1}{e_i})}[1 - b(\overline{m}_i-1)]$ (ii) runway charge: $\frac{p_i}{c_i} = \frac{1}{(1-\frac{1}{e_i})}(1 + b)$	(i) between passenger charges: as $\overline{m}_1 = \overline{m}_2$, $\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})}{(1-\frac{1}{e_1})}$ same as (M) (ii) runway charge p_1 and passenger charge p_2: $\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})}{(1-\frac{1}{e_1})}\frac{1+b}{[1-b(\overline{m}_1-1)]}$ the ratio is higher by $b\overline{m}_1$ than the mark-up ratio under(M)	(i) among the services whose quantities enter in the (AAR)'s denominator, the service facing higher cost will have a higher mark-up than the service that is produced with lower cost (same as (AR)*) (ii) regardless of the cost difference, $\frac{m_1}{m_2} > 1$, because $\frac{m_1}{m_2} = \frac{1+b}{1+b-b\frac{p}{c_1}}$
(RV)	$\frac{p_i}{c_i} = \frac{\varphi}{1-\frac{1}{e_i}}$ where $\varphi = \frac{\lambda_{RV}}{1+\lambda_{RV}}$	as $\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})}{(1-\frac{1}{e_1})}$ same as in (M)	same as in (M)
(RG)	$\frac{p_i}{c_i} = \frac{\varphi}{1-\frac{1}{e_i}}(1 + \frac{I}{5Ac_i})$ where i is passenger charge $\frac{p_i}{c_i} = \frac{\varphi}{1-\frac{1}{e_i}}$ where i is runway charge (service which is not directly related to passenger numbers)	(i) between passenger charges: same as in (RV) (ii) between runway charge p_1 and passenger charge p_2: $\frac{m_1}{m_2} = \frac{(1-\frac{1}{e_2})}{(1-\frac{1}{e_1})}\frac{5Ac_2}{5Ac_2+I}$ $\frac{m_1}{m_2}$ is lower than (M)	(i) $\frac{m_1}{m_2} < \frac{(1-\frac{1}{e_2})}{(1-\frac{1}{e_1})} = 1$: the ratio of the mark-ups is lower than what would be realised under (M) and (RV) (ii) the ratio is lower than under (M) and also lower than (RV)

(AR)* denotes the ordinary Average Revenue Approach.

Notes to Chapter 4

1. There is another type of regulation similar to the Average Revenue Approach applied to AT&T in the USA. Some called this 'lagged Average Revenue Regulation' See Cowan (1997a).

2. In the UK airports' case it is called the Revenue Yield Approach, rather than the Average Revenue Approach.

3. The context was used in terms of regional gas supply.

4. Tariff Basket Approach would not require this kind of adjustment caused by forecasting the yield. This is one of the advantages of the Tariff Basket Approach, which was stressed by the NERA's report.

5. It is also interesting to consider how the payment methods of some of the 'commercial-side' activities would change under different objectives of the airport operator. The price setting behaviour of the operator can be looked upon as a strategy. BAA used to receive some percentage of the turnover from the concessionaires of tax-free/duty-free shops. However since the early '90s it has owned the business and pays a management fee to the concessionaires. This is mentioned in the MMC4 report. According to Doganis (1992) there is a tendency in general for the commercial airport operator to increase the percentage of the turnover from the concessionaire as the profit margin of the concessionaire's business increases.

6. In the rest of this chapter the airport charge related to this 'runway' output is called 'runway' charge. Runway charge as defined here means the airport charge other than passenger charges, whilst at some airports such as Manchester, the charge imposed on

the airline per landing or taking-off is called 'runway charge'. Therefore, in the context of Manchester, our 'runway' charge implies the airport's runway charge plus aircraft parking charge.

7. I show an example of the share of each airport charge category in the table below. Each number shows the proportion of the revenue to the total airport charge revenue. The data are for 1990/91 and 1994/95 and this is the only data in the public domain available from the MMC reports.

1990/91

%	Heathrow 90/91	Gatwick 90/91	Stansted 90/91	Manchester 90/91
Passenger charge	58.6	60.7	50.1	51.7
Landing charge	27.8	19.5	32.9	46.9
Parking charge	13.6	19.8	17	1.4
Total airport charge	100	100	100	100

1994/1995

%	Heathrow 94/95	Gatwick 94/95	Stansted 94/95	Manchester 94/95
Passenger charge	60	65	56	57
Landing charge	26	18	32	41.9
Parking charge	14	17	12	1.1
Total airport charge	100	100	100	100

8. Toms (1994); See section 3-2 in Chapter 3.

9. Charter airlines tend to offer a single type of fare product, whereas there are innumerable variations existing in non-charter flights, due to the yield management practised by the airlines, as suggested in the previous section.

Chapter 5

Empirical Analysis of Airport Charges

5-1. Introduction

The purpose of this chapter is to investigate whether there exists any evidence to indicate the likely outcomes of price structure changes that were predicted in the previous chapter. Comparing the price marginal cost mark-up ratios between different airport charges under different constraints would be ideal. The summary of the price mark-up ratios using the simple model (no demand interdependency) has been shown in Appendix (6) of the previous chapter. However, in order to carry out the comparisons using price marginal cost mark-ups it would be essential to have an estimation of marginal costs in each category of airport charge. In the next section I explain some of the problems in estimating marginal costs. In section 5-3 I explain the alternative method which I have used in this chapter in an attempt to find any evidence as to how the predictions in Chapter 4 fit the actual trend of airport charge structures. In section 5-4 I show the results of the analysis and conclude in section 5-5 with some implications.

5-2. Cost estimation problems

So far as I am aware, the only estimation of marginal cost in the UK in an attempt to separately identify both peak and off-peak passenger service was in the investigation regarding the cost of the passenger charges at Heathrow and Gatwick carried out by the then nationalised British Airports Authority following the conflict which led to

MOU as I have described in Chapter 4. The method of estimation and the actual estimated values are unknown to me as the reports on the investigation are not in the public domain.

Since the regulatory reform followed by the Airports Act 1986, so-called 'Regulatory Accounts' have been submitted by the airports where they were required to ask the CAA for permission to levy airport charges. The accounts are available from 1988/89 onwards. It is normal for the CAA to propose an accounting condition upon the application for a permission by a regulated airport (not only 'designated' airports). The accounting condition requires the airport (a) to describe the broad principles as to how its costs have been allocated between the activities directly related to airport charges and other 'operational activities' and (b) to show both total revenue and total expenditure associated with the activities that are related to airport charges.

The regulated airports' total expenditure figures that are available in the 'Regulatory Accounts' are aggregate figures. In order to tease out the marginal cost figure from the 'Regulatory Accounts', one would need the information which can be used in estimating a cost function such as landing numbers and passenger numbers broken down into peak and off-peak. BAA now has a brief annual report for each of the three London airports published for the purpose of explaining the following year's airport charge level to the users. Each report includes peak passenger numbers and off-peak passenger numbers for both international and domestic flights, peak landing numbers and off-peak landing numbers[1]. However, before the year 1992, this kind of report was never published, and the counting of each demand quantity separately has never been a custom (apart from 1989/90 and 90/91 data at Heathrow shown in the MMC2 report).

Because (a) there have been 18 airports continuously submitting their 'Regulatory Accounts' each year from 1988/89 to 1997/98 there was a panel of $18 \times 10 = 180$ data which I could use and (b) at least traffic statistics had been published by the CAA for both terminal passenger numbers and aircraft landing numbers broken down into international and domestic[2]. I tried to calculate marginal costs for international passenger service, domestic passenger service, international landing service and domestic landing service, after estimating the coefficients of the regression model[3] in which air-side total cost was a dependent variable, using the form of $TC = f(q_I, q_D, q_{WI}, q_{WD})$. The independent variables are: international passenger numbers (q_I), domestic passenger numbers (q_D), international landing numbers (q_{WI}) and domestic landing numbers (q_{WD}). TC here means the 'air-side' total cost and I used the figure of airport charge related expenditure obtainable from the 'Regulatory Accounts' (after inflation adjustment). The use of panel data matched the concept of obtaining the short run costs, as the time length was 10 years. One could use time series data for each airport of the then nationalised British Airports Authority and current BAA (which are available unlike those of the then local authority airports and currently regulated airports either private or still under local authority management), there would be a problem of scale, i.e., the confusing mixture of long run cost and short run cost would be unavoidable.

I used a variety of functional forms such as linear functional forms, power functional forms, log linear functional forms or two-step estimation such as the first step estimation being $TC = f(q_{WI}, q_{WD})$, followed by the second step estimation of $q_I = g(q_{WI})$ and $q_D = h(q_{WD})$. None of the results were consistent with the logic as to the relative size of marginal cost of landing and marginal cost of passenger service, or the relative size of marginal cost of international passenger service and marginal cost of domestic passenger service. It was always the case that some airports, regardless of their scale, showed non-significant coefficients. Even when the panel of 180 airports' data was separated into several groups with the same scale of size to make each model stable, none of the results of the models with which the F-test was passed were meaningful in obtaining the airports' marginal cost estimates. The main reason for the failure of the estimation attempt lies in the fact that the number and the types of independent variables are irrelevant to the total cost of 'air-side' operation, i.e., there are many more unknown factors affecting the size of TC. However, more importantly, there is a crucial drawback in any attempt to estimate the costs using panel data for different airports in that the method of cost allocation is different from one airport to another. The CAA merely requires the regulated airports to describe their own method used to allocate the costs between 'air-side' activities and 'commercial-side' activities within the total costs incurred by the 'operational activities'. The CAA does not provide any particular benchmark for the cost allocation. It approves the application by a regulated airport for permission to levy its airport charges by judging the 'reasonableness'. There may be some airports whose allocation method varies from some years to others. Such being the case, the cost estimation attempt that I tried to carry out failed.

5-3. Data, methodology and hypotheses

(1) Data availability in relation to the price structure comparisons

Airport charges' data from 1978/79 to 1997/98 is available regarding the then nationalised British Airports Authority and the current BAA for each of their airports. However, the airport charges information before the regulatory reform other than for BAA's airports is not available. It has proved difficult to obtain airport charges information prior to the reform for those airports which were previously owned and managed by local authorities. In so far as I was able to ascertain, there were no records for Luton and there were several years missing at Birmingham. Most of the data is also missing at Manchester. Therefore I have used the airport charges data for Heathrow, Gatwick and Stansted which are designated and subject to AAR price cap regulation, also Glasgow, Edinburgh and Aberdeen which are non-designated and not subject to price regulation. As to the first three London airports, it is possible to use the airport charges data to test the price ratios which were previously under the constraint of (Q), (QG) and after privatisation under the (AAR) constraint. As for the three Scottish airports, the airport charges can be regarded as moved from under the constraint of (Q) to under (M) after privatisation as they can now be looked upon as an unconstrained monopoly without any direct price regulations. They were irrelevant to (QG) constraint as shown in Table 2-1. During the period when the three London airports were subject to financial target with passenger growth rate, the Scottish airports had been under break-even constraint. The predicted relationship between the price and the related marginal cost of each service during that period for each of the three Scottish airports would have been exactly the same as under (Q).

The data I use here are for two kinds of airport charges, i.e., landing charge and passenger charge. In order to calculate aircraft parking charge one would need to specify both the type/weight of aircraft and the hours of parking. On the other hand the revenue from parking charge is relatively small compared to the revenue from passenger charge and landing charge (See note 7 in Chapter 4). Therefore I have used landing charge as a surrogate for the 'runway' charge that I defined in the previous chapter.

As to the unregulated commercial 'price', none of the price data for any of the relevant services is available covering both the period when the then nationalised British Airports Authority was in charge and the period after the regulatory reform. Thus my analysis addresses the price ratio changes that involve only passenger charges and landing charges. As to the comparison between peak and off-peak landing charges, I have used two types of aircraft namely B767-300 (hereafter B767) and B737-300 (hereafter B737). This is because these aircraft are used for both international and domestic flights and therefore suitable for the comparison of international charges and domestic charges. The maximum capacity and weight are 250 passengers and 158 tonnes for B767 and 145 passengers and 64 tonnes for B737. Also both aircraft types are categorised by the International Civil Aviation Organization (hereafter ICAO; the international regulatory body for civil aviation) in so-called 'Chapter 3' and they are not subject to any additional penalty due to noise[4].

(2) Methodology

There are two interesting papers related to the empirical evidence on the tariff structure changes of the UK privatised public utility industries. Giulietti and Otero (1998) used the cumulative sum of residuals (hereafter CUSUM) test in order to find the timing of any structural changes in the industries. They analysed the changes of the ratio $\frac{p_{Wi}}{p_{Pi}}$ at three London airports of BAA using the same data set I use (i.e., airport charge from 1978/79 to 1997/98) and using several types of aircraft sizes. Based on the CUSUM test they found that the strongest evidence of structural breaks was observed for large aircraft of the B747-400 type. In the case of B747-400 at Heathrow the structural change's timings seem to be 1983/84 for peak period, and 1985/86 for off-peak period. For B747-400 at Gatwick the peak period's ratio showed 1983/84 as a possible structural break. For the other types of aircraft and all aircraft at Stansted, the timings of structural breaks for both peak and off-peak were rather inconclusive.

Giulietti and Waddams Price (2000) analysed the directions and levels as to the rebalancing of prices of the UK regulated industries after price cap regulations were imposed, and they included the three London airports of BAA using the same price data I use (i.e., airport charges from 1978/79 to 1997/98). Their emphasis was put on (a) the rebalancing of standing charges and average bills, where, in the three London airports case they regarded landing charge plus parking charge as a standing charge while passenger charge was regarded as an average bill, (b) the difference of the total airport charge averaged per passenger between where the total cost was high (when a large aircraft was used and the operation was during the peak period) and where the total cost was low (when a small aircraft was used and the flights was during the off-peak period), and (c) the rebalancing of peak and off-peak charges. They used a two-sided t-test with 5% significance level and assumed that there was a structural break at 1985/86 based on the findings above by Giulietti and Otero (1998). In both (a) and (b) ((c) is the same examination as (b)) they used a time series trend with dummy variables with 1 after 1985 for both slope and interception and investigated if the null hypothesis that the trend in 1985-1998 is the same in 1978-1984 would be rejected or not. They showed results which significantly rejected the null hypothesise. In terms of (a), they compared the ratios of $\frac{p_{Wi}}{p_{Pi}}$ in peak and off-peak for both international flights and domestic flights, and observed that at Heathrow and Gatwick the ratio revealed a decrease in most cases and that Stansted's ratio was inconclusive. As to (b) and (c), they compared the ratios of off-peak average airport charge per passenger to peak average airport charge per passenger. At Heathrow, as a whole, they observed an increase of the ratio of off-peak to peak charge, but at Stansted the ratio seemed to have decreased. Gatwick's ratios' direction was mixed and inconclusive.

I have used the same method which Giulietti and Waddams Price (2000) used, i.e., observing the trend of the price ratios with dummy variables over the time in question. The purpose of the empirical analysis I carry out here is to examine whether a particular price ratio's level for the period under nationalisation (i.e., before the constraint (AAR) was imposed on BAA) is different in the predicted way to the price ratio's level after privatisation (i.e., after the constraint (AAR) was imposed on BAA). I measured the coefficients of a linear regression model for each price ratio over the period with dummy variables. The dummy variables are two kinds. One is for the intercept and the other is for the slope. The regression model for each price ratio Y using time trend X as explanatory variable is as follows:

$$Y = \alpha_1 + \beta_1 X + D(\alpha_2 - \alpha_1) + D(\beta_2 - \beta_1)X$$

$D = 0$ for the period before (AAR) constraint was imposed

$D = 1$ for the period after (AAR) constraint was imposed

Thus the model is explaining the two regressions with two different periods:

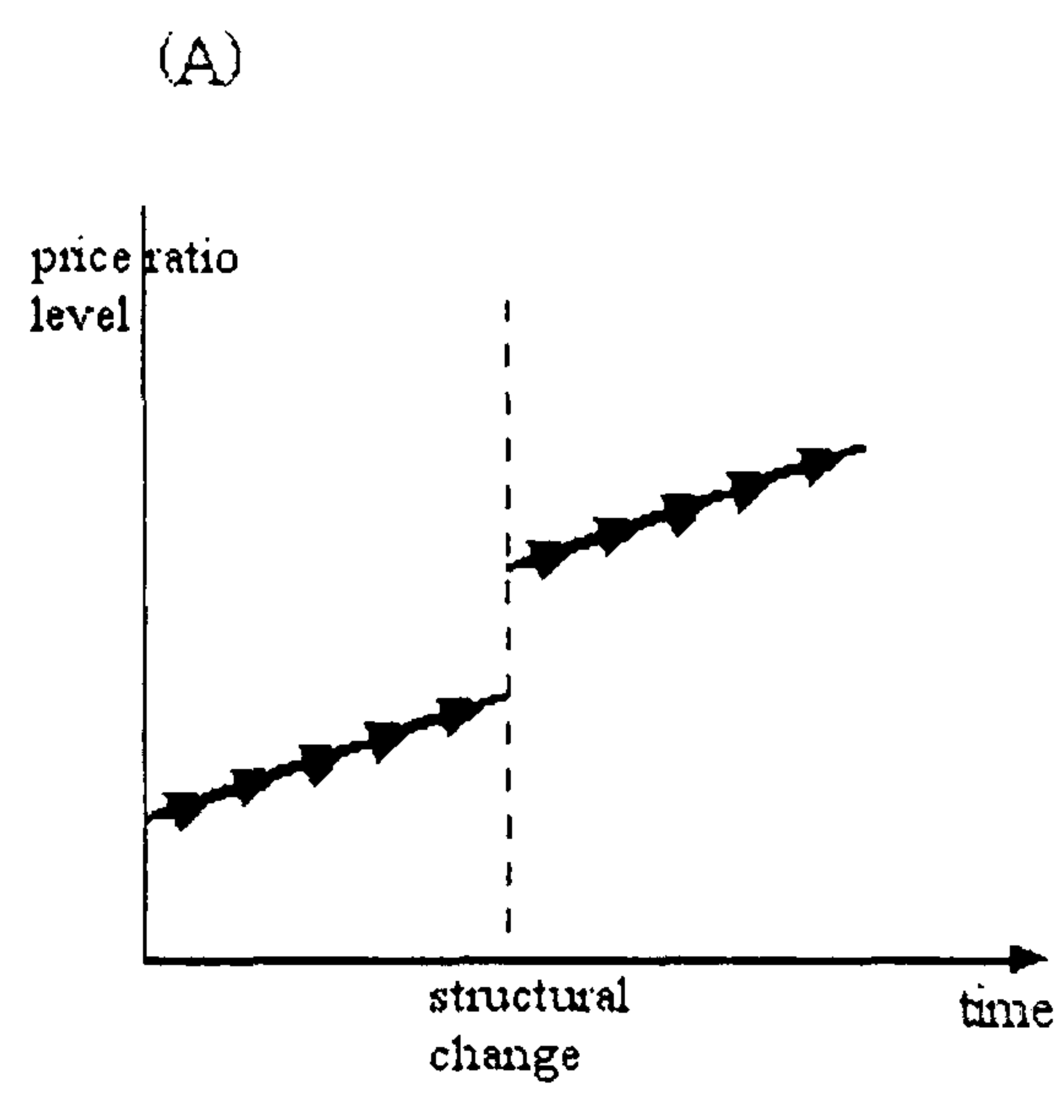
period before (AAR): $Y = \alpha_1 + \beta_1 X$

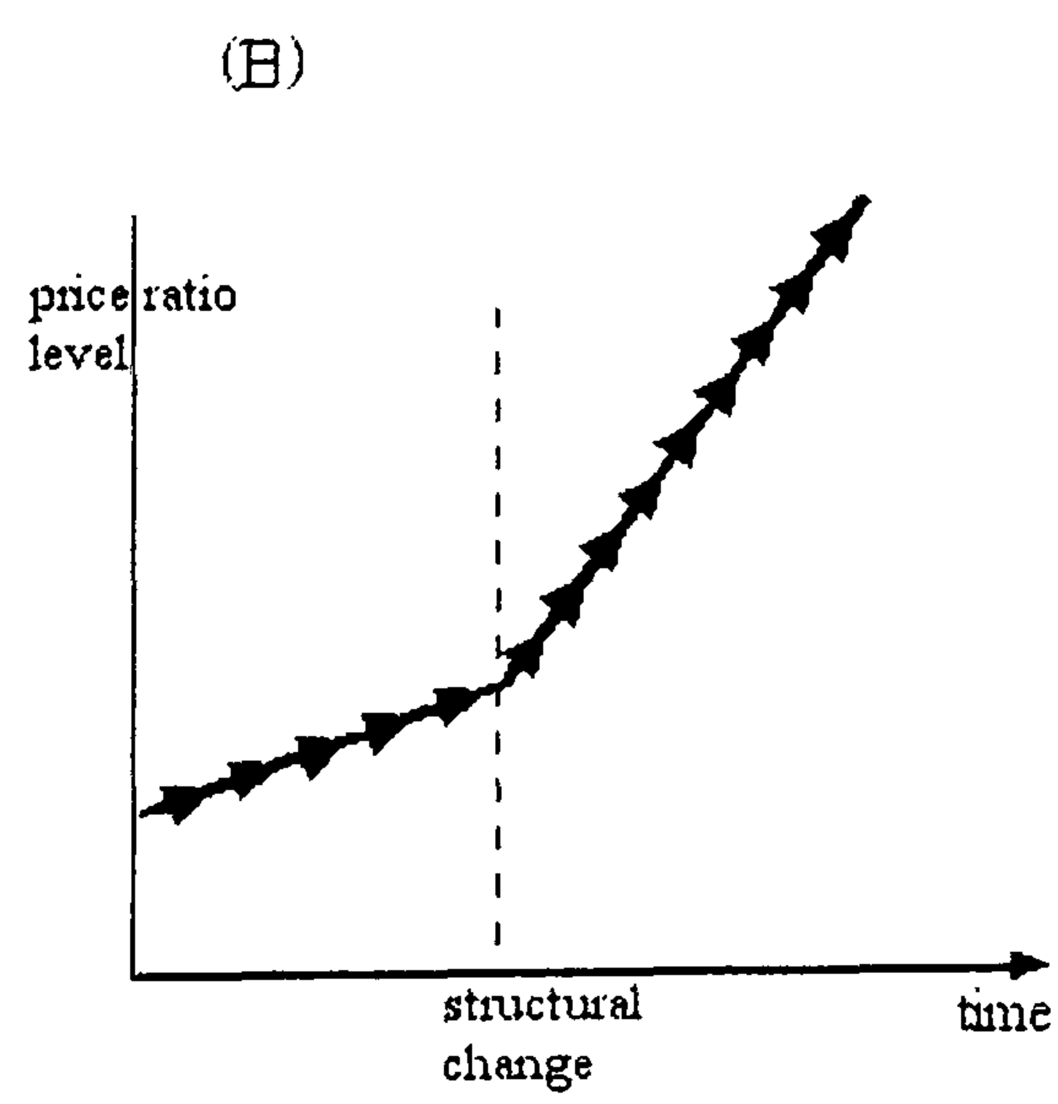
period after (AAR): $Y = \alpha_2 + \beta_2 X$

For each model I used a two-sided t-test with a 5% significance level to investigate if each coefficient is significant and if the coefficient value (and the sign) for the latter period is significantly different from the value for the former period. In this procedure the hypotheses $H_0 : \beta_1 = \beta_2$ and $H_0' : \alpha_1 = \alpha_2$ were tested. This type of dummy analysis would allow us to observe any changes in both the intercept coefficient and the slope coefficient. One of the drawbacks for the other kinds of stability tests such as the F-test is that they can only test the regression models as a whole. This drawback can be avoided by adopting dummies for both intercept coefficient and slope coefficients.

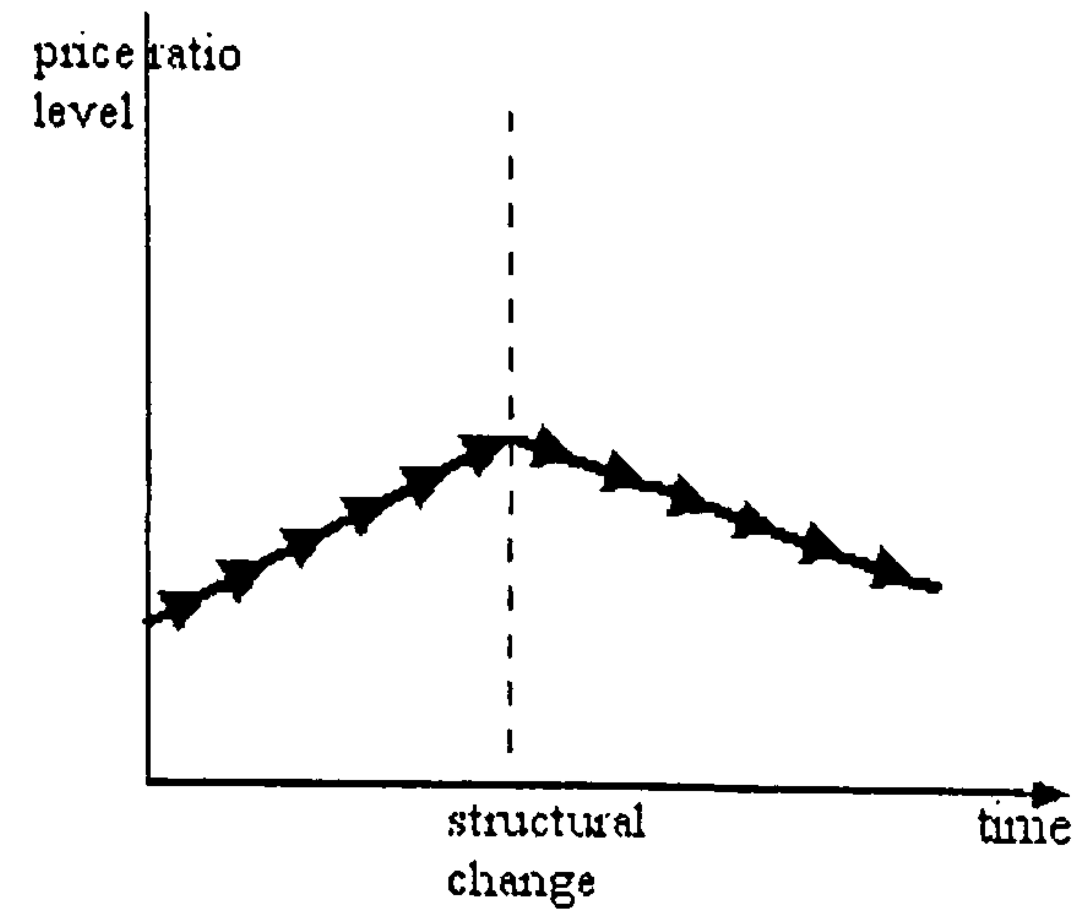
The empirical analysis I carried out in this chapter is an investigation of different trends over time, i.e., price ratio changes (in both the sizes and directions) over time. However, the predictions in the previous chapter were based on the level differences which do not include the concept of changes over time, i.e., the results from the predictions in Chapter 4 are atemporal. Therefore there is a problem as to how one can link the previous chapter's predictions to the results in this chapter. In order to interpret the results in this chapter I considered the possible variations of the regression results. There would be roughly three types in the form of difference between the regression result for the period before (AAR) constraint was imposed and that for the period after (AAR) constraint was imposed. In the illustration below, case (A) shows the situation where $H_0 : \beta_1 = \beta_2$ is not rejected but $\alpha_1 \neq \alpha_2$. In this case the the slope for both periods is the same. The interpretation is that there was a sudden jump after the (AAR) was imposed (in the illustration, the dotted line means that at this point (AAR) was imposed and I have marked the point as 'structural change' for simplicity), but there was no apparent change in price ratio itself after (AAR) was imposed. Case (B) illustrates the situation where both $\beta_1 \neq \beta_2$ and $\alpha_1 \neq \alpha_2$ hold. I interpret this type of change as evidence of price ratio level change. Case (C) is slightly more complicated than (A) and (B). In this type of situation, although the directions of two periods' slope coefficients are different, the price ratio level at the end of the latter period reverted to the same level as at the beginning of the former period. There were two kinds of constraints during the period of nationalisation, i.e., (Q) and (QG) as I explained in Chapter 4 where I predicted the relationship of price ratio level among (Q), (QG) and (AAR). In cases such as $\frac{p_{P1}}{p_{P2}}$, $\frac{p_{P1}}{p_{W1}}$ and $\frac{p_{P1}}{p_U}$ the price ratio level under constraint (QG) was predicted to be either the lowest or the highest among the levels under (Q), (QG) and (AAR). In section 5-4 where I explain the results of the trend analysis, I take the effect of (QG) constraint into consideration.

possible variations of the regression results





(C)



The focus of this empirical testing is to investigate (a) if the price ratios after the regulatory reform would be significantly different from the ratios before the constraint (AAR) was placed on the three London airports and (b) if the price ratios after becoming monopolistic without any price regulations would be significantly different under the constraint of (Q) or the break-even constraint (both of which produce the same price ratios as I mentioned above) in the case of the three Scottish airports of BAA.

One of the questions as to the regulatory reform's effect put by both Giulietti and Otero (1998) and Giulietti and Waddams Price (2000) was whether the effect might have already begun before the actual organisational change or price constraint's change was introduced. They are conscious of the possibility that the managers might have been influenced by the knowledge that the ownership/constraint form was to be changed, as already in 1983 the Conservative Government had announced in the Queen's Speech that '*as many as possible of Britain's airports shall become private sector companies*'.

As I have already mentioned, the constraint (QG) seems to have been introduced as an incentive for managers to increase efficiency *because of the preparation for the ownership change* (see Chapter 3). Also the break-even target as a constraint imposed on the Scottish airports of the then nationalised British Airports Authority seems to have been in preparation for the ownership change. Thus my interest lies in how (AAR) was effective after the regulatory reform in the case of London airports, and how (M) became effective after the reform in the case of Scottish airports, rather than *when* the influence of regulatory reform might have been observed. Although I have tested all the years after which the slope coefficients were significantly different from the previous period for each category of price ratios, the year 1987 which *is* the first year after the regulatory reform turned out to be one of the most frequent years in terms of the number of the results where the null hypothesis was significantly rejected. The only exception was the results on price ratios between passenger charges at Stansted where the break point year seemed to be 1991/92 at which the significant results appeared most frequently. At Stansted the new terminal was opened in March 1991 and it seems that this opening was the trigger for the change to passenger charge ratios. Such being the case, in order to see the effect of (AAR) I have selected 1987 as the structural break for Heathrow, Gatwick, Glasgow, Edinburgh and Aberdeen for the all price ratio categories I carry out, and 1991 for the ratios involving passenger charges and 1987 for other ratios at Stansted.

(3) The price ratios I compare and the hypotheses

Considering the data availability one can test the following predictions I have made in the previous chapter:

(1) ratio of peak passenger charge to off-peak passenger charge (section 4-5)

(2) ratio of peak (off-peak) passenger charge to peak (off-peak) runway charge (section 4-5)

(3) ratio of peak runway charge to off-peak runway charge (section 4-5)

(A) ratio of international passenger charge to domestic passenger charge (Appendix (5))

(B) ratio of international passenger charge to runway charge (Appendix (5))

I avoid the ratio comparison (2) above, as there is a difficulty in the interpretation of price ratio comparison in that (a) as the 'yield management' technique is employed by the airlines, the effect of the ratio of runway charge to passenger charge would not be of great issue to the airlines, but (b) rather this ratio would affect the selection of the type of aircraft and the destination/origin of a route. However, this comparison would have a meaning if one's focus is placed on the fairness issue between a larger aircraft with a long distance route and a smaller aircraft with a short distance route. For the same reason I do not carry out the ratio comparison of (B) in Appendix (5).

Hypotheses as to the ratios (1), (3) and (A) above according to the previous chapter's prediction (as a summary see Table 4-8) are as follows:

(1)-1 the three London airports:

if the price cap constraint is effective, the price ratio of peak passenger charge to off-peak passenger charge would be raised after 1987

(1)-2 the three Scottish airports:

the price ratio of peak passenger charge to off-peak passenger charge would be decreased after 1987

(3)-1 the three London airports:

if the price cap constraint is effective, the price ratio of peak landing charge to off-peak landing charge would be raised after 1987

(3)-2 the three Scottish airports:

the price ratio of peak landing charge to off-peak landing charge would be raised after 1987

(A)-1 the three London airports:

if the price cap constraint is effective, the price ratio of international passenger charge to domestic passenger charge would be raised after 1987

(A)-2 the three Scottish airports:

the price ratio of international passenger charge to domestic passenger charge would be decreased after 1987

The assumptions regarding the hypotheses above are the same as in section 4-5 of

Chapter 4 and they are:

(a) that the constraint (Q) which was supposed to be imposed on the then nationalised British Airports Authority was not effective. As described in Chapter 2, financial targets were quite often missing in several years and in some periods 'cash limits' overruled the organisation's constraint (See Table 2-1) and

(b) that the constraint (QG) which was introduced during the period from 1983/84 to 1986/87 was effective, but the value of $\frac{I}{5A}$ (explained in section 4-5 of Chapter 4) was lower than the value of v so that each price level did not exceed the level of unconstrained monopolist setting.

5-4. Results

I show the results here as summaries from Table 5-1 to Table 5-5. The results marked with asterisks in the tables are the ones which are significant in slope coefficients and/or intercept coefficients, i.e., the case where both $H_0 : \beta_1 = \beta_2$ and $H_0' : \alpha_1 = \alpha_2$ are rejected, the case where $H_0 : \beta_1 = \beta_2$ is rejected but $H_0' : \alpha_1 = \alpha_2$ cannot be rejected, and the case where $H_0 : \beta_1 = \beta_2$ cannot be rejected but $H_0' : \alpha_1 = \alpha_2$ is rejected. The values shown in the brackets in the tables are t-values. In Table 5-1 to Table 5-5 the regressions are expressed as $Y = \alpha_1 + \beta_1 X$ for the period before the change and $Y = \alpha_2 + \beta_2 X$ for the period after the change, as I have explained in section 5-3 (2). In many cases the t-values' sign is opposite to the coefficients' sign. However, this is due to the inclusion of dummy variables, i.e., the t-value shown under each β_2 is actually the t-value for $\beta_2 - \beta_1$. This is same as in the case of the t-values for each α_2.

The summary of the results for Scottish airports as to the price ratio of peak landing charge to off-peak landing charge is missing, because none of three Scottish airports have differentiated peak and off-peak in the landing charge. As to the result in summary (Table 5-2) of the ratio of peak international passenger charge to off-peak international passenger charge, Glasgow airport once set a higher international passenger charge for passengers using larger aircraft (heavier than 125 metric tonne) during the period from 1990 to 1992. Because there was a sudden jump due to this policy in 1991, I used the ratio for passengers using B737 in Glasgow's case. B737 is not the aircraft categorised as "larger aircraft".

There are four variations of peak and off-peak charges. The notations for them are as follows:

spdp: seasonal peak (including weekly peak) and daily peak
spdo: seasonal peak and daily off-peak
sodp: seasonal off-peak and daily peak
sodo: seasonal off-peak and daily off-peak

Therefore, in terms of their variation of peak/off-peak ratios, the following four kinds exist:

(1) spdp/spdo (ratio of daily peak/off-peak within peak season (or peak week))
(2) spdp/sodp (ratio of seasonal peak/off-peak when applied to peak hours in a day)
(3) spdo/sodo (ratio of seasonal peak/off-peak when applied to off-peak hours in a day)
(4) sodp/sodo (ratio of daily peak/off-peak within off-peak season)

The difference between peak and off-peak does not exist in any year at Scottish airports, therefore there are no results regarding the hypothesis (3)-2 in the last section.

Differences between international landing charge and domestic landing charge existed until 1981, but since May 1981 it has not been the practice at any of BAA's airports. Therefore it is not meaningful to calculate the ratio regarding the change of price ratio of international landing charge to domestic landing charge.

Table 5-1 Ratios of peak passenger charge to off-peak passenger charge at London airports (corresponding to the hypothesis (1)-1 in the last section)

HEATHROW INTERNATIONAL			
	78-86	87-98	
spdp/spdo	$Y = 2.489 + 0.979X$ (3.406) (7.539)	$Y = 15.578 - 0.646X$ (8.597) (−10.503)	$R^2 = 0.886$ $DW = 0.978$ *
spdp/sodp	$Y = 6.095 + 0.457X$ (6.845) (2.876)	$Y = 15.578 + 0.646X$ (5.089) (−5.826)	$R^2 = 0.814$ $DW = 0.929$ *
spdo/sodo	$Y = 2.005 - 0.146X$ (10.652) (−4.354)	$Y = 1.000 + 0.000X$ (−2.563) (3.655)	$R^2 = 0.594$ $DW = 1.225$ *
sodp/sodo	sodp=sodo		

HEATHROW DOMESTIC			
	78-86	87-98	
spdp/spdo	$Y = 1.774 + 0.304X$ (3.642) (3.512)	$Y = 7.398 - 0.279X$ (5.542) (−5.651)	$R^2 = 0.689$ $DW = 1.417$ *
spdp/sodp	$Y = 3.176 + 0.101X$ (4.655) (0.833)	$Y = 3.142 - 0.095X$ (−0.024) (−1.359)	$R^2 = 0.604$ $DW = 1.952$
spdo/sodo	$Y = 1.503 - 0.073X$ (15.964) (−4.354)	$Y = 1.000 + 0.000X$ (−2.563) (3.655)	$R^2 = 0.594$ $DW = 1.225$ *
sodp/sodo	$Y = 1.000 - (2.7E - 16)X$ (2.594) $(-3.9E - 15)$	$Y = 4.164 - 0.142X$ (3.940) (−1.742)	$R^2 = 0.615$ $DW = 2.213$ *

GATWICK INTERNATIONAL			
	78-86	87-98	
spdp/spdo	$Y = 1.529 + 0.553X$ (3.622) (7.369)	$Y = 12.616 - 0.519X$ (12.605) (−11.988)	$R^2 = 0.909$ $DW = 1.379$ *
spdp/sodp	$Y = 4.263 + 0.157X$ (5.406) (1.120)	$Y = 12.646 - 0.676X$ (5.083) (−4.046)	$R^2 = 0.672$ $DW = 1.138$ *
spdo/sodo	$Y = 1.987 - 0.143X$ (10.789) (−4.375)	$Y = 1.000 + 0.000X$ (−2.573) (3.672)	$R^2 = 0.596$ $DW = 1.175$ *
sodp/sodo	sodp=sodo		

GATWICK DOMESTIC			
	78-86	87-98	
spdp/spdo	$Y = 1.427 + 0.187X$ (5.449) (4.025)	$Y = 5.828 - 0.230X$ (8.063) (−7.522)	$R^2 = 0.815$ $DW = 1.181$ *
spdp/sodp	$Y = 2.523 + 0.029X$ (5.657) (0.361)	$Y = 5.828 - 0.230X$ (3.556) (−2.736)	$R^2 = 0.568$ $DW = 1.104$ *
spdo/sodo	$Y = 1.494 - 0.072X$ (16.217) (−4.375)	$Y = 1.000 + 0.000X$ (−2.573) (3.672)	$R^2 = 0.596$ $DW = 1.175$ *
sodp/sodo	sodp=sodo		

STANSTED INTERNATIONAL			
	78-90	91-98	
spdp/spdo	$Y = 1.241 + 0.004X$ (4.488) (0.104)	$Y = 8.449 - 0.316X$ (5.506) (−3.969)	$R^2 = 0.826$ $DW = 1.055$ *
spdp/sodp	$Y = 0.794 + 0.134X$ (2.345) (3.148)	$Y = 8.449 - 0.316X$ (4.775) (−4.568)	$R^2 = 0.720$ $DW = 0.920$ *
spdo/sodo	$Y = 0.684 + 0.094X$ (8.404) (9.176)	$Y = 1.000 + 0.000X$ (0.820) (−3.973)	$R^2 = 0.871$ $DW = 1.164$ *
sodp/sodo	sodp=sodo		

STANSTED DOMESTIC			
	78-90	91-98	
spdp/spdo	$Y = 1.140 - 0.004X$ (8.125) (−0.215)	$Y = 5.040 - 0.187X$ (5.869) (−4.483)	$R^2 = 0.789$ $DW = 1.155$ *
spdp/sodp	$Y = 0.776 + 0.104X$ (4.034) (4.286)	$Y = 5.040 - 0.187X$ (4.679) (−5.193)	$R^2 = 0.675$ $DW = 0.936$ *
spdo/sodo	$Y = 0.684 + 0.094X$ (8.404) (9.176)	$Y = 1.000 + 0.000X$ (0.820) (−3.973)	$R^2 = 0.871$ $DW = 1.164$ *
sodp/sodo	sodp=sodo		

Table 5-2 Ratios of peak passenger charge to off-peak passenger charge at Scottish airports (corresponding to the hypothesis (1)-2 in the last section)

GLASGOW INTERNATIONAL the case for B737 aircraft			
	78-86	87-98	
spdp/spdo	$Y = 1.000 - (1.0E - 15)X$ $(24.391)\ (-1.4E - 13)$	$Y = 1.061 - 0.013X$ $(0.709)\ (1.471)$	$R^2 = 0.871$ $DW = 1.641$
spdp/sodp	spdo=sodp=sodo		
spdo/sodo	spdo=sodp=sodo		
sodp/sodo	spdo=sodp=sodo		

GLASGOW			
DOMESTIC	78-86	87-98	
spdp/spdo	$Y = 1.000 + (2.6E - 17)X$ $(118.601)\ (1.7E - 14)$	$Y = 0.893 + 0.009X$ $(-6.116)\ (5.083)$	$R^2 = 0.884$ $DW = 1.026$ *
spdp/sodp	spdo=sodp=sodo		
spdo/sodo	spdo=sodp=sodo		
sodp/sodo	spdo=sodp=sodo		

EDINBURGH INTERNATIONAL			
	78-86	87-98	
spdp/spdo	$Y = 1.000 + (1.4E - 15)X$ $(36.293)\ (2.8E - 13)$	$Y = 1.063 + 0.006X$ $(1.099)\ (0.967)$	$R^2 = 0.832$ $DW = 1.668$
spdp/sodp	spdo=sodp=sodo		
spdo/sodo	spdo=sodp=sodo		
sodp/sodo	spdo=sodp=sodo		

EDINBURGH DOMESTIC			
	78-86	87-98	
spdp/spdo	$Y = 1.000 - (4.5E - 17)X$ $(123.457)\ (-3.1E - 14)$	$Y = 0.894 + 0.009X$ $(-6.273)\ (5.213)$	$R^2 = 0.889$ $DW = 1.017$ *
spdp/sodp	spdo=sodp=sodo		
spdo/sodo	spdo=sodp=sodo		
sodp/sodo	spdo=sodp=sodo		

ABERDEEN Not relevant as spdp=spdo=sodp=sodo			
INTERNATIONAL	78-86	87-98	

ABERDEEN DOMESTIC			
	78-86	87-98	
spdp/spdo	$Y = 1.000 - (2.6E-16)X$ $(77.768)\ (-1.2E-13)$	$Y = 0.823 + 0.015X$ $(-6.602)\ (5.372)$	$R^2 = 0.891$ $DW = 1.006$ *
spdp/sodp	spdo=sodp=sodo		
spdo/sodo	spdo=sodp=sodo		
sodp/sodo	spdo=sodp=sodo		

Table 5-3 Ratios of peak runway charge to off-peak runway charge at London airports (corresponding to the hypothesis (3)-1 in the last section) (international charge=domestic charge)

HEATHROW B767			
	78-86	87-98	
spdp/spdo	$Y = 1.000 - (1.9E-15)X$ $(18.566)\ (-2.0E-13)$	$Y = 1.462 - 0.004X$ $(4.115)\ (-0.343)$	$R^2 = 0.899$ $DW = 2.617$ *
spdp/sodp	$Y = 2.417 - 0.150X$ $(14.683)\ (-5.129)$	$Y = 1.825 - 0.032X$ $(-1.727)\ (3.398)$	$R^2 = 0.702$ $DW = 1.481$ *
spdo/sodo	$Y = 2.417 - 0.150X$ $(17.012)\ (-5.942)$	$Y = 1.000 + 0.000X$ $(-4.786)\ (4.987)$	$R^2 = 0.848$ $DW = 1.361$ *
sodp/sodo	$Y = 1.000 + (2.2E-16)X$ $(14.577)\ (1.8E-14)$	$Y = 0.637 + 0.028X$ $(-2.538)\ (1.904)$	$R^2 = 0.465$ $DW = 1.003$ *

HEATHROW B737			
	78-86	87-98	
spdp/spdo	$Y = 1.000 - (1.5E - 15)X$ $(18.567)\ (-1.6E - 13)$	$Y = 1.462 - 0.004X$ $(4.118)\ (-0.345)$	$R^2 = 0.899$ $DW = 2.618$ *
spdp/sodp	$Y = 2.417 - 0.150X$ $(14.683)\ (-5.128)$	$Y = 1.824 - 0.032X$ $(-1.727)\ (3.398)$	$R^2 = 0.702$ $DW = 1.481$ *
spdo/sodo	$Y = 2.417 - 0.150X$ $(17.012)\ (-5.942)$	$Y = 1.000 + 0.000X$ $(-4.786)\ (4.987)$	$R^2 = 0.848$ $DW = 1.361$ *
sodp/sodo	$Y = 1.000 - (2.9E - 16)X$ $(14.596)\ (-2.4E - 14)$	$Y = -0.362 + 0.028X$ $(-2.539)\ (1.905)$	$R^2 = 0.465$ $DW = 1.001$ *

GATWICK B767			
	78-86	87-98	
spdp/spdo	$Y = 1.000 - (1.9E - 16)X$ $(5.449)\ (-5.9E - 15)$	$Y = -0.008 + 0.134X$ $(-2.638)\ (3.452)$	$R^2 = 0.886$ $DW = 1.411$ *
spdp/sodp	$Y = 1.702 + 0.096X$ $(8.372)\ (2.665)$	$Y = 1.478 + 0.067X$ $(-0.531)\ (-0.686)$	$R^2 = 0.567$ $DW = 1.524$
spdo/sodo	$Y = 1.702 + 0.096X$ $(12.083)\ (3.845)$	$Y = 2.008 - 0.048X$ $(1.040)\ (-4.850)$	$R^2 = 0.892$ $DW = 1.409$ *
sodp/sodo	sodp=sodo		

GATWICK B737			
	78-86	87-98	
spdp/spdo	$Y = 1.000 - (9.6E - 17)X$ $(4.298)\ (-2.3E - 15)$	$Y = 0.932 + 0.125X$ $(-0.140)\ (2.545)$	$R^2 = 0.921$ $DW = 0.672$ *
spdp/sodp	$Y = 1.910 + 0.029X$ $(4.196)\ (0.362)$	$Y = 2.878 + 0.064X$ $(1.022)\ (0.366)$	$R^2 = 0.727$ $DW = 0.694$
spdo/sodo	$Y = 1.910 + 0.029X$ $(26.181)\ (2.257)$	$Y = 1.977 - 0.040X$ $(0.444)\ (-4.452)$	$R^2 = 0.941$ $DW = 1.265$ *
sodp/sodo	sodp=sodo		

STANSTED B767 spdp=spdo, sodp=sodo			
	78-86	87-98	
sp/so	$Y = 1.029 + 0.100X$ $(4.404)\ (2.397)$	$Y = 2.417 - 0.018X$ $(2.851)\ (-2.382)$	$R^2 = 0.590$ $DW = 1.232$ *

STANSTED B737	spdp=spdo, sodp=sodo		
	78-86	87-98	
sp/so	$Y = 1.029 + 0.100X$ (4.404) (2.397)	$Y = 2.417 - 0.018X$ (2.851) (−2.382)	$R^2 = 0.590$ $DW = 1.232$ *

Note: Although the actual landing charges are different between B767 and B737, the ratio has been set exactly the same at Stansted.

Table 5-4 Ratios of international passenger charge to domestic passenger charge at London airports (corresponding to the hypothesis (A)-1 in the last section)

HEATHROW			
	78-86	87-98	
spdp	$Y = 2.812 - 0.044X$ (4.284) (−0.382)	$Y = 1.809 - 0.008X$ (−0.733) (0.381)	$R^2 = 0.142$ $DW = 2.452$
spdo	$Y = 1.309 - 0.045X$ (11.100) (−2.139)	$Y = 0.164 + 0.065X$ (−4.660) (4.395)	$R^2 = 0.629$ $DW = 1.481$ *
sodp	$Y = 1.000 - (2.7E - 16)X$ (4.384) (−6.7E − 15)	$Y = 0.876 - 0.107X$ (−3.947) (2.218)	$R^2 = 0.529$ $DW = 1.027$ *
sodo	$Y = 1.000 + (4.4E - 17)X$ (9.737) (2.4E − 15)	$Y = 0.164 + 0.065X$ (−3.907) (2.986)	$R^2 = 0.465$ $DW = 1.001$ *

GATWICK			
	78-86	87-98	
spdp	$Y = 1.776 + 0.028X$ (23.152) (2.039)	$Y = 2.138 - 0.005X$ (2.270) (−1.990)	$R^2 = 0.474$ $DW = 1.377$ *
spdo	$Y = 1.306 - 0.044X$ (16.938) (−3.237)	$Y = 0.633 + 0.029X$ (4.188) (4.451)	$R^2 = 0.549$ $DW = 0.903$ *
sodp	$Y = 1.000 + (4.0E - 16)X$ (19.355) (4.4E − 14)	$Y = 0.633 + 0.028X$ (−3.407) (2.588)	$R^2 = 0.622$ $DW = 0.710$ *
sodo	sodp=sodo		

STANSTED			
	78-90	91-98	
spdp	$Y = 1.037 + 0.012X$ $(12.722)\ (1.132)$	$Y = 0.793 + 0.056X$ $(-0.631)\ (1.866)$	$R^2 = 0.874$ $DW = 1.391$
spdo	$Y = 1.000 + (1.6E-16)X$ $(29.157)\ (3.6E-14)$	$Y = 0.205 + 0.050X$ $(-4.893)\ (5.060)$	$R^2 = 0.717$ $DW = 0.856$ *
sodp	$Y = 1.000 + (1.6E-16)X$ $(29.157)\ (3.6E-14)$	$Y = 0.205 + 0.050X$ $(-4.893)\ (5.060)$	$R^2 = 0.717$ $DW = 0.856$ *
sodo	sodp=sodo		

Note: Although the actual passenger charges are different between international spdo and sodp and also between domestic spdo and sodp, the ratio of international spdo to domestic spdo and the ratio of international sodp to domestic sodp have been set exactly the same at Stansted.

Table 5-5 Ratios of international passenger charge to domestic passenger charge at Scottish airports (corresponding to the hypothesis (A)-2 in the last section)

GLASGOW the case for B737 aircraft			
	78-86	87-98	
spdp	$Y = 1.278 + 0.026X$ $(28.851)\ (3.297)$	$Y = 1.639 + 0.005X$ $(3.915)\ (-2.272)$	$R^2 = 0.891$ $DW = 1.490$ *
spdo & so	$Y = 1.278 + 0.026X$ $(34.186)\ (3.907)$	$Y = 1.395 + 0.001X$ $(1.500)\ (-3.176)$	$R^2 = 0.474$ $DW = 1.564$ *

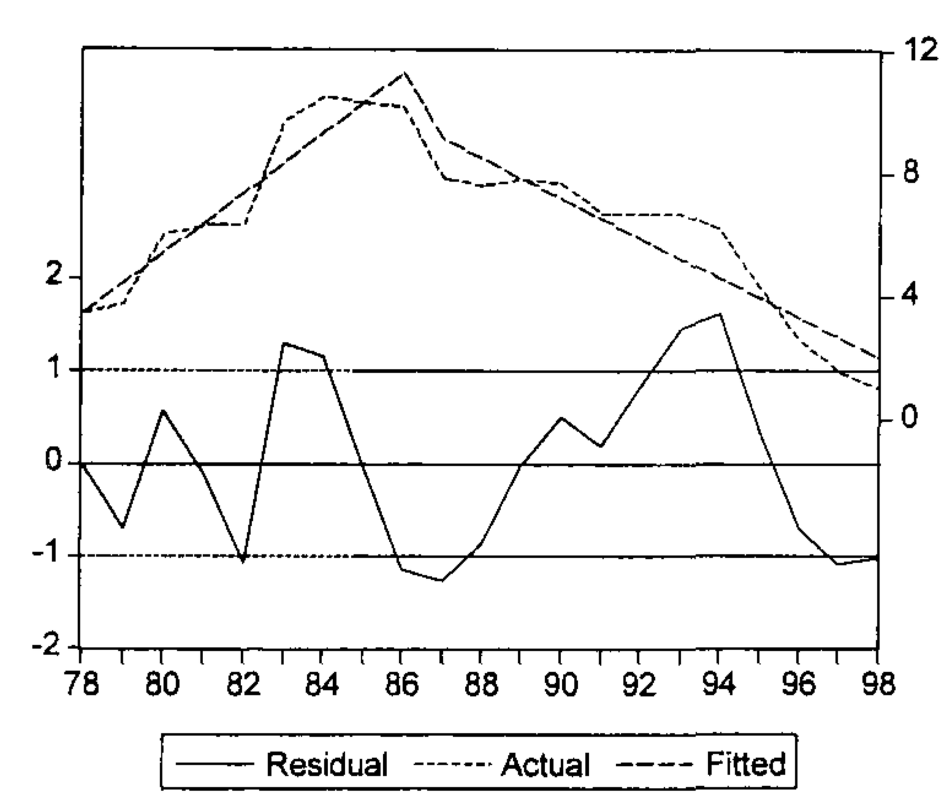
EDINBURGH			
	78-86	87-98	
spdp	$Y = 1.278 + 0.026X$ $(41.953)\ (4.795)$	$Y = 1.624 - 0.004X$ $(5.449)\ (-4.580)$	$R^2 = 0.854$ $DW = 1.511$ *
spdo & so	$Y = 1.278 + 0.026X$ $(33.880)\ (3.872)$	$Y = 1.387 + 0.001X$ $(1.384)\ (-3.072)$	$R^2 = 0.470$ $DW = 1.552$ *

ABERDEEN			
	78-86	87-98	
spdp	$Y = 1.278 + 0.026X$ (50.815) (5.808)	$Y = 1.559 - 0.005X$ (5.361) (−5.786)	$R^2 = 0.783$ $DW = 1.543$ *
spdo & so	$Y = 1.278 + 0.026X$ (38.801) (4.435)	$Y = 1.492 + 0.017X$ (0.313) (−1.341)	$R^2 = 0.847$ $DW = 1.378$

Below are a few representative diagrams illustrating some typical results among all the results shown with asterisks in the above tables, i.e., the results with significant coefficients.

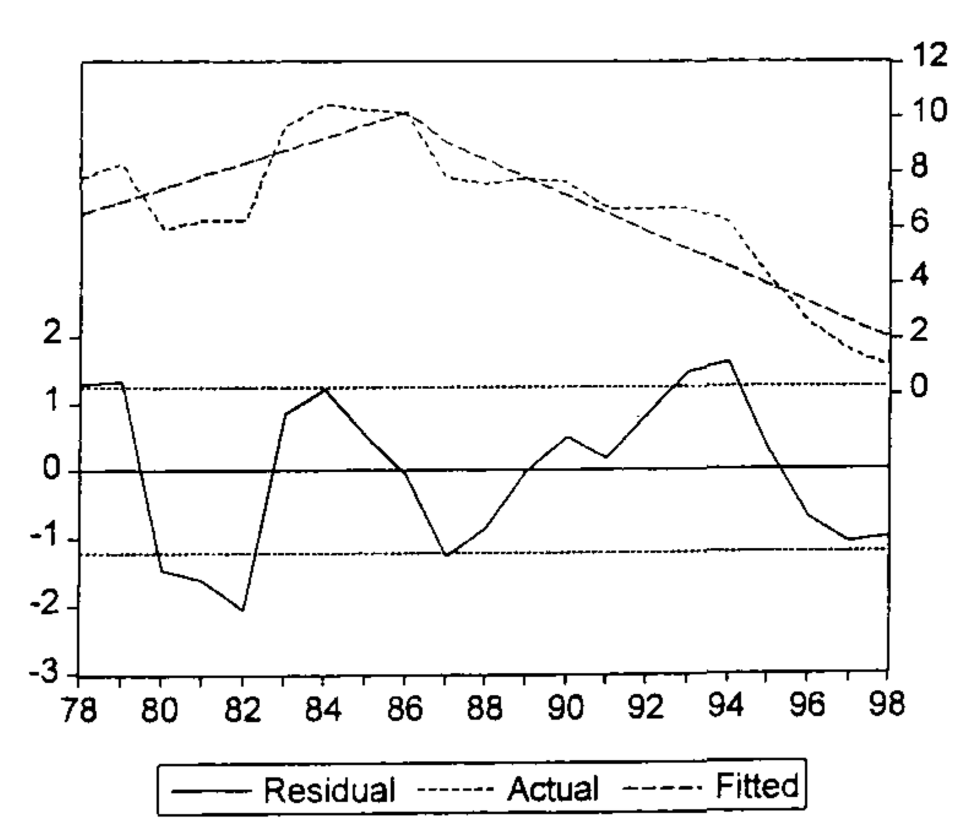
diagrams related to the results in Table 5-1

Heathrow: International passengers spdp/spdo



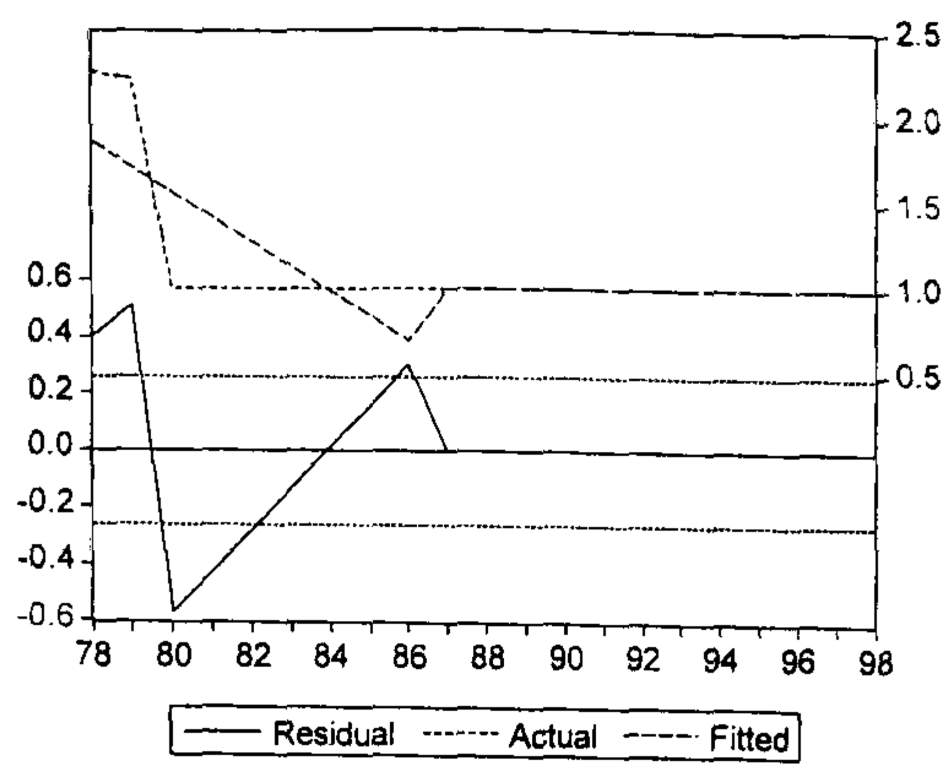
The above pattern is similar to Gatwick International spdp/spdo.

Heathrow: International passengers spdp/sodp



The above pattern is similar to Heathrow Domestic spdp/spdo, Gatwick International spdp/sodp, Gatwick Domestic spdp/spdo and Gatwick Domestic spdp/sodp.

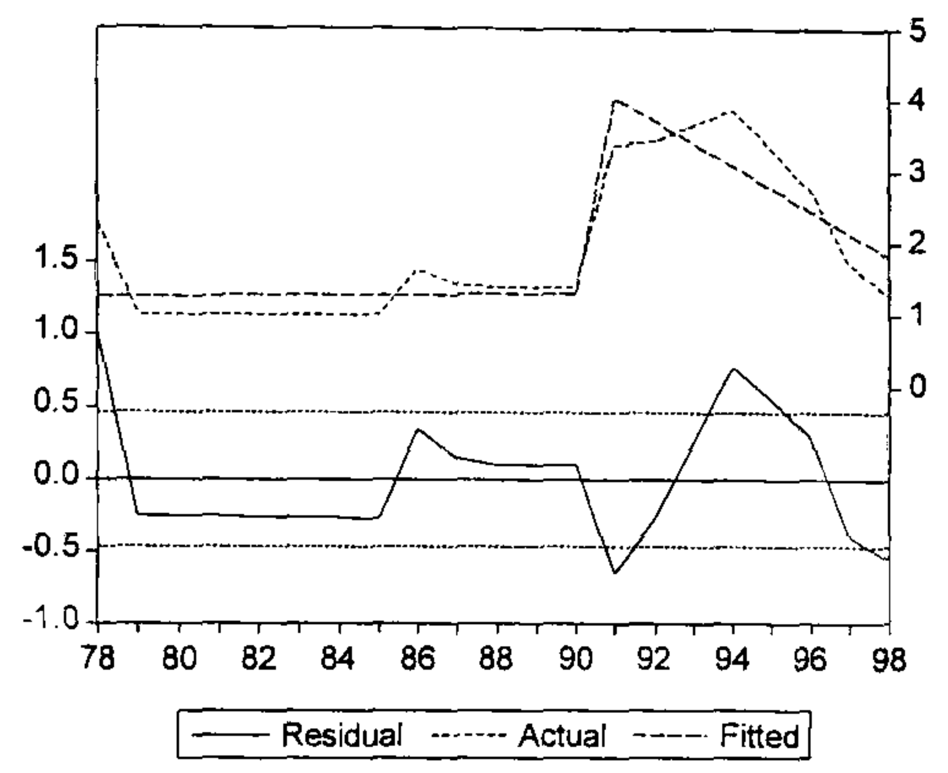
Heathrow: International passengers spdo/sodo



The above pattern is similar to Heathrow Domestic spdo/sodo,

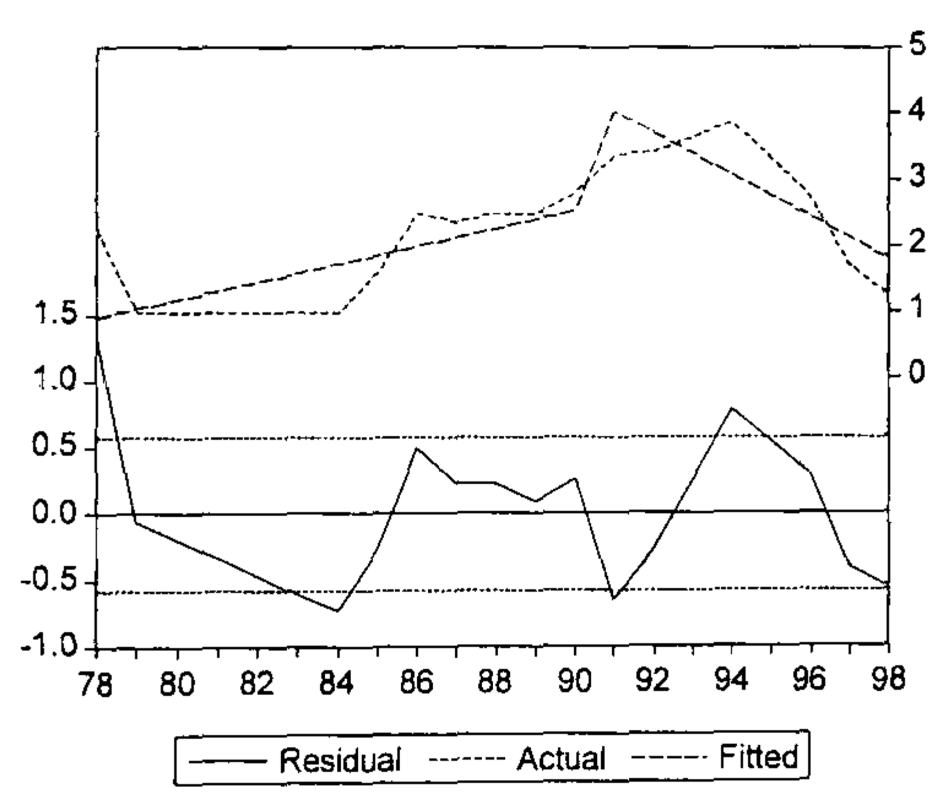
Gatwick International spdo/sodo and Gatwick Domestic spdo/sodo.

Stansted International spdp/spdo



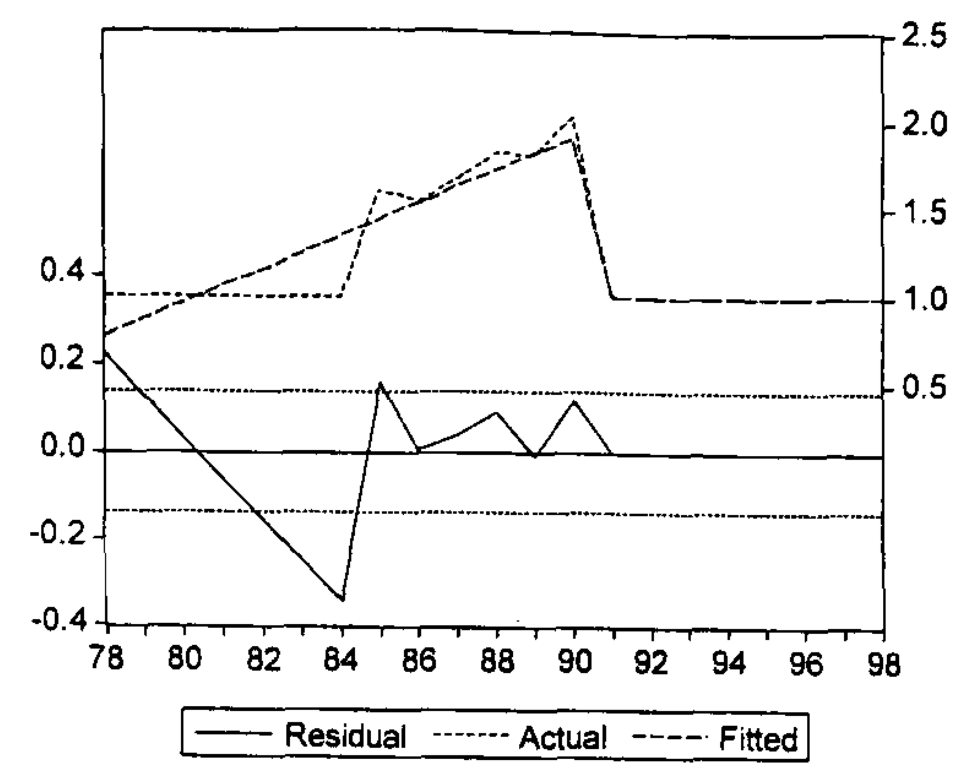
The above pattern is similar to Stansted Domestic spdp/spdo.

Stansted International spdp/sodp



The above pattern is similar to Stansted Domestic spdp/sodp.

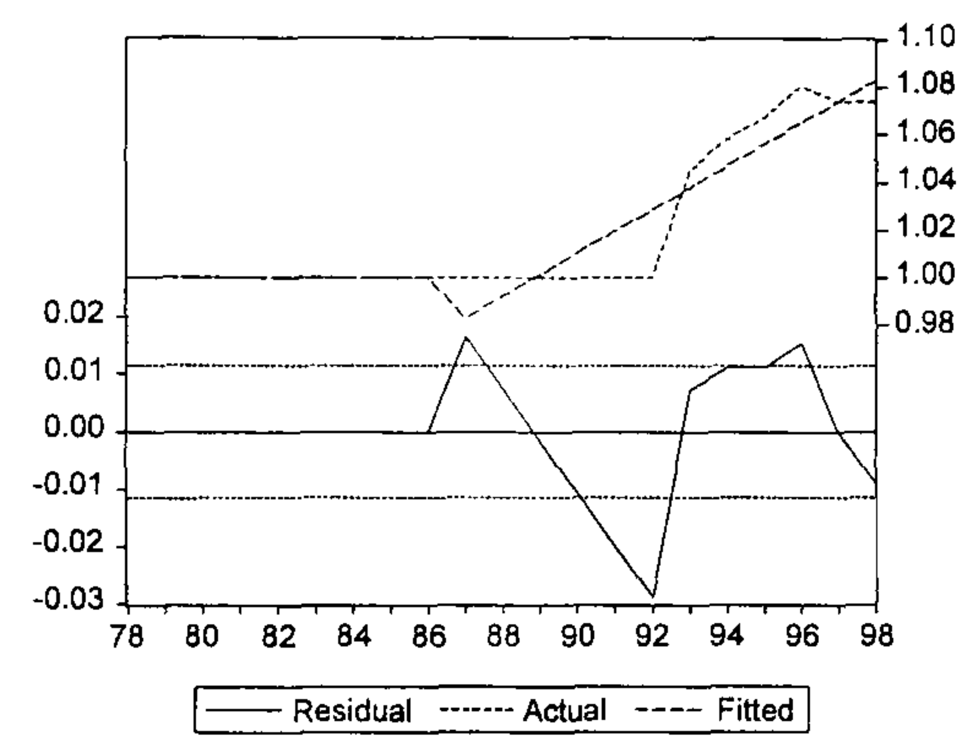
Stansted International spdo/sodo



The above pattern is similar to Stansted Domestic spdo/sodo.

diagrams related to the results in Table 5-2

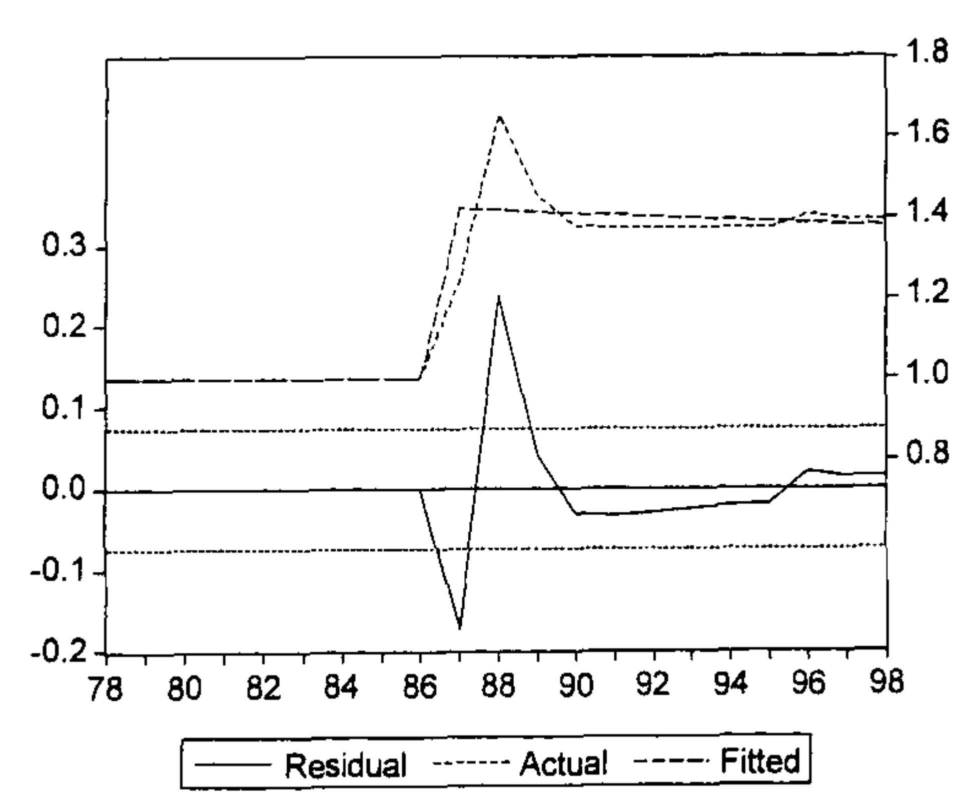
Glasgow Domestic spdp/spdo



The above pattern is similar to Edinburgh Domestic spdp/spdo and Aberdeen Domestic spdp/spdo.

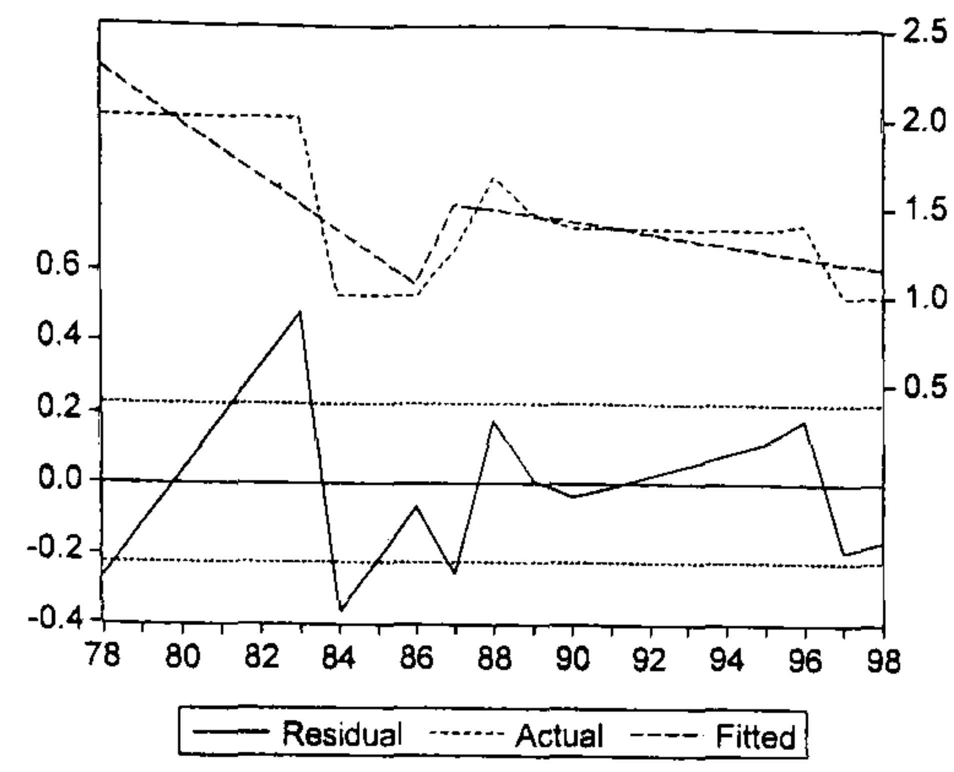
diagrams related to the results in Table 5-3

Heathrow B767 spdp/spdo



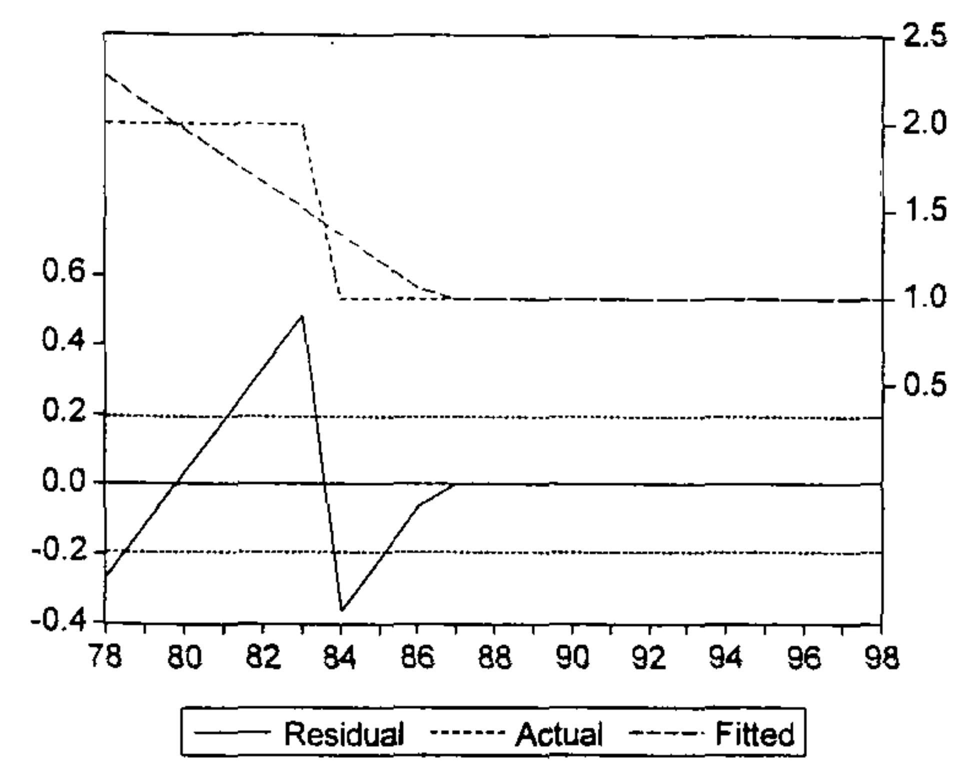
The above pattern is similar to Heathrow B737 spdp/spdo.

Heathrow B767 spdp/sodp



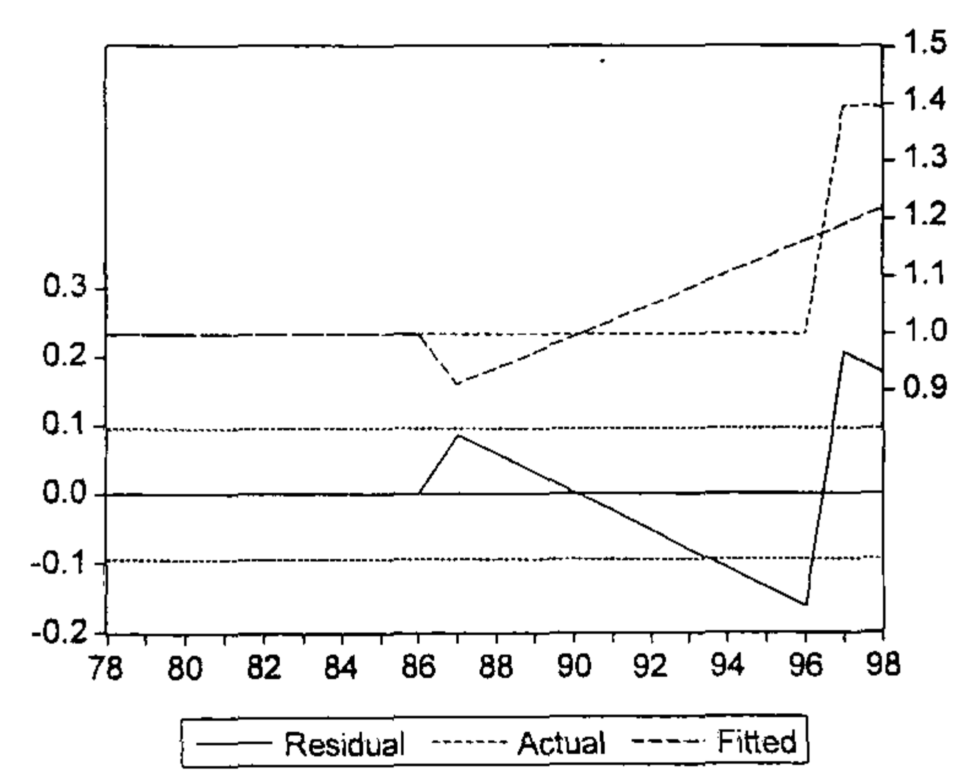
The above pattern is similar to Heathrow B737 spdp/sodp.

Heathrow B767 spdo/sodo



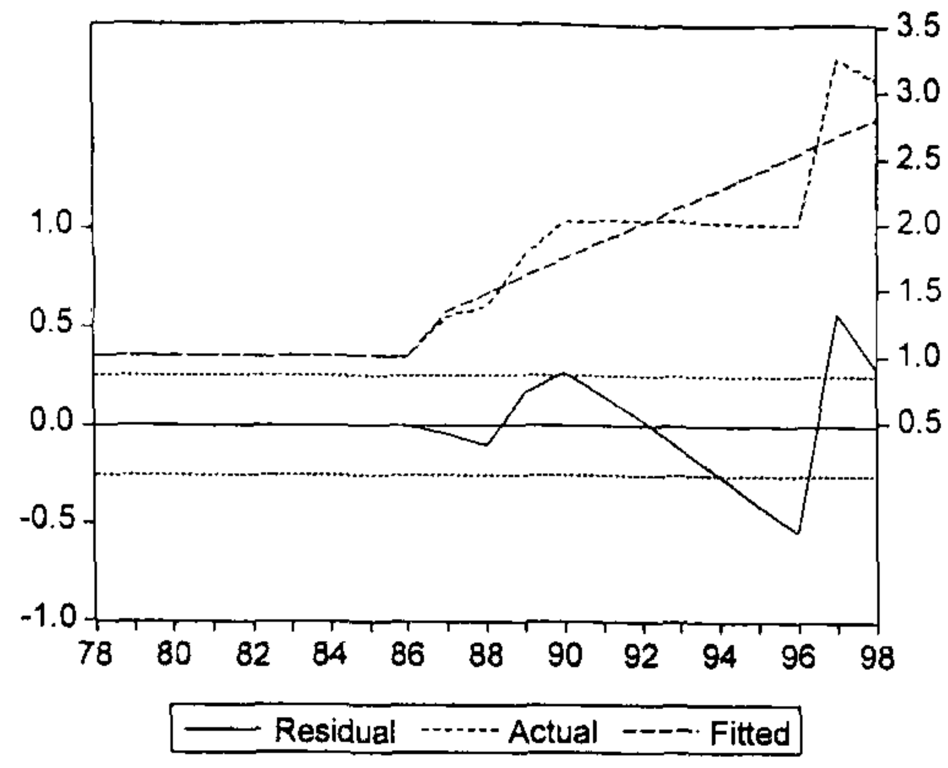
The above pattern is similar to Heathrow B737 spdo/sodo.

Heathrow B767 sodp/sodo



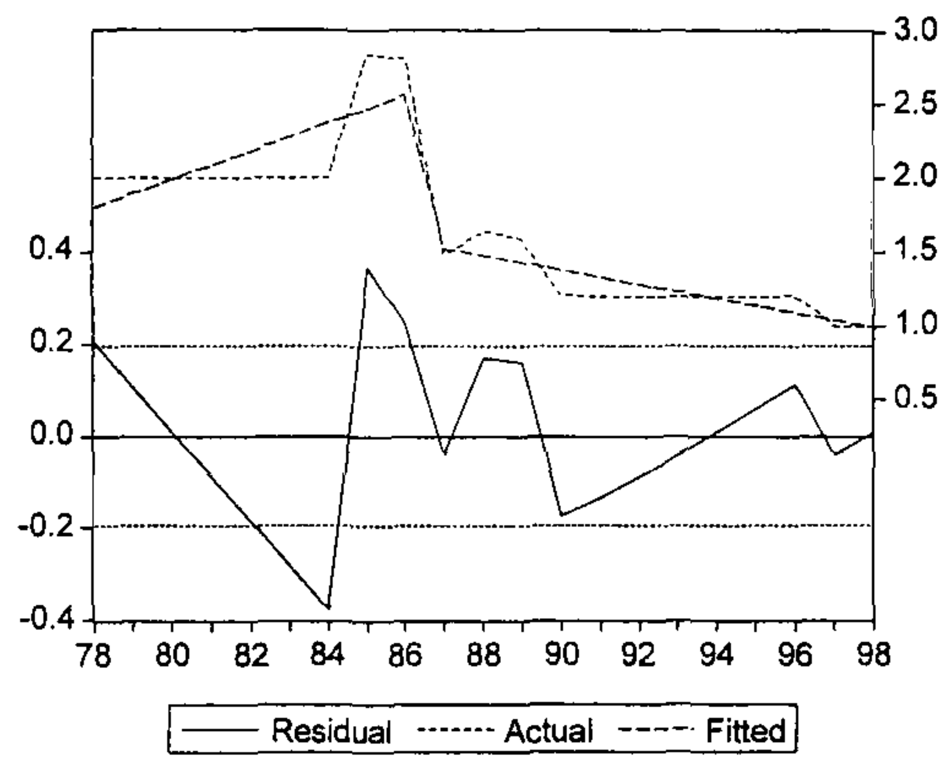
The above pattern is similar to Heathrow B737 sodp/sodo.

Gatwick B767 spdp/spdo



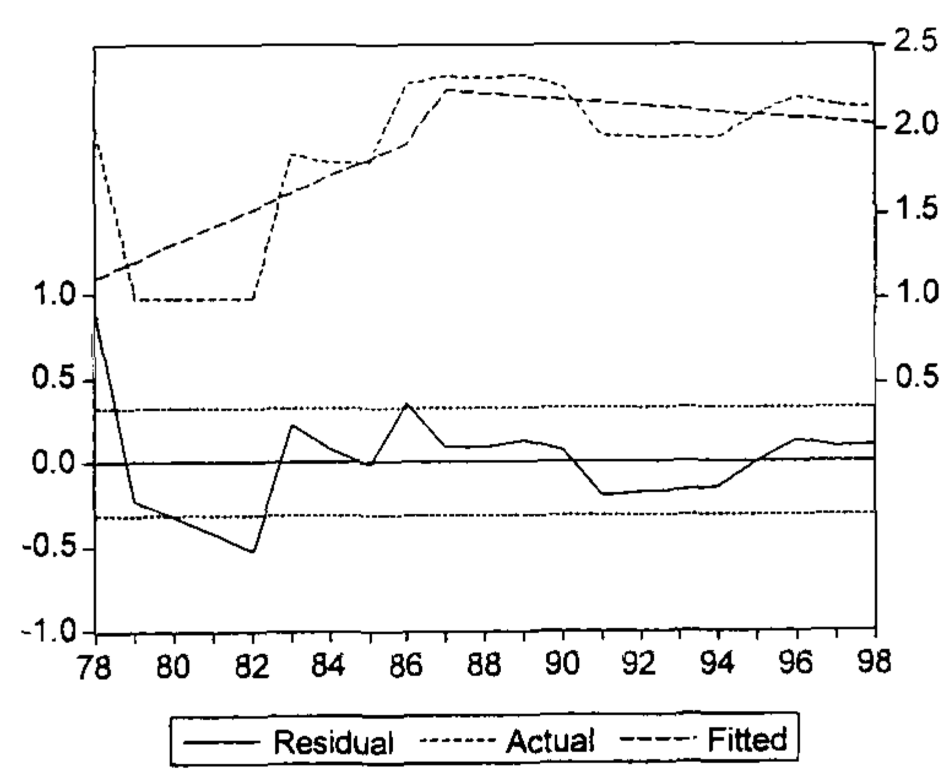
The above pattern is similar to Gatwick B737 spdp/spdo.

Gatwick B767 spdo/sodo



The above pattern is similar to Gatwick B737 spdo/sodo.

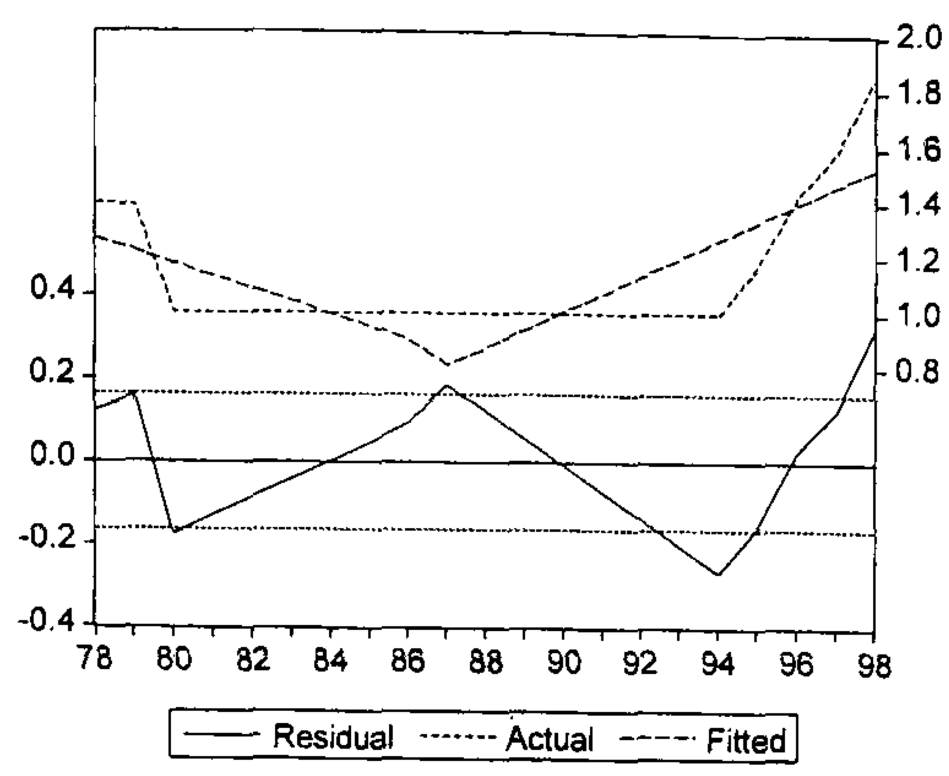
Stansted B767 spdp/sodp



The above pattern is similar to Stansted B737 spdp/sodp.

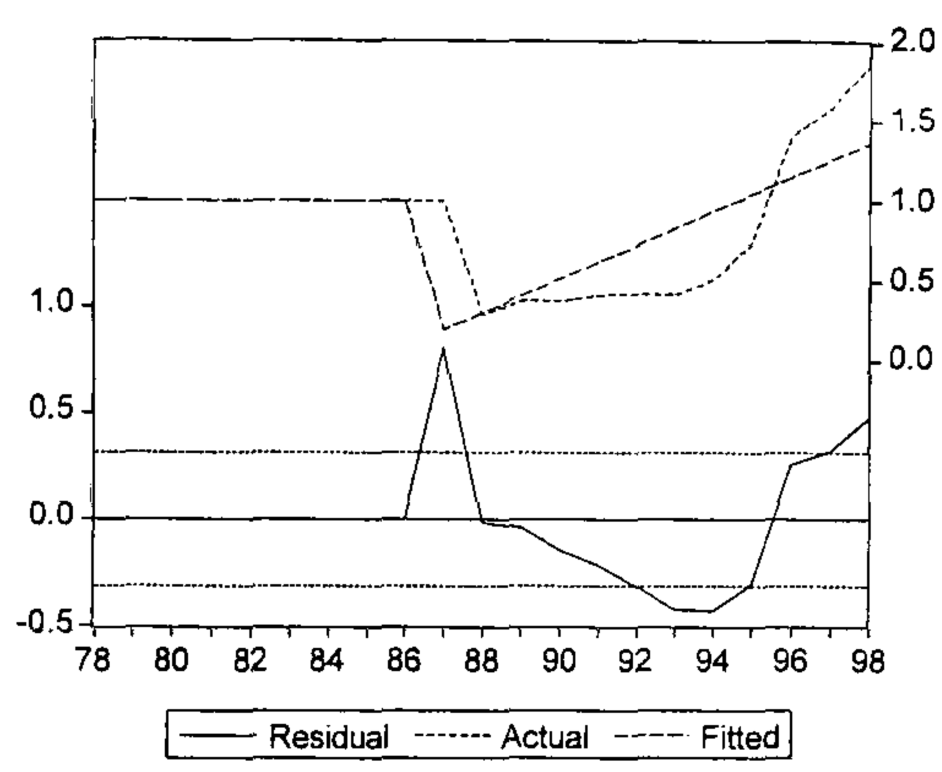
diagrams related to the results in Table 5-4

Heathrow spdo



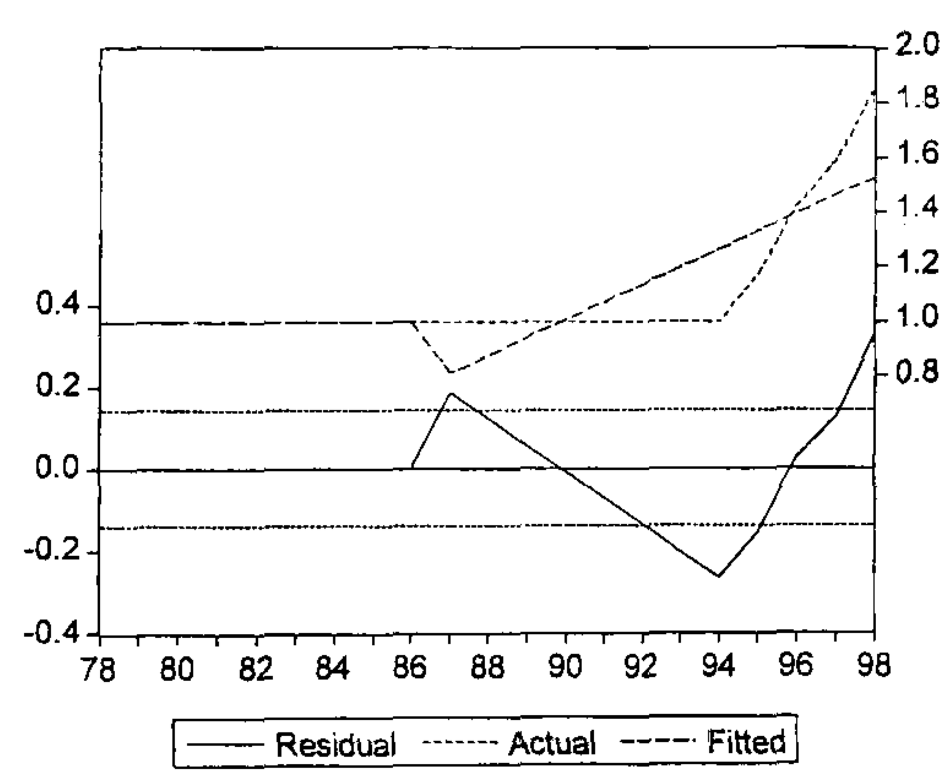
The above pattern is similar to Gatwick spdo.

Heathrow sodp



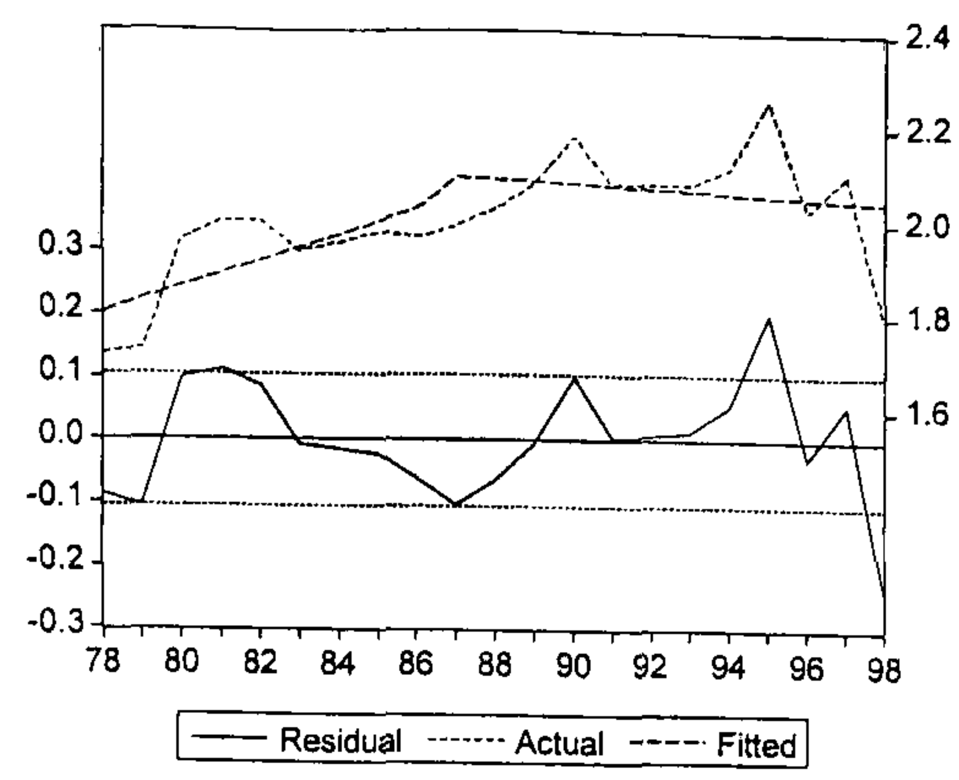
The above pattern is similar to Gatwick sodp.

Heathrow sodo



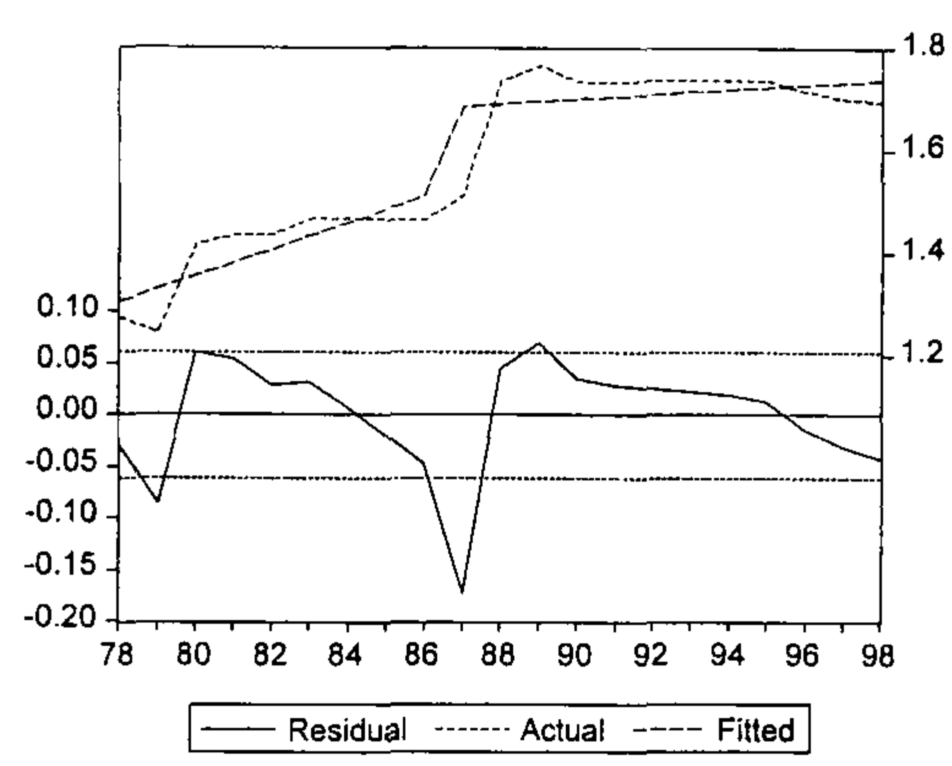
The above pattern is similar to Stansted spdo and Stansted sodp.

Gatwick spdp

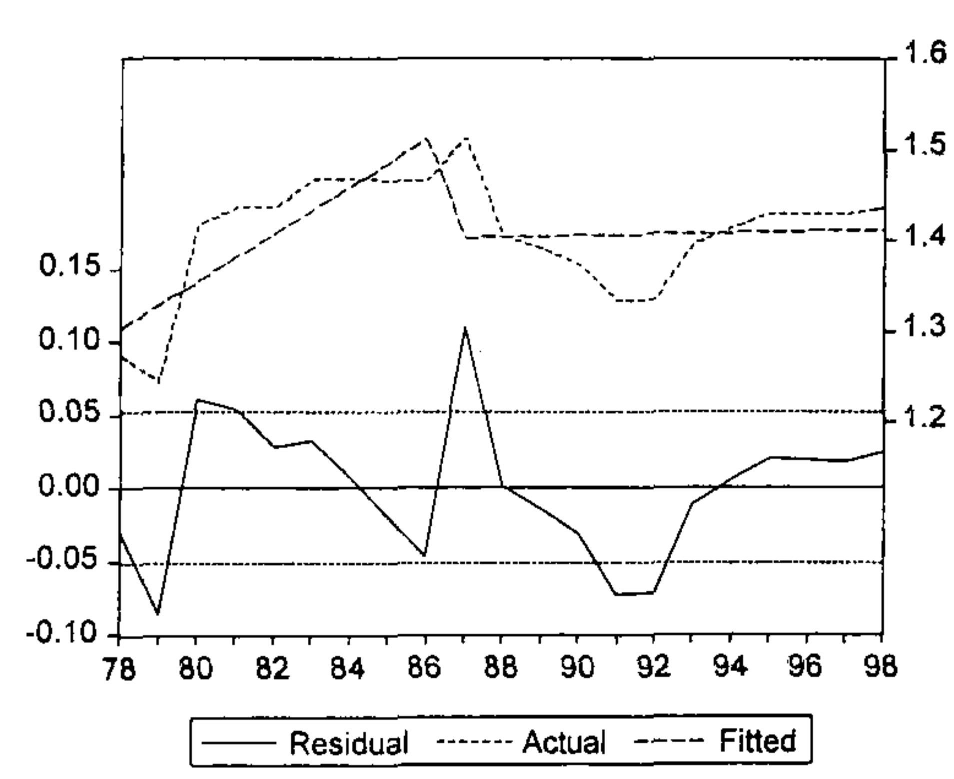


diagrams related to the results in Table 5-5

Glasgow spdp

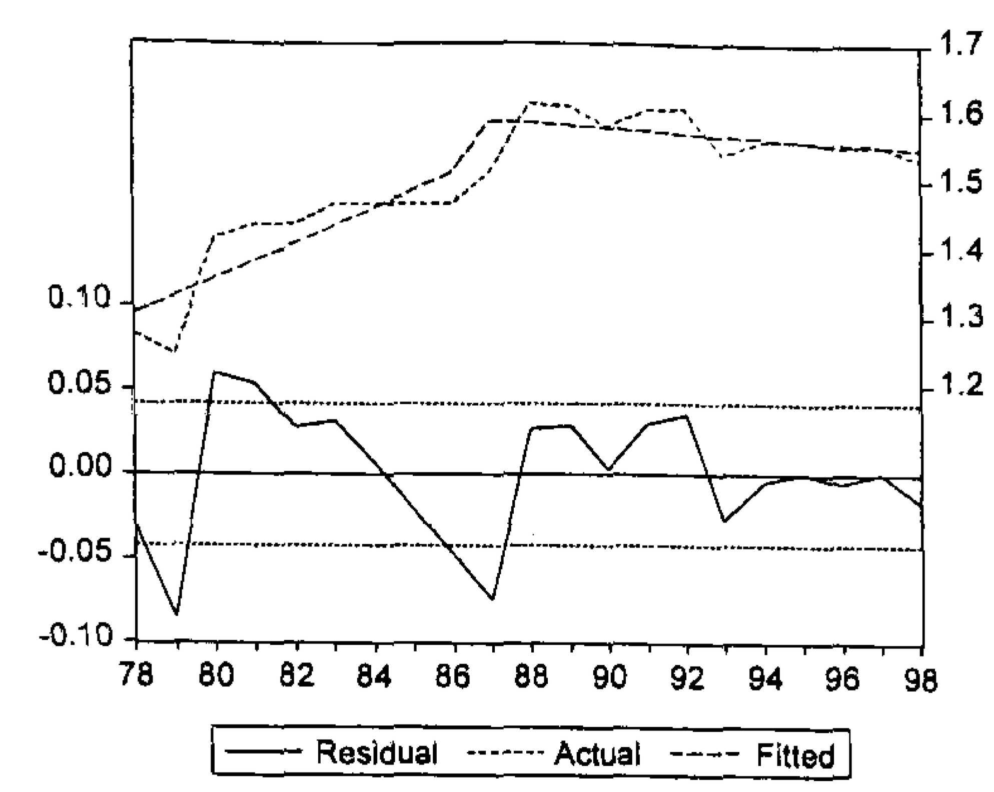


Glasgow spdo



The above pattern is similar to Edinburgh spdo.

Edinburgh spdp



The above pattern is similar to Aberdeen spdp.

The results of the tests to see if the hypothesis (1)-1 (see Table 5-1) is the case in reality are mixed, i.e., as to whether the price ratio of peak passenger charge to off-peak passenger charge seems to be raised after (AAR) had been imposed on BAA. One cannot rely on the result of Heathrow's international ratios, because at Heathrow the differential between the peak passenger charge and the off-peak passenger charge for international flights has had to be reduced gradually during the period from 1995 to 1998 by international obligation (by the 'Exchange of Notes' 1994 mentioned in Chapter 2). However, at Gatwick the patterns of the price ratio trends are very similar to those at Heathrow as shown in the diagrammatic representations. At Heathrow and Gatwick, none of the results seem to support the hypothesis (1)-1. On the contrary, on most of the cases, the directions of the slope coefficients turned out to be the opposite to the predicted price ratio level change. At Heathrow the difference between peak and off-peak passenger charges for domestic flights are not relevant to the international obligation, yet the trend shows the decreasing ratio in daily peak time. At Stansted spdp/spdo ratio for both international and domestic is rather different. However, in these cases, the factor which makes both the *average* price ratio for the period before 1990 and that for the period after 1991 different is the sudden jump at 1991. The slope coefficient after the year 1991 is negative, but there is a big difference in intercept coefficients between the two periods. The related type of trend to this Stansted spdp/spdo case was mentioned earlier in section 5-3 in the form of illustration (A). The type of trend such as (A) is not evidence for the price ratio level change. The sudden jump of the price ratio is better explained as the related jump of the peak passenger charge along with the sudden cost jump due to the opening of the new terminal at Stansted.

As to the Scottish airports' result for the ratio of peak to off-peak passenger charges (see Table 5-2), the trend shown is that it was raised at least for domestic passengers, which is opposite to the prediction. It is worth noting that at Glasgow and Edinburgh BAA has introduced a 'voluntary RPI-3' price cap since 1993. It is supposed to be evidence that BAA has been under an implicit threat from the CAA, in case it might impose price regulation on the two airports. Condie (2000) showed that as the result of this 'voluntary RPI-3', the airport charge revenue per passenger at Scottish airports has been reduced. If the effect of this voluntary (AAR) constraint is effective, the ratio of peak passenger charge to off-peak passenger charge would be predicted to rise. However, the main reason for the ratio being raised seems to be the sudden jump in 1988/89 which is one year after the regulatory reform, and since 1988/89 the ratio seems to be constant for both Glasgow and Edinburgh.

The results from the test of (3)-1 (see Table 5-3) are mixed. The results for Gatwick in terms of spdp/spdo for both B767 and B737 seem to have the price ratio raised after 1987. Regarding the result of Heathrow as to sodp/sodo for both aircraft types, as far as one can see from the diagrammatic representation, there is no change apart from the last two years, 1997 and 1998. One cannot therefore rely on this result as an evidence for the prediction. Another quite unusual case which shows the *average* price ratio was raised during the period between 1987 and 1998 is the case for spdp/spdo for B767 and B737 at Heathrow. The price ratio level was raised continuously in 1987 and 1988, but the slope coefficient for the period between 1987 and 1998 is not significantly different to that for the previous period. It is arguable whether this Heathrow's spdp/spdo case provides us with any evidence for the prediction. In any other cases the results show the opposite to the predicted price ratio change.

Regarding the results from the test (A)-1 and (A)-2, i.e., the difference between international passenger charge and domestic passenger charge, the predictions for both London airports and Scottish airports seem to fit the actual trends, apart from the result of the Gatwick's spdp case. The ratios for all three London airports' other than Gatwick's spdp (see Table 5-4) seem to have been raised since 1987 as in the hypothesis (A)-1. The results in Table 5-5 show that at two Scottish airports the decrease in the slope coefficient after the reform was observed as in the hypothesis (A)-2. As to Heathrow it is worth noting that there was a complaint against Heathrow's peak domestic passenger charge in 1988 by the airlines which specialised in domestic flights (British Midland, Dan-Air, Air UK and Manx)[5]. As the CAA judge any complaints on the basis of whether the price setting was against section 41(3) of the Airports Act 1986, i.e., whether this conduct unreasonably discriminates against any class of users of the airport, the CAA concluded this price setting was not against 41(3). These airlines complained that the peak passenger charge for domestic airlines increased at twice the rate of that for international airlines. If the (AAR) constraint was effective the ratio of international passenger charge to domestic passenger charge would have shown an opposite direction. As I mentioned before, the constraint of (QG) is quite similar to (AAR) in that the manipulative factor of current year's passenger numbers is included inside the constraint. This is the reason why (QG(A)) can be larger than (AAR(A)) if the effect of the (QG) constraint is strong (as described in Appendix (5)).

It would need further analysis for the difference between 'what the traffic would bear', i.e., the price elasticity, and the costs with the effect of constraints for both the international passenger service and the domestic passenger service, and for both peak passenger service and domestic passenger service, in order to examine the precise effect of the constraint's change. The results of the price ratio of international passenger charge to domestic passenger charge and the results of the price ratio of peak passenger charge to off-peak passenger charge might have been influenced more by the change of elasticity difference since 1987 than by the constraint's effect. This may be the case if the domestic transport modes are becoming more competitive relative to the international transport modes.

5-5. Implications

BAA recently stated in its MMC4 report that throughout the second quinquennium (1992-1996) it had been constrained by the Heathrow and Gatwick price caps, but the system price cap (a cap relevant to the three London airports' total airport charge revenue) had not been binding. Therefore during the second quinquennium at least at Heathrow and Gatwick the (AAR) constraints were binding. However, the results of the empirical tests except for the price ratio of international passenger charge to domestic passenger charge show that the predictions were not supported. Apart from the possible change in the demand elasticity difference, there are several factors which work as implicit constraints that BAA might have been more conscious of than the visible constraint of price regulation. The two most important factors to consider with regard to the matters that BAA may have taken into account are:

(1) the process through which the airport charge revenue is determined as the amount that the airport operator can earn, which is 'single-till' and

(2) international obligations

As to (1) above, 'the single-till' is the general practice of airports in the UK and overseas (in the case of Britain, this is also reinforced by 'Bermuda 2' as I described in Chapter 2). Under this practice, the level of profits from the 'commercial-side' that is used to offset the level of airport charges is irrelevant. In theory this could then lead to a negative airport charge. All that matters is that the total cost of the airport should be covered by the sum of the revenue from the 'commercial-side activities' and the revenue from the 'air-side activities'. Therefore the process of determining the level of X requires the designated airport operator to show the regulator (and the MMC) the projections of the total cost of both air-side and commercial-side, followed by the projections for the commercial-side revenue, based on the forecast passenger numbers. Finally the difference between the total cost of the 'operational activities' and the projected revenue from the 'commercial-side activities' is forecasted. This difference is the allowed revenue from the 'air-side' and is related to the decision on the level of X.

This process needs in-depth investigation concerning the cost of capital at an early stage of the regulatory review. The level of the projected total cost is linked to the overall profit and there is room for the operator to manipulate the capital base to increase profits. This problem is related to a well-known tendency for a regulated firm to inflate the cost of capital when the firm is subject to the rate of return regulation.

The CAA once turned down the recommendation by the MMC on the level of X during the second quinquennium, and set a higher series of X values than the MMC's X, insisting that BAA's three London airports' rate of return should be 7% rather than 8%. 8% was the figure estimated to be reasonable by the MMC. BAA was concerned about the X values that the CAA had set, and tried with the help of the user airlines to persuade the CAA to change them. One of the major reasons why BAA disapproved of the CAA's announcement was that BAA was uncertain about the CAA's future action in terms of setting X for the construction of Terminal 5. At the time of the review, it was known that Terminal 5 would be constructed during either the 3rd or 4th quinquennium depending on the public enquiry. The terminal 5 construction issue was not of immediate relevance during the second quinquennium, nevertheless BAA was wary that the way the CAA had acted in setting the X values might have an influence on the way the CAA would set the X values in the 3rd or 4th quinquennium. This incident can be regarded as a good example of the possibility that a regulated airport operator may be interested in securing the long run capital base by trying to manipulate the setting of X in the short term, i.e., a price capping for five years can be looked upon by the operator as just a regulatory lag.

It has also been pointed out that the tendency for over-investment under the rate of return regulation can be realised through distortion of the price structure.[6] By reducing the peak price, depending on the elasticity, it may be possible that the expansion of the capital base is justified through the increased peak demand. It is quite difficult to carry out any empirical analysis to find out if there has been any reduction of peak airport charges, particularly for passenger charges (in the case of BAA's London airports the option of building additional runways has been non-existent as described in the 1985

White Paper (see Chapter 2)) with the intention of increasing the peak demand in order for the operator to be able to justify the *seemingly proper cost projection* during the reviews. However, it is worth mentioning that at Gatwick, when the passenger charge applied to the same time period and same day for each year is compared, it is clearly indicated that the period allocated as the peak months has been getting wider, at the same time the difference between the seasonal (monthly) peak charge and the seasonal (monthly) off-peak charge has been reduced gradually since 1991/92 for both international flight passengers and domestic flight passengers[7].

As for (2) above, the international agreement that is of particular importance as a constraint to BAA's London airports is the 'Exchange of Notes 1994' which is an arbitration settlement cancelling the 1983's MOU. Under this agreement BAA is obliged to phase out the difference between international peak passenger charge and international off-peak passenger charge. However, in reality both at Gatwick and Stansted the differential between peak passenger charge and off-peak passenger charge have been phased out in a very similar way to the differential which has been phasing out at Heathrow over the same period. This may mean that BAA chose to avoid any future penalty against the other two airports. It is becoming 'normal' for a regulator of a utility industry to 'informally advise' the companies to carry out a particular form of rebalancing of charges. It is not known if the CAA has informal contacts with the regulated airports or not, yet this kind of contact is possible. The 'voluntary RPI-X' on their airport charges at Glasgow and Edinburgh could have been the BAA's strategy to avoid the CAA's 'informal' contact in advance. It would be interesting to see how the fact that the CAA is also the regulator of the airline industry (i.e., the user side of the airport industry) affects the risk perceived by the designated airports of the possible imposition of penalties.

Notes to Chapter 5

1. BAA calls them 'charging parameters'.

2. The 18 airports are Heathrow, Gatwick, Stansted, Glasgow, Edinburgh, Aberdeen, Manchester, Birmingham, Luton, Newcastle, East Midlands, Bristol, Leeds-Bradford, Cardiff, Teesside, Norwich, Blackpool, and Bournemouth.

3. There was an analysis of airports' cost structures in a part of a report by Doganis and Thompson (1973). Regression models were used to identify the long run cost of air-side operations. Their principal model of the cost functional form was as follows:

$$lnTC = A + b1 \cdot lnQ + b2 \cdot lnINT + b3 \cdot DVT + b4 \cdot ATC,$$

where TC is the total cost of air-side operation, Q is output measured in terms of Work Load Unit (this is a conventional measure to combine both passengers and freight; this report's conversion unit was 1 Work Load Unit as either one terminal passenger or 100 kg of freight or mail, see Doganis (1992)). INT denotes the percentage of the passengers on international flights to the total passenger numbers, DVT is a dummy variable to any existence of a major development programme (either 0 if none, or 1 if a major development programme existed in the past ten years) and ATC denotes a dummy variable as to the airport's involvement in the air traffic control operation (either 0 if the airport was responsible for air traffic control, or 1 if not). They used cross-section data for the estimation of TC.

4. Recently categorisation by noise level of aircraft was introduced by ICAO. BAA's airports recently introduced penalties on noisy aircraft. Basically 'Chapter 1 or 2' aircraft types are the noisiest and 'Chapter 4' type aircraft are regarded as the quietest.

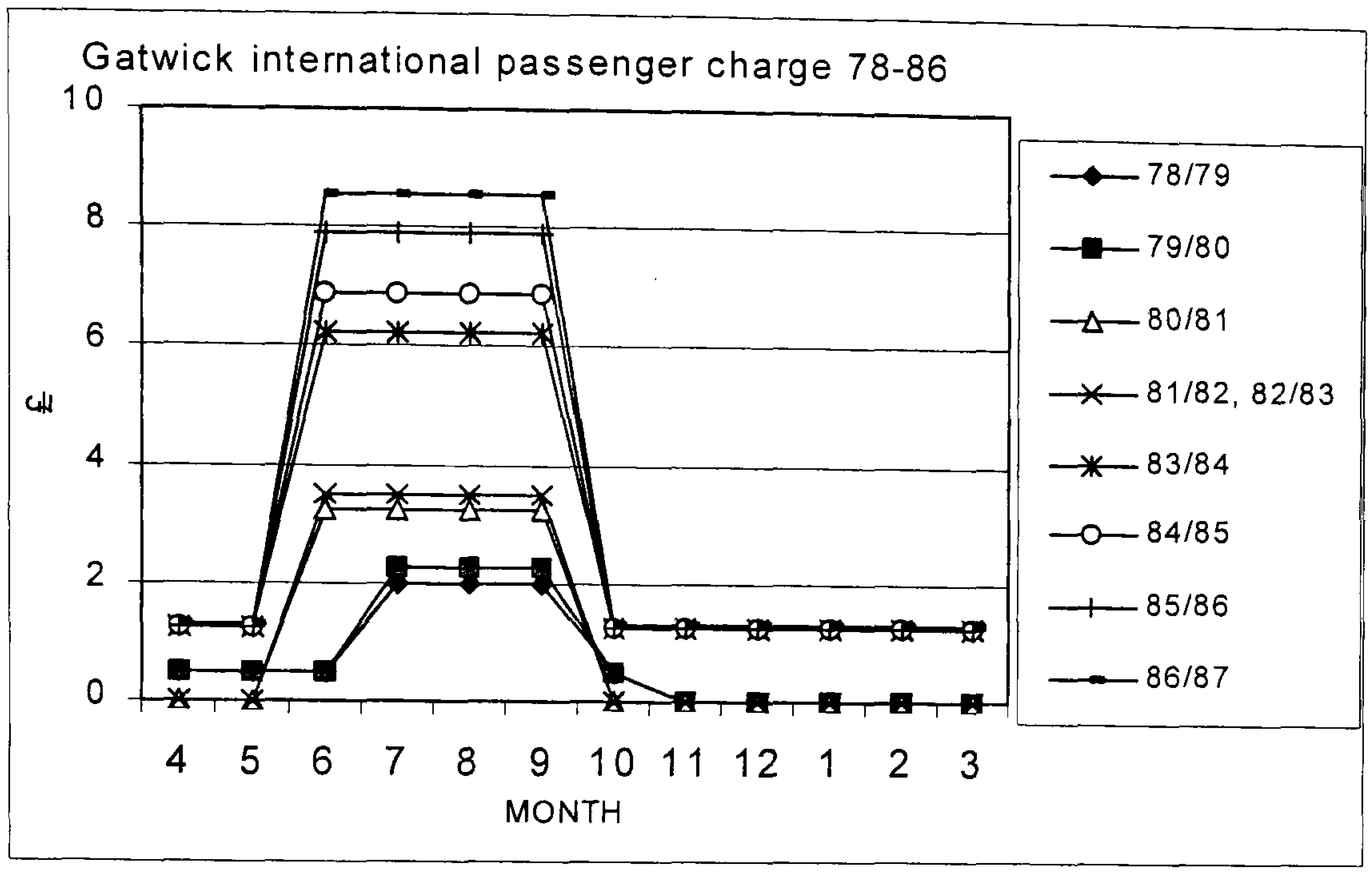
'Chapter 3' aircraft are relatively quiet and at BAA's airports there is no noise penalty charge for landing the 'Chapter 3' aircraft. The noise factor in airport charge regulation, however, is not an issue in this thesis.

5. Civil Aviation Authority document 'APD3'.

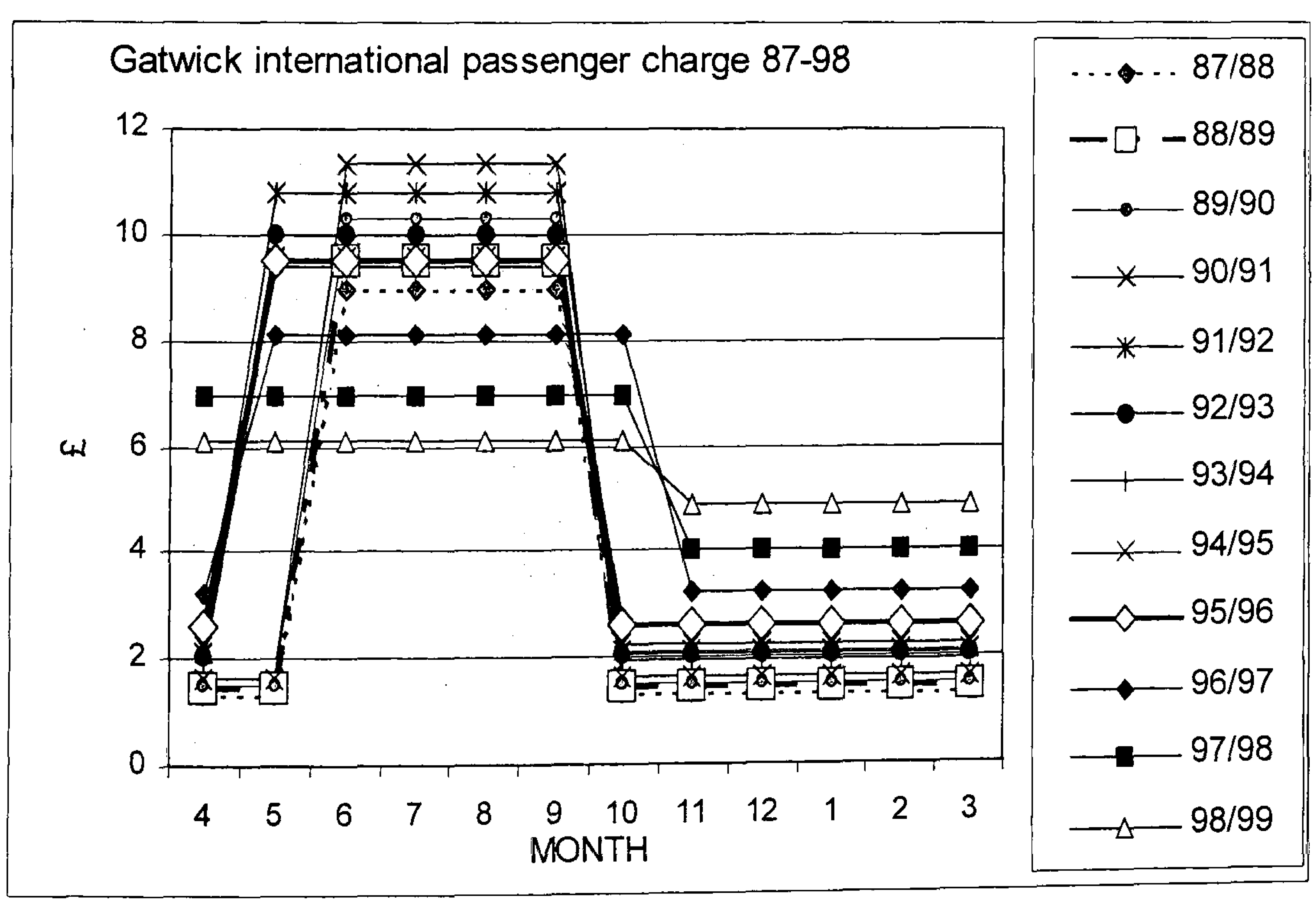
6. Sherman (1985) and Bailey and White (1974).

7. The tables below show the actual international passenger charge's seasonal trends for the period between 1978/79 and 1986/87 and the period between 1987/88 and 1998/99, i.e., before and after the regulatory reform respectively. The charge is applied to the international passengers who depart on Saturdays or Sundays during the time period between 9:00 AM and 15:00 PM. The horizontal axis shows months from April to March. Using the same notation as in this Chapter, the comparison showing the tables are between the price categories of spdp and sodp. The tables show that (1) particularly from 1983/84 (when the new traffic growth related financial target was introduced) the 'peakiness' has been sharpened and (2) from 1990/91 the difference of the charge between peak months and off-peak months has been gradually reduced.

Gatwick's seasonal trend of international passenger charge: before the regulatory reform



Gatwick's seasonal trend of international passenger charge: after the regulatory reform



Chapter 6

UK Airport Industry: Productive Efficiency

6-1. Introduction

The purpose of this chapter is to seek evidence concerning differences in productive efficiency for the different types of airport operators under different sets of objectives and constraints. As we have already seen, the regulatory reform following the 1986 Airports Act changed the ownership of and constraints on UK airports, and four categories of airports under different 'institutional arrangement' were established as described in Chapter 3. In this chapter, I address the issue of changes in efficiency from the point of view of productivity. As I have analysed in Chapter 3, the main changes we can see in the UK airport industry are as follows:

(1) from nationalised to privatised with price regulation

(2) from nationalised to privatised without price regulation

(3) from direct local authority management to local authority plc with price regulation

(4) from direct local authority management to local authority plc without price regulation

In Chapter 3 I have used a basic regulatory model and have predicted different levels of both cost-reduction and investment for each of the above four types in the period before and after the regulatory reform. The differences were mainly caused by changes in objectives and in the style of constraints. The following tables are summaries of the predictions from the regulatory models I used in Chapter 3.

(1) BAA's 3 London airports

	~82/83 nationalised	83/84~86/87 growth related f.t.*	87/88~ privatised
cost reduction effort	$-c_x = \frac{b-1}{\lambda} + 1$ (3-3)	$-c_x = \frac{b-1}{\lambda} + 1$ (3-11)	$-c_x = a$ (3-18)
level of investment	$-c_k = \theta(k)\{1 - \eta(k)\}$ (3-4)	$-c_k = \theta(k)$ (3-12)	$-c_k = r$ (3-7)

* f.t. denotes financial target

(2) BAA's Scottish airports

	~86/87 nationalised	87/88~ privatised
cost reduction effort	$-c_x = \frac{b-1}{\lambda} + 1$ (3-3)	$-c_x = a$ (3-18)
level of investment	$-c_k = \theta(k)\{1 - \eta(k)\}$ (3-4)	$-c_k = r$ (3-7)

(3) Manchester Airport

	~86/87 direct local authority management	87/88~ plc
cost reduction effort	$-c_x = 1 - \frac{d-1}{\lambda}$ (3-15)	$-c_x = \alpha$ (3-24)
level of investment	$-c_k = r - G_k - \frac{\rho}{\lambda}$ (3-16)	$-c_k = r + \gamma$ (3-25)

(4) local authorities' airports other than Manchester

	~86/87 direct local authority management	87/88~ plc
cost reduction effort	$-c_x = 1 - \frac{d-1}{\lambda}$ (3-15)	$-c_x = \beta$ (3-21)
level of investment	$-c_k = r - G_k - \frac{\rho}{\lambda}$ (3-16)	$-c_k = r + \delta$ (3-22)

Benchmarks

cost reduction effort	$-c_x = 1$ (3-6)
level of investment	$-c_k = r$ (3-7)

Regarding categories (1) and (2) above, i.e., BAA's London and Scottish airports, the improvement in both cost-reduction and level of investment is predicted after privatisation (from (3-3) and (3-4) to (3-18) and (3-7) respectively). The main impact of the privatisation of the then British Airports Authority is considered to be the pressure of the capital market, rather than pressure through competition among airports. I have assumed in Chapter 3 that value a is smaller than b, because of the stronger monitoring of the managers placed upon their managerial effort. Where $a < b$ holds, it is always the case that $\frac{b-1}{\lambda} + 1 > a$ holds as to the cost-reduction effort when comparing (3-3) with (3-18). During the period between 1983/84 and 1986/87 (when a unique traffic growth related financial target form was imposed each year) there seems to have been stronger pressure on management to raise their cost-reduction effort, as analysed in Chapter 3, via an increased value of λ. However, as long as $a < b$, the amount of x input as the cost-reduction activity in this period cannot have been greater than the amount which is realised after privatisation. Regarding the investment level, the model result in Chapter 3 predicts that BAA's airports after privatisation are efficient in the sense that the marginal benefit of reducing the non-capital cost due to investing in capital stock is equal to the opportunity cost of capital as $-c_k = r$. Under nationalisation, (3-4) implies that the investment level of capital stock is either too large or too small compared to the optimum, depending on whether $\theta(k)\{1 - \eta(k)\}$ is less than or greater than the cost of capital r (there was no guarantee that $\theta(k)\{1 - \eta(k)\} = r$). During the period between 1983/84 and 1986/87, the investment condition was directly determined by the traffic growth related financial target and indirectly determined by the output as shown by (3-12) as $-c_k = \theta(k)$ (although in the case of Scottish airports this constraint is considered to be irrelevant, as explained in section 5-3-(1) they were subject to a break-even constraint during this period). There may be, again, either over-investment or under-investment, depending on whether $\theta(k)$ is less than or greater than r. As the financial target in each year during this period was met, the financial target constraint was binding each year and the value of θ is considered to become larger via the value of λ as the traffic was growing increasingly during this period (as mentioned in Chapter 3). Thus at least it is reasonable to make a hypothesis that compared to the period between 1983/84 and

1986/87, the investment level had been changed from under-investment toward the optimum after privatisation. Combining the effect of both changing the cost-reduction effort level determined by $-c_x = \frac{b-1}{\lambda} + 1$ to the level determined by $-c_x = a$ and changing the investment level determined by $-c_k = \theta(k)\{1 - \eta(k)\}$ (and $-c_k = \theta(k)$ just before privatisation) to the optimal level, it is considered as a hypothesis that the productive efficiency of the then British Airports Authority was improved after privatisation as BAA.

As to the categories (3) and (4) which are local authority airports, it is difficult to predict how the cost-reduction effort may have been changed, because the comparison between (3-15) and (3-24) and the comparison between (3-15) and (3-21) would require us to know the strength of the constraint of (3-13). However, at least in so far as political pressure towards providing employment within the local community was removed after the regulatory reform, we can assume $d > \alpha > 1$ and $d > \beta > 1$. Thus it is likely that the marginal cost to the managers of the local authority airports of the cost-reduction activities would be smaller after the regulatory reform than before. The change in the level of investment was clear. It was predicted, by the comparison between (3-16) and (3-22) (in Manchester's case by the comparison between (3-16) and (3-25)), that the tendency towards over-investment was reduced as the constraint of the central government grant was removed and only the capital borrowing limit was left, meaning that they are facing an under-investment problem. Overall it can be predicted that productive efficiency in local authority airports was improved after the regulatory reform.

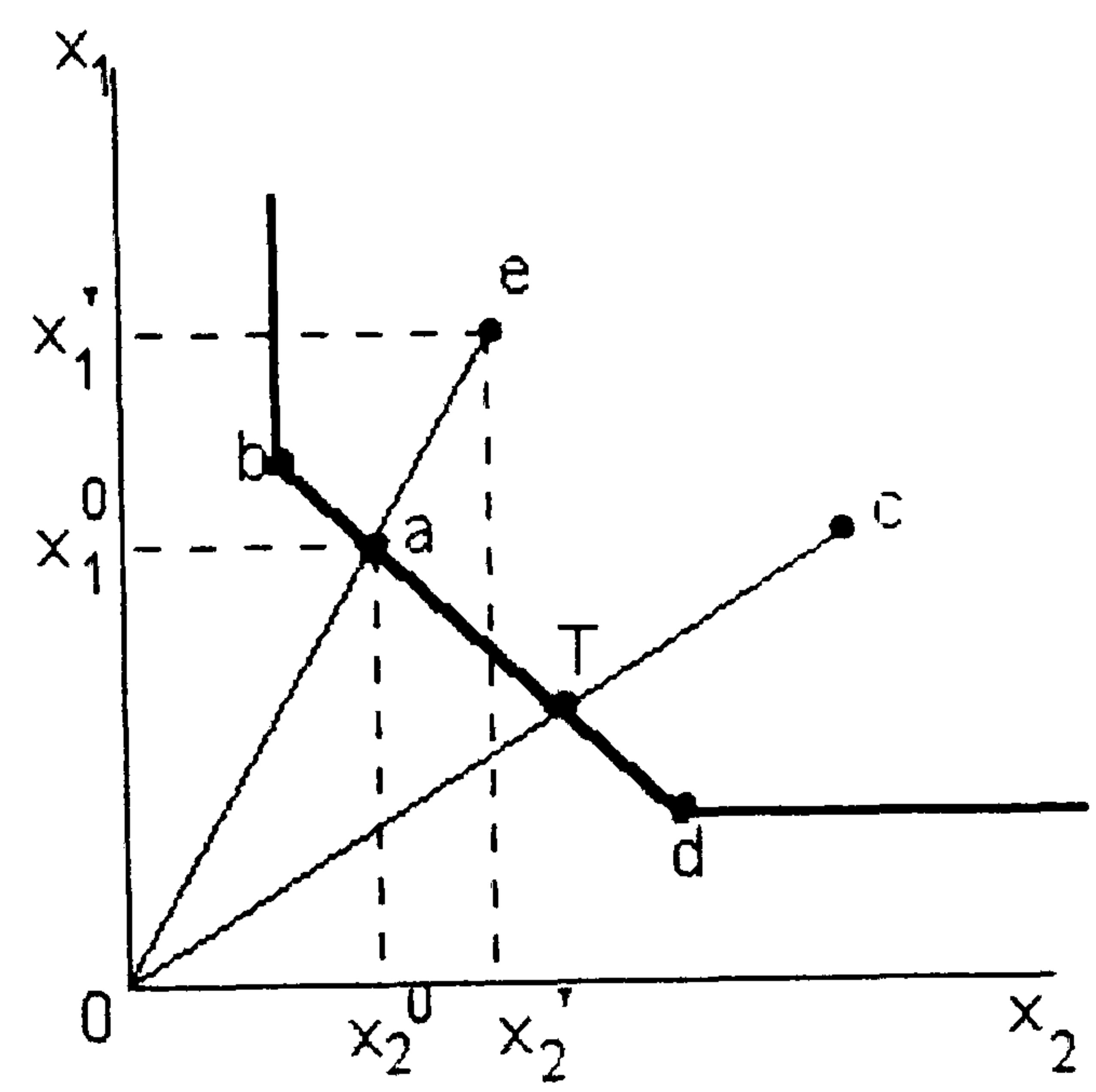
In the next section I explain the framework for the efficiency measurements I carry out in this chapter. In section 6-3 the data and the methodologies regarding the two types of efficiency measurements I use in this chapter are described. Section 6-4 and 6-5 are the results of the two empirical efficiency measurements. I summarise in section 6-6 the results of productive efficiency tests including those of BAA which were carried out by other researchers and compare them with my result.

6-2. Framework for technical efficiency measurement

I use Data Envelopment Analysis (hereafter DEA) which originated from Farrell's work (1957) on frontier analysis and developed by Charnes, Cooper and Rhodes (1978). DEA enables us to measure the efficiency of each 'decision making unit (hereafter DMU)' based only on the observed most efficient units. Assessments can be carried out by DEA as to the relative efficiency of a set of DMUs producing a set of outputs using a set of inputs. One of the advantages of DEA is that one does not need to specify any production functions so that only the observed data is relied upon. Another advantage of DEA is that it is not based on the process of 'averaging' data unlike regression analysis. DEA is based on the construction of the technology frontier and calculation of the efficiency score for each unit and can be made using the frontier as a benchmark of a 100% efficiency level, i.e., the efficiency score is measured by the distance from the frontier. DEA efficiency measurement can be looked upon as the combined efficiency caused both by any cost-reduction effort and by any improvement in investment level in the context of Chapter 3's models.

Suppose there are five organisational units that belong to an industry that uses two inputs, x_1 and x_2, and produces one output, y. All units produce exactly the same amount of the output which is $\overline{y}$. The important assumption is that if one combines existing units using non-negative multiples of their input output levels, the resulting input output levels are feasible in principle. Thus after plotting the actual levels one can make a boundary as shown in Figure 6-1, which is a boundary below which no combination of two inputs can produce the amount of $\overline{y}$. This is called the efficiency boundary. For instance, the unit operating with an input-output mix of $(x_1^0, x_2^0, \overline{y})$ is plotted as **a**, and is considered as input efficient, while the unit expressed as **e** using $(x_1^/, x_2^/, \overline{y})$ is not efficient compared with **a**. Unit **b** and **d** are also efficient. The technical input efficiency of **a**, **b** and **d** is 1, while that of **e** is measured as **oa/oe**. In the case of **c**, the measurement of efficiency is **oT/oc**. Where **T** shows the lowest input levels unit **c** could have used to produce $\overline{y}$. In the context of Figure 6-1, a unit can be said to be efficient if no other individual unit or combination of units can reduce at least one of its input levels without requiring either a lower level on at least one of the outputs, or a higher level of at least one other input.

Figure 6-1 an efficiency boundary



The general method for seeking the efficiency of unit m_0 is as follows:

$$\max \quad e^0 = \frac{\sum_{j=1}^{t} w_j y_{jmo}}{\sum_{i=1}^{s} v_i x_{imo}} \tag{6-1}$$

$$\text{s.t.} \quad \frac{\sum_{j=1}^{t} w_j y_{jm}}{\sum_{i=1}^{s} v_i x_{im}} \leq 1, \quad w_j, v_i \geq \varepsilon \qquad m=1,\ldots,n; \forall \ j \text{ and } i,$$

where

y_{jm} = amount of output j from unit m,

x_{im} = amount of input i from unit m,

w_j = the weight given to output j,

v_i = the weight given to input i,

n = the number of units,

t = the number of outputs,

s = the number of inputs,

ε = a small positive number.

The above model starts from a concept of efficiency which is $\frac{output}{input}$. Since typically an organisational unit operates with more than one input and output, efficiency measure can be defined as $\frac{weighted\ sum\ of\ outputs}{weighted\ sum\ of\ inputs}$. To solve the model (6-1) it is necessary to convert it into linear form so that the methods of linear programming can be applied. The linear programming version of the model (6-1) is as follows:

$$
\begin{aligned}
max \quad & e_0 = \sum_{j=1}^{t} w_j y_{jm_o} \\
s.t. \quad & \sum_{i=1}^{s} v_i x_{im_0} = 1 , \\
& -\sum_{i=1}^{s} v_i x_{im} + \sum_{j=1}^{t} w_j y_{jm} \leq 0 , \\
& \qquad m = 1,..,n;\ i = 1,..,s;\ j = 1,..,t;\ v_i, w_j \geq 0
\end{aligned}
$$

(6-2-*P*)

The fractional programming problem of (6-1) is equivalent to the linear programming problem (6-2-P).

For any linear programming model it is possible to formulate a partner model using the same data. The solution to either the original linear programming model (the primal) or the partner (the dual) provides the same information about the problem being modelled. The dual formulation of (6-2-P) model can be arranged as follows:

$$
\begin{aligned}
min \quad & \theta_0 \\
s.t. \quad & -\sum_{m=1}^{n} x_{im}\lambda_m + \theta_0 x_{im_0} \geq 0 , \\
& \sum_{m=1}^{n} y_{jm}\lambda_m \geq y_{jm_0} , \\
& \qquad \lambda_m \geq 0 ; \quad \theta_0 \ unconstrained
\end{aligned}
$$

(6-2-*D*)

θ_0 and λ_m are related dual variables. When slack variables are defined as:

$d_i^- = \theta_0 x_{im_0} - \sum_{m=1}^{n} x_{im}\lambda_m$ (d_i^- : the slack in the *i*th input, i.e., the 'surplus' of input amount, the difference between the actual input use and the input availability) and

$d_j^+ = \sum_{m=1}^{n} y_{jm}\lambda_m - y_{jm_0}$ (d_j^+ : the slack in the *j*th output, i.e., the 'lack' of output amount, the difference between the output amount which is possible to be produced and the realised output amount),

the problem (6-2-D) is expressed as follows:

$$
\begin{aligned}
min \quad & \theta_0 \\
s.t. \quad & \sum_{m=1}^{n} x_{im}\lambda_m + d_i^- = \theta_0 x_{im_0} , \\
& \sum_{m=1}^{n} y_{jm}\lambda_m - d_j^+ = y_{jm_0} , \\
& \qquad \lambda_m,\ d_i^-,\ d_j^+ \geq 0; \quad \theta_0 \ unconstrained
\end{aligned}
$$

(6-2-*D*)'

The primal model (6-2-P) has $n + s + t + 1$ constraints whilst the dual model (6-2-D)' has $s + t$ constraints. As the number of n, the total number of units, is usually larger than $s + t$, the number of inputs and outputs, the primal model has many more constraints than the dual model. The less the constraints, the easier to solve a linear programming model, and thus it is usual to solve the dual DEA model rather than the primal. The DEA optimal solution set consists of the optimal solution $(\theta^*, \lambda_1^*, .., \lambda_n^*)$ and the optimal slacks $(d_1^{-*}, .., d_s^{-*}, d_1^{+*}, .., d_t^{+*})$. If $\theta^* = 1$ and all slacks are zero the DMU is defined as efficient (as 100% efficient).

The above model is often called the CCR model named after the initials of Charnes, Cooper and Rhodes (1978) who introduced the technique of DEA. One of the postulates that justify the construction of the production possibility set for the CCR formulation is called the 'Ray Unboundedness' postulate. Because of this postulate the production possibility set under the CCR model is constructed on the assumption of constant returns to scale. When one uses simple input-output configurations, (X_m, Y_m), where $X_m = (x_{1m}, \ldots x_{im}, \ldots, x_{sm})$ is a vector of observed inputs $(X \in R^s)$ and $Y_m = (y_{1m}, \ldots, y_{jm}, \ldots, y_{tm})$ is a vector of observed outputs $(Y \in R^t)$ for DMU m, the production possibility set T under the CCR formulation can be defined as follows:

$T_{CCR} = \{(X, Y) \mid X \geq X_m\lambda,\ Y \leq Y_m\lambda,\ \lambda \geq 0\}$ where λ denotes a non-negative (column) vector of dimension n.

The 'Ray Unboundedness' postulate, is an assumption that *if* $(X, Y) \in T$, *then* $(kX, kY) \in T$ *for any* $k > 0$. This assumption enables one to extrapolate the performance of the most efficient DMUs with efficient scale sizes.

Banker, Charnes and Cooper (1984), developed another model in which they deleted this postulate 'Ray Unboundedness' thus adding a new constraint $\sum_{m=1}^{n} \lambda_m = 1$ to (6-2-D). Adding this constraint $\sum \lambda_m = 1$ requires that the weights of the comparison group sum to be one. Therefore they developed an efficiency measurement procedure that assigns an efficiency rating of 1 to a DMU if and only if this DMU lies on the efficient production surface, i.e., the efficiency measurement procedure where comparison is by interpolation between DMUs only. This model is often called the BCC model named after the initials of Banker, Charnes and Cooper (1984). The BCC model's production possibility set is as follows:

$T_{BCC} = \{(X, Y) \mid X \geq X_m\lambda,\ Y \leq Y_m\lambda,\ \mathbf{e}\lambda = 1,\ \lambda \geq 0\}$ where $\mathbf{e} = (1, \ldots, 1)$.

The dual and the primal of the BCC formulation are as follows respectively:

$$
\begin{aligned}
&\min \quad \theta_0 \\
&s.t. \quad -\sum_{m=1}^{n} x_{im}\lambda_m + \theta_0 x_{im_0} \geq 0, \\
&\qquad \sum_{m=1}^{n} y_{jm}\lambda_m \geq y_{jm_0}, \\
&\qquad \sum_{m=1}^{m} \lambda_m = 1, \\
&\qquad\qquad \lambda_m \geq 0; \quad \theta_0 \ unconstrained
\end{aligned}
$$

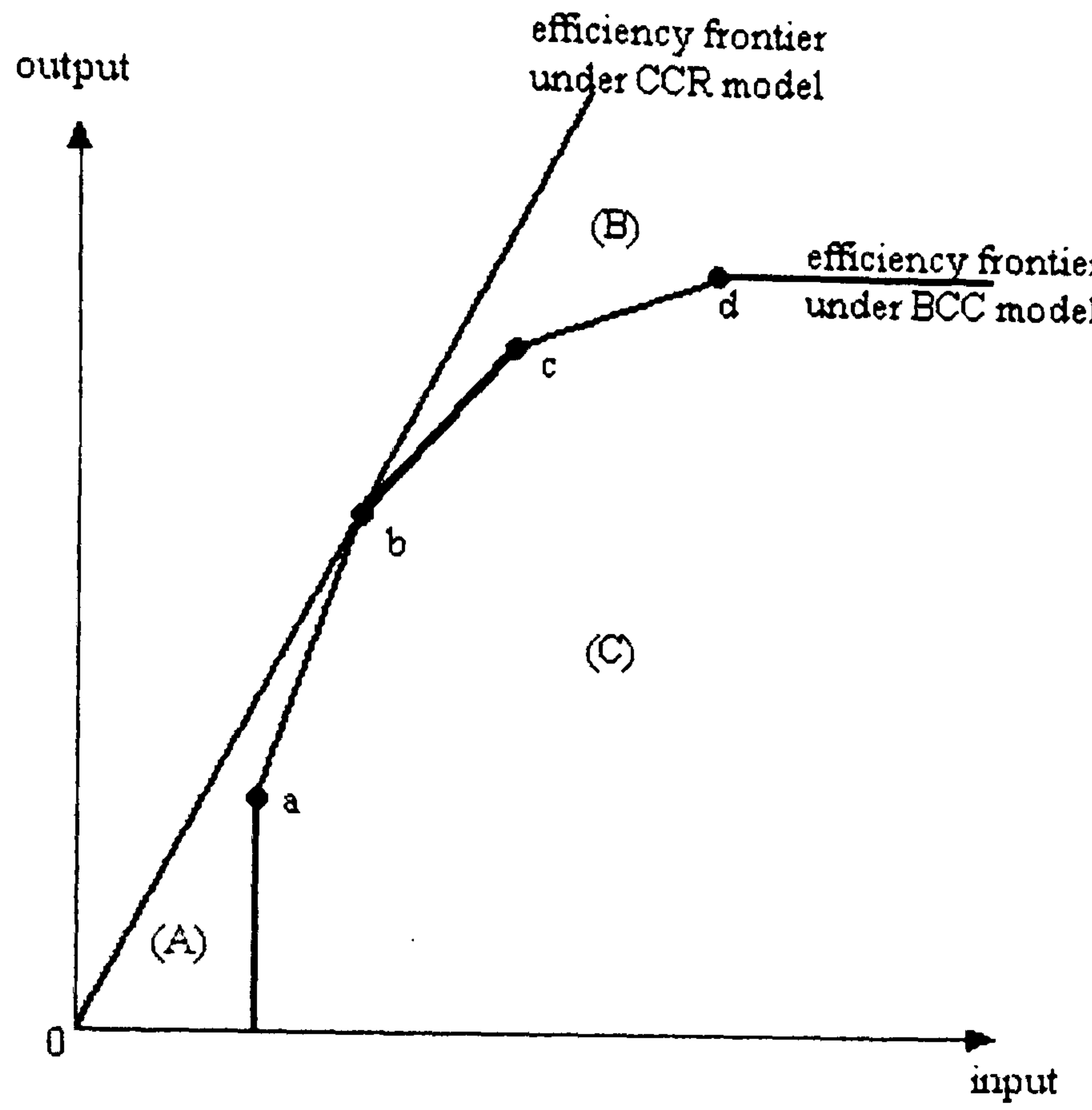
(6-3-*D*)

$$
\begin{aligned}
max \quad & e_0 = \sum_{j=1}^{t} w_j y_{jm_o} + \omega \\
s.t. \quad & \sum_{i=1}^{s} v_i x_{im_0} = 1 , \\
& -\sum_{i=1}^{s} v_i x_{im} + \sum_{j=1}^{t} w_j y_{jm} + \omega \le 0 , \\
& m = 1,..,n;\ i = 1,..,s;\ j = 1,..,t;\ v_i, w_j \ge 0 \\
& \omega \ \ unconstrained
\end{aligned}
\tag{6-3-P}
$$

The new variable ω in (6-3-P) is a dual variable related to the new constraint $\sum_{m=1}^{m} \lambda m = 1$ in (6-3-D). Since T_{CCR} and T_{BCC} are different, the efficiency frontier under the BCC formulation is different to that under the CCR formulation. Figure 6-2 diagrammatically shows the difference. In the figure 6-2 four DMUs, a, b, c and d are shown and each DMU produces one output using one input. The efficiency frontier under the CCR formulation is formed as the line which passes through the origin and the point b. Because of the constraint $\sum \lambda m = 1$, the efficiency frontier under the BCC formulation is formed as the boundary when all four points a, b, c and d are joined up. Therefore, the production possibility set under the CCR formulation is defined as the area (A) + (B) + (C), whereas the production possibility set under the BCC formulation is defined as the area (C) and it is a polyhedral set. The efficiency frontier under the BCC formulation in this one-input-one-output example is constructed by the set of supporting lines of $-v^*x + w^*y + \omega^* = 0$. The efficiency frontier in the case of DMUs producing multiple outputs using multiple inputs is constructed by the set of supporting hyperplanes instead of lines. In the case of (6-3-P), the supporting hyperplane in $(s + t)$-dimensional Euclidean space is given by

$$
-\sum_{i=1}^{s} v_i^* x_i + \sum_{j=1}^{t} w_j^* y_j + \omega^* = 0
$$
[1].

Figure 6-2 different efficiency frontiers

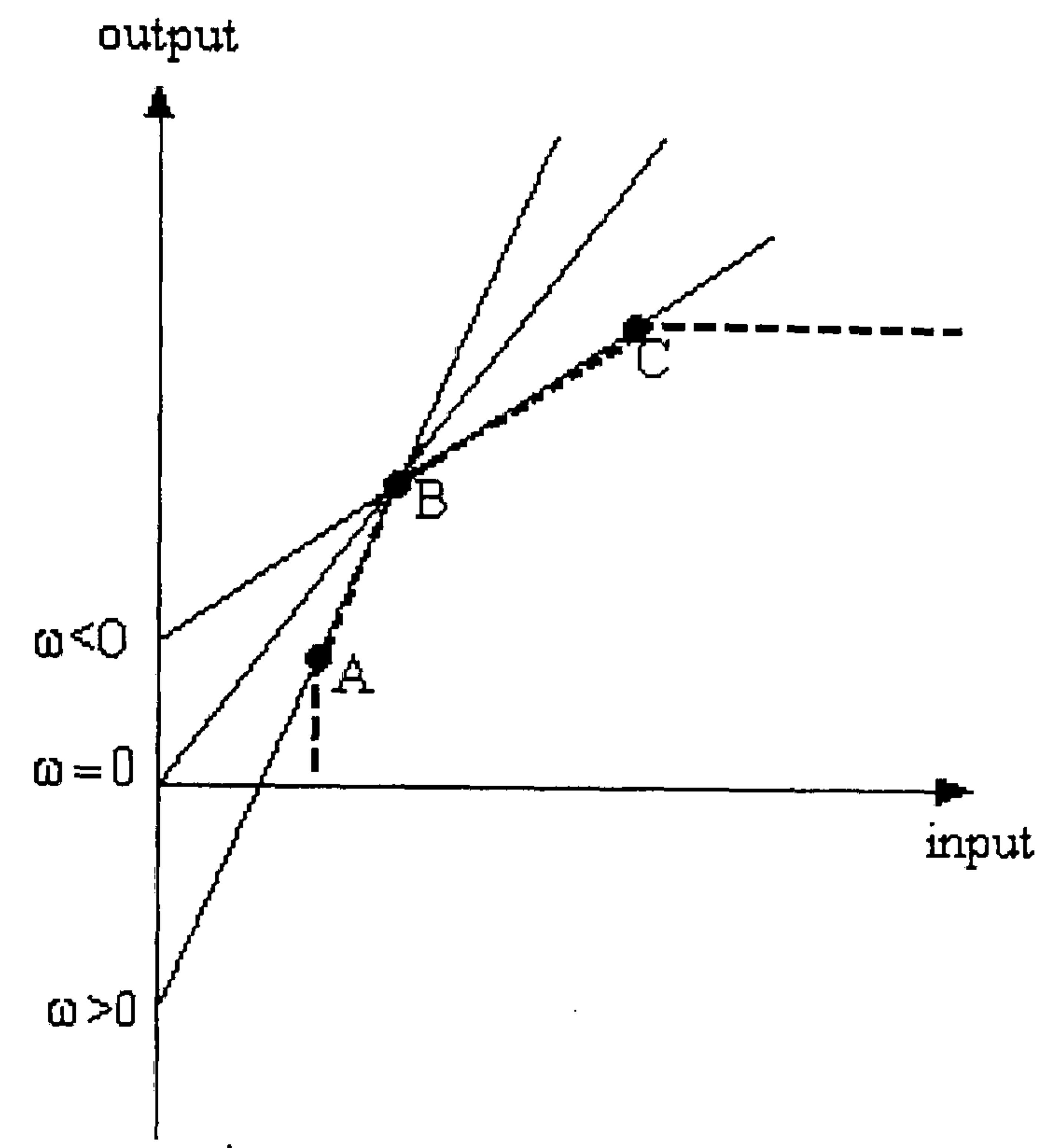


In the one-input-one-output example, each supporting line constructing the BCC efficiency frontier is written as $y = \frac{v^*}{w^*}x - \frac{\omega^*}{w^*}$. The intercept is $-\frac{\omega^*}{w^*}$. The sign of ω^* is useful as the reference regarding whether an efficient unit $E = (x_E, y_E)$ (by definition E is also on the frontier) is operating on increasing returns to scale, constant returns to scale or decreasing returns to scale. When the efficiency frontier is constructed by the three efficient DMUs A, B and C as in Figure 6-3, when (x_E, y_E) is on the frontier between A and B, increasing returns to scale are present. DMU B is operating on constant returns to scale. When (x_E, y_E) is on the frontier between B and C, decreasing returns to scale are present. In the general multiple-input-multiple-output case, when a unique supporting hyperplane of

$-\sum_{i=1}^{s} v_i^* x_i + \sum_{j=1}^{t} w_j^* y_j + \omega^* = 0$ passes through an efficient point (X_E, Y_E),

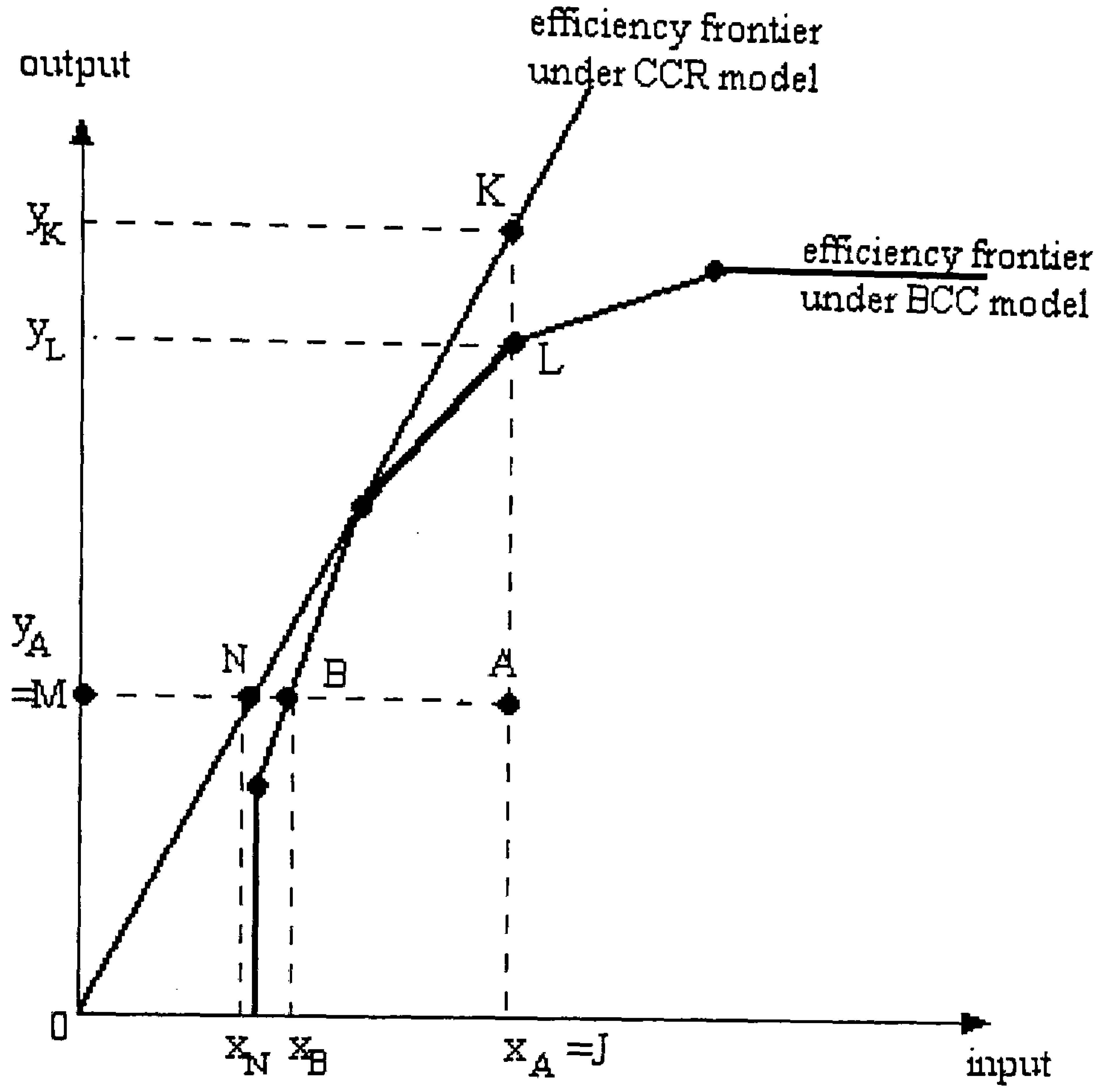
- increasing returns to scale is present at $(X_E, Y_E) \Leftrightarrow \omega^* > 0$
- constant returns to scale is present at $(X_E, Y_E) \Leftrightarrow \omega^* = 0$
- decreasing returns to scale is present at $(X_E, Y_E) \Leftrightarrow \omega^* < 0$

Figure 6-3 DEA's returns to scale concept in T_{BCC}



As T_{BCC} is convex, if the DMUs $A = (x_A, y_A)$ and $B = (x_B, y_A)$ as shown in Figure 6-4, the efficiency score under BCC formulation for the DMU A would be measured as $\frac{MB}{MA}(= \frac{Ox_B}{Ox_A})$, whilst under CCR formulation the DMU A's efficiency score is measured as $\frac{MN}{MA}$. The DMU B would not be scored as efficient with the productivity possibility frontier under CCR formulation, but B is scored as a unit measured as efficient with the production possibility frontier under BCC formulation. All DMUs' efficiency scores under BCC formulation are either the same as, or higher than, under CCR formulation because of the additional convexity constraint under BCC formulation.

Figure 6-4 efficiency scores under BCC formulation



Another difference between the CCR formulation and the BCC formulation is that the efficiency score of a DMU measured based on the input minimisation model as in (6-2-D) is corresponding straightforwardly to the efficiency score of a DMU based on the output maximisation model in the case of the CCR formulation. The concept of the output maximisation model is basically to look for the maximum amount of output using the input available (in the case of input minimisation model one looks for the minimum amount of input in order to produce the output that is theoretically possible). Using the illustration of Figure 6-4, the efficiency score of the DMU A in the CCR formulation as to the input minimisation model is expressed as $\frac{MN}{MA}(=\frac{Ox_N}{Ox_A})$, and as to the output maximisation model is expressed as $\frac{JA}{JK}(=\frac{Oy_A}{Oy_K})$. As the CCR efficiency frontier is linear, the efficiency score of a DMU under the output maximisation model is the same as the efficiency score obtained under the input minimisation model. However, under the BCC formulation, the efficiency score of A

using the input minimisation model which is $\frac{MB}{MA}(=\frac{Ox_B}{Ox_A})$ is different to A's efficiency score using the output maximisation model which is $\frac{JA}{JL}(=\frac{Oy_A}{Oy_L})$.

DEA can also be used to measure input allocative efficiency incorporating the input price data for the inputs. Strictly speaking, 'productive efficiency' as a concept is a combination of 'technical efficiency' and 'input allocative efficiency'. In order for 'input allocative efficiency' to be calculated, reliable data for the inputs' prices over different DMUs is required. However, the data regarding inputs' prices are not available for the UK airport industry. Thus the focus in this chapter is on the technical efficiency of production, which is a limitation in the efficiency analyses.

In the next section I explain the two kinds of technical efficiency measurements.

6-3. Efficiency measurements: types, data and methodology

(1) Two types of measurement carried out in this chapter

There are two types of measurements (A) and (B) I carry out in this chapter.

Measurement (A)

Comparing the efficiency scores for each airport in each year as a DMU among all the airports involved, i.e., the four categories I described in section 6-1 as (1) to (4) would be ideal. Unfortunately, the then nationalised British Airports Authority had not published the data regarding capital inputs for each airport before 1987/88. Therefore, analysing efficiency scores before that year is not possible. Treating a group of airports which has belonged to this organisation is possible, thus the first measurement is carried out in order to investigate whether BAA, rather than its individual airports, as an organisation had changed in terms of technical efficiency over time, including the time when this organisation was nationalised under the name of the then British

Airports Authority (measurement (A)). The purpose of this measurement is to investigate whether the hypothesis, as described in section 6-1, that the productive efficiency of the then British Airports Authority was improved after privatisation as BAA is supported.

There is a specific problem in the DEA measurement which is undertaken on observations at different points in time. BAA might have expected to have been affected by technological change over the period of observation. This means that there might have been a shift (or multiple shifts) of the production frontiers during the observation period. Where improvements in technology made the frontier shift towards higher productivity the results would be biased in favour of the DMUs which belong to the improved production possibility set. Technical efficiencies measured by DEA cannot themselves detect whether an inefficient DMU was at a stage where the organisation was catching up with the new frontier or at a stage where the organisation was operating *on* the old frontier.

There are several ways to tackle this problem. One method is to use an index called the 'Malmquist index'. Where there are two DMUs observed in different periods t and $t + 1$ and if one can assume that due to the productivity growth the efficiency frontier in the period $t + 1$, say f_{t+1}, is different to the efficiency frontier in the period t, say f_t, the efficiency score of the DMU in period t can be revalued using f_{t+1}, and the efficiency score of the DMU in period $t + 1$ can be revalued using f_t. The Malmquist index is a geometric mean of the two revalued efficiency scores of the two different DMUs. A good example of using the Malmquist index to decompose the efficiency effects of privatisation both in frontier shift effect and in pure technical efficiency can be seen in Waddams Price and Weyman-Jones (1996) where they investigated whether there was a shift towards productive efficiency in the UK natural gas industry.

A drawback of this method is that it is difficult to justify the evaluation of a DMU observed in the period t using the efficiency frontier realised in the period $t + 1$, though there would be no problem in evaluating a DMU observed in the period $t + 1$ using the efficiency frontier in the period t. The managers in the period t would have no access to the technology which would be realised in the period $t + 1$. If it was used to compare different regions or different countries, the Malmquist index method would be a useful technique (Waddams Price and Weyman-Jones (1996) mentioned above used a rich panel data consisting of time series of 15 years and 12 different regions). However, if applied to a single organisation using observations at different points in time, it would have the serious drawback of not being realistic in its assumptions. In my calculation of BAA's efficiency I did not use this method for this reason. Another reason for not using this method is that one cannot assume with certainty that the efficiency frontier after the regulatory reform (period $t + 1$) was shifted towards a more efficient direction compared to the efficiency frontier before the regulatory reform (period t). The airport industry is not typically renowned as a fast growing industry for technological growth.

Another way of tackling the problem in using DEA in time series is to incorporate technological change as one of the inputs. The work by Boussofiane, Martin and Parker (1997), which I will mention later in section 6-6, as a part of their calculations used a linear time trend variable to capture technological improvements. As the authors mentioned '*its crudity is self-evident*' because the variable was not based on specific information on the technology of each industry whose efficiency scores they calculated in time series. Thus they did not put great emphasis on the result. Although their trial gives us a useful insight as a method, incorporation of any variable which is basically an estimation constructed on the data outside the managers' control should be treated with caution. In the calculation I carried out in this chapter I have avoided such data.

Measurement (B)

The second measurement (measurement (B)) is to investigate whether there was any significant performance difference between privatised airports (i.e., BAA's airports) and local authority airports after the regulatory reform. As I mentioned in Chapter 2, the accounting methods of local authority airports before they became plcs were different to the current accounting methods which are used for plcs. After 1988/89 there are 'Regulatory Accounts' available (as I mentioned in Chapter 5) for each regulated airport. Therefore for the period from 1988/89 (when the first 'Regulatory Accounts' were published) to 1995/96[2] the airports efficiency scores were calculated as a panel comparison between local authority airports and private airports.

As to the cost-reduction effort, i.e., the input amount of x in the predictions carried out in Chapter 3, it is assumed that $1 < a < \alpha$ and $1 < a < \beta$, and therefore there is assumed to be greater cost-reduction effort attached to the privatised airports' managers than to the local authority airports' managers. This is because of the stronger pressure placed upon the management of privatised airports. Unlike the case of BAA's airports or other privatised airports, local authority airports' managers are still sheltered from the pressure of shareholders and from the takeover threat. Regarding the investment level of capital stock, the models in Chapter 3 predict that after the regulatory reform local authority airports suffer from under-investment due to the borrowing limit constraint, whereas privatised airports' investment level in capital stock is predicted to be optimum. Therefore, as one can (a) compare $-c_x = a$ with $-c_x = \alpha$ or $-c_x = \beta$ and (b) compare $-c_k = r$ with $-c_k = r + \gamma$ or $-c_k = r + \delta$, the productivity of the privatised airports is considered to be greater than that of the local authority airports, which is the hypothesis to be tested in measurement (B).

(2) Data for measurements (A) and (B)

Physical data is most reliable in terms of efficiency measurement by DEA. As to inputs, physical data such as 'staff man-hours', 'runway capacity' or 'area of the terminals owned' would be desirable. However, there is no consistently available data for all airports, i.e., these figures are neither constantly published (such as terminal size or staff man-hours) nor counted by the UK airports. As to inputs I use only pecuniary data: (a) staff costs and (b) capital employed as the inputs for the calculations. In the case of the staff costs[3] the data was deflated by the RPI. The local authority airports publish their staff costs each year. Capital input was calculated as the total tangible assets minus current liabilities from modified based historic cost accounts (including revaluation), which were in the public domain as the data was taken from the annual report of each airport. The implication of using this pecuniary data is that (1) the effect of cost-reduction effort would be shown only in the form of staff related input, and would not, for example, be measured as an improvement in the efficient use of space. Also (2) as the staff costs consist of both the wages and staff numbers, it might be possible that there would be a distortion caused by the wage level difference among different airports as they are located in different regions. The use of capital employed would make the airports which have less of an over-investment problem be measured as efficient to a greater degree than if capital were not directly used as the input. One of the predictions made in Chapter 3 ($-c_k = r$ was the benchmark) concerned whether the investment level was reduced toward the more efficient level after the regulatory reform in both the BAA and local authority airports' cases (although the prediction with regard to the local authority airports after the regulatory reform was the problem of under-investment), thus the use of capital as an input is acceptable.

The then nationalised British Airports Authority used to publish both CCA (current cost accounts) and HCA (historic cost accounts). From an opportunity costs' point of view CCA data is better. However, the then nationalised British Airports Authority stopped publishing its CCA data after 1986 (see Table 2-1), I have therefore used HCA.

Regarding the outputs, physical data such as total passenger numbers, Air Transport Movement (hereafter ATM), and tonnes of cargo and mail carried by airports are available. There are two problems. Firstly there are strong correlations between the data. Secondly this data referring to passenger numbers, ATM and tonnes of cargo and mail is only relevant to the 'air-side' operation. Therefore there is a problem as to how to express the output of the 'commercial-side'. As a method one can use only one output which is the total turnover. The drawback in using only one output in the airport industry is in ignoring that there are two categories of operations. A useful question is: what do the operators want to maximise as to their output? As to the use of 'air-side' operation the likely answer to this question is in the number of aircraft landed and taken-off. As to the 'commercial-side' the likely answer is the commercial revenue. One can regard passenger numbers as the measure of the *inputs* for the commercial operation, as I explained in Chapter 4 in the context of how to treat 'commercial-side'. The trade off is that if passenger numbers are used as the input (in which case ATM cannot be used as the result of correlations between passenger numbers and ATM) the feature of 'air-side' efficiency (which is related to the question; what the airport would like to do to maximise its efficiency?) would be ignored. I experimentally tried adopting the ratio of passenger numbers per aircraft but this did not work as it distorted the results. As a compromise, I decided to use the following output data; (1) ATM and (2) commercial revenue (after being deflated by the RPI).

(3) methodology

I call the efficiency measurement method under the CCR formulation as expressed in (6-2-D) 'constant returns to scale method' (hereafter CRS) and the method under the BCC formulation as in (6-3-D) 'variable returns to scale method' (hereafter VRS). I use VRS and deduce efficiency scores based on input minimisation. This means that I search for the minimum input level required to produce a chosen level of output. The reason for choosing input minimisation VRS is that in the case of the airport industry the demand has been forecasted in advance and is less likely to be influenced by demand fluctuation. Unlike the airline industry the airport industry enjoys a more or less natural monopoly at least locally. Each airport faces a predetermined objective in the presence of limited resources (this tendency was even more so during the period when there was capital rationing constraint). The model I use is, therefore written as follows:

a set of n DMUs (here any airport operation in a financial year), $m = 1, \ldots, n$

each DMU uses 2 different inputs;

amount of ith input being x_{im}, $i = 1,2$ to produce

2 different outputs; amount of jth output being y_{jm}, $j = 1,2$.

Input Minimisation Model:

$$\max \ e_0 = \sum w_j y_{jm_0} + \omega$$

$$\text{s.t.} \quad \sum v_i x_{im_0} = 1,$$

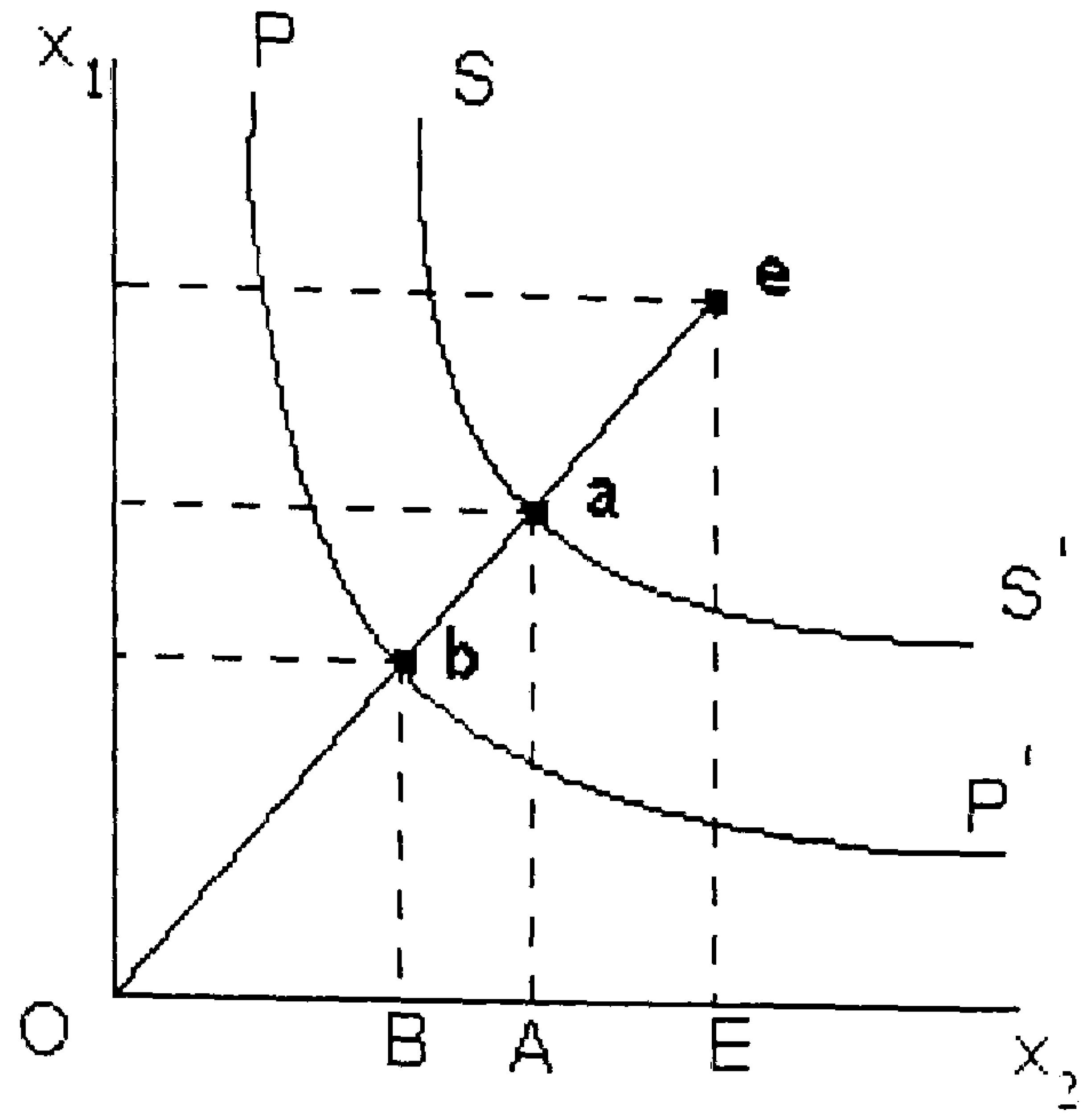
$$-\sum v_i x_{im} + \sum w_j y_{jm} + \omega \leq 0 \qquad m = 1,\ldots,n$$

$$v_i,\ w_j \geq 0 \qquad \forall i,j \qquad \text{(M)}$$

Regarding the measurement (A) the calculation of each year's technical efficiency is straightforward using the model (M).

Measurement (B)'s purpose is to compare efficiency between private airports and local authority airports. Each technical efficiency measurement is carried out using the model (M). However, in order to investigate whether there is any significant difference in efficiency between management under private ownership and that under local authority ownership, measurement (B) additionally involves breaking down the result of the overall technical efficiency measurement into two groups and comparing the results for the efficiency measured within the group of data which the DMU belongs to, with the result for the overall technical efficiency. This method was originated from a useful technique by Charnes, Cooper and Rhodes (1981) to disentangle managerial efficiency and policy efficiency, which can be achieved by breaking down technical efficiency[4]. 'Managerial inefficiency' is defined here as technical inefficiency measured relative to the most efficient DMUs *within* the same type of ownership, whilst 'policy inefficiency' is defined as inefficiency that is attributable to policy constraints within which management is required to operate due to the type of ownership the DMU belongs to.

Figure 6-5 disentangling 'managerial efficiency' and 'policy efficiency'



In the illustration given by Figure 6-5 where there are two efficiency boundaries, P-P' is the efficiency boundary which is formed by a reference set from the total set of data. S-S' is the efficiency boundary that is formed by another reference set which is deduced from a separate data set containing only one type of ownership group. In this example, the overall technical efficiency of **e** is measured by the distance between **b** and **e**, so that it is calculated as the ratio of OB/OE. On the other hand, 'managerial efficiency' of **e** is measured by the distance between **a** and **e**, so that it is calculated as the ratio of OA/OE. 'Policy efficiency' is measured by the distance between **a** and **b**, OB/OA, and thus can be calculated by dividing overall technical efficiency by 'managerial efficiency', i.e., $\frac{OB}{OE}/\frac{OA}{OE}$. I will use this technique in order to compare the efficiency between private airports and local authority airports.

6-4. Results of the time series efficiency measurement of the then nationalised British Airports Authority and BAA

The results of the efficiency scores[5] of the measurement (A) is shown in Table 6-1 and also shown graphically in Figure 6-6. The results also show the target reduction rates of both inputs with which efficiency would have been achieved. I show in Table

6-2 the major constraints' changes and other events which are outside the control of BAA's management. Figure 6-7 shows the comparison between the efficiency scores and the real GDP, and Figure 6-8 shows the comparison between the efficiency scores and the real GDP growth rate per year. Figure 6-9 shows the relationship between the efficiency scores and the real fuel price index.

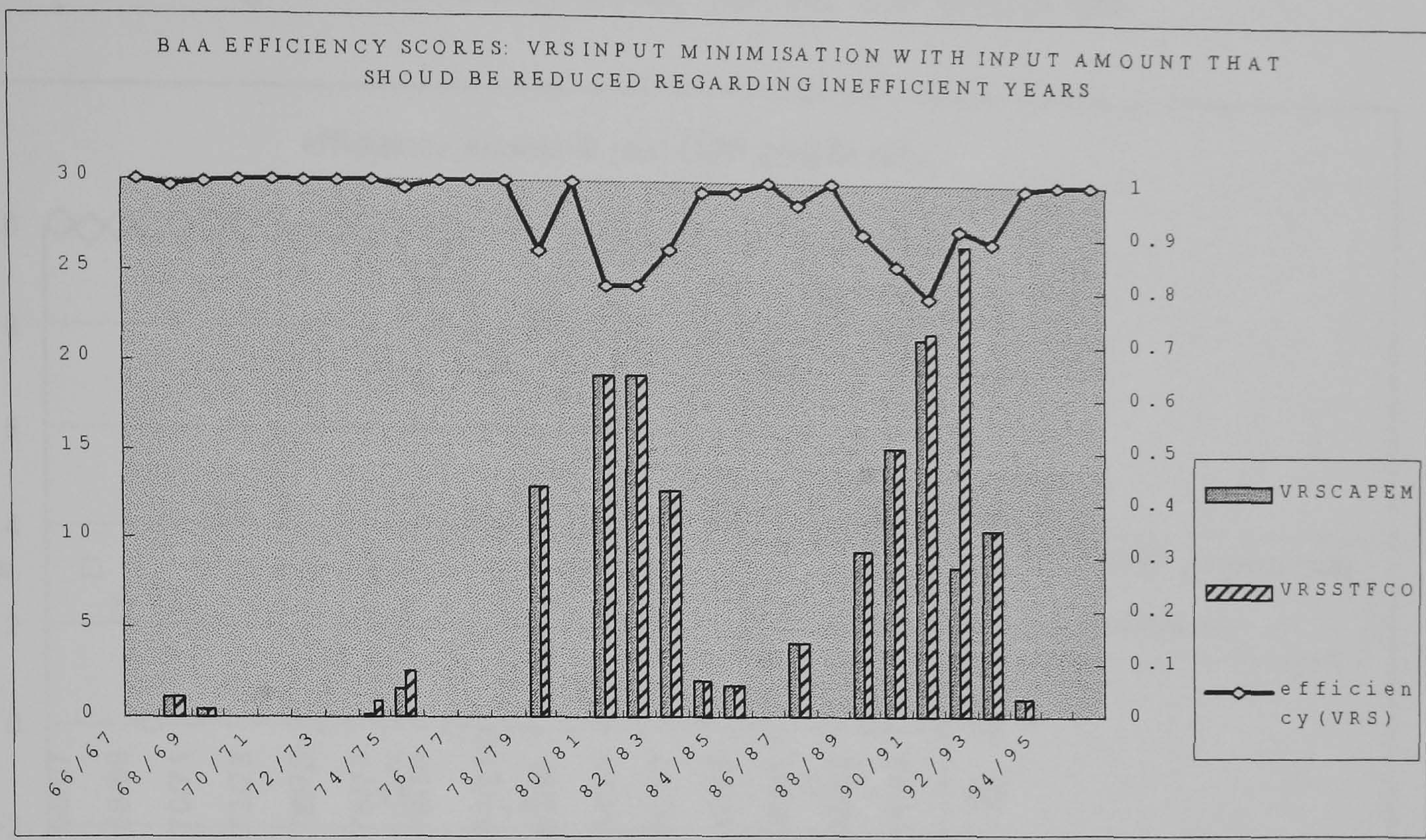
Table 6-1 the then nationalised British Airports Authority and BAA efficiency scores from 1966/67 to 1995/96; time series result

YEAR	efficiency VRS scores	reduction to achieve efficiency Capital (%)	reduction to achieve efficiency Stuff cost (%)
66/67	1	0	0
67/68	0.989	1.1	1.1
68/69	0.995	0.5	0.5
69/70	1	0	0
70/71	1	0	0
71/72	1	0	0
72/73	1	0	0
73/74	0.999	0.1	0.9
74/75	0.984	1.6	2.6
75/76	1	0	0
76/77	1	0	0
77/78	1	0	0
78/79	0.871	12.9	12.9
79/80	1	0	0
80/81	0.808	19.2	19.2
81/82	0.808	19.2	19.2
82/83	0.873	12.7	12.7
83/84	0.98	2	2
84/85	0.982	1.8	1.8
85/86	1	0	0
86/87	0.959	4.1	4.1
87/88	1	0	0
88/89	0.906	9.4	9.4
89/90	0.848	15.2	15.2
90/91	0.787	21.3	21.6
91/92	0.915	8.5	26.5
92/93	0.894	10.6	10.6
93/94	0.991	1	1
94/95	1	0	0
95/96	1	0	0

Table 6-2 policy constraints and events which were out of BAA's control

YEAR	VRS score	policy constraints	events outside BAA's control
66/67	1	established	
67/68	0.989	nationalised industries White Paper	
68/69	0.995		
69/70	1		
70/71	1		
71/72	1		
72/73	1		
73/74	0.999	Maplin project rejected	oil crisis
74/75	0.984		oil crisis
75/76	1		
76/77	1		
77/78	1		
78/79	0.871	airport policy White Paper	recession
79/80	1		recession / oil crisis
80/81	0.808		recession
81/82	0.808		recession
82/83	0.873	Queen's Speech	
83/84	0.98		
84/85	0.982		deregulation: airline industry inside EU
85/86	1	airport policy White Paper	
86/87	0.959	the Airports Act	privatisation of BA / merger of BA/Bcal
87/88	1	PRIVATISED	
88/89	0.906		
89/90	0.848		
90/91	0.787		Gulf war
91/92	0.915	Stansted new terminal	Gulf war
92/93	0.894	tighter X (8%)	
93/94	0.991	tighter X (8%)	night flight restriction in London area
94/95	1		heavier security burden
95/96	1		

Figure 6-6 graphic illustration of Table 6-1



VRSCAPEM denotes target reduction rate of capital input which would be required to achieve efficiency

VRSSTFCO denotes target reduction rate of staff costs which would be required to achieve efficiency

Figure 6-7 efficiency scores and real GDP

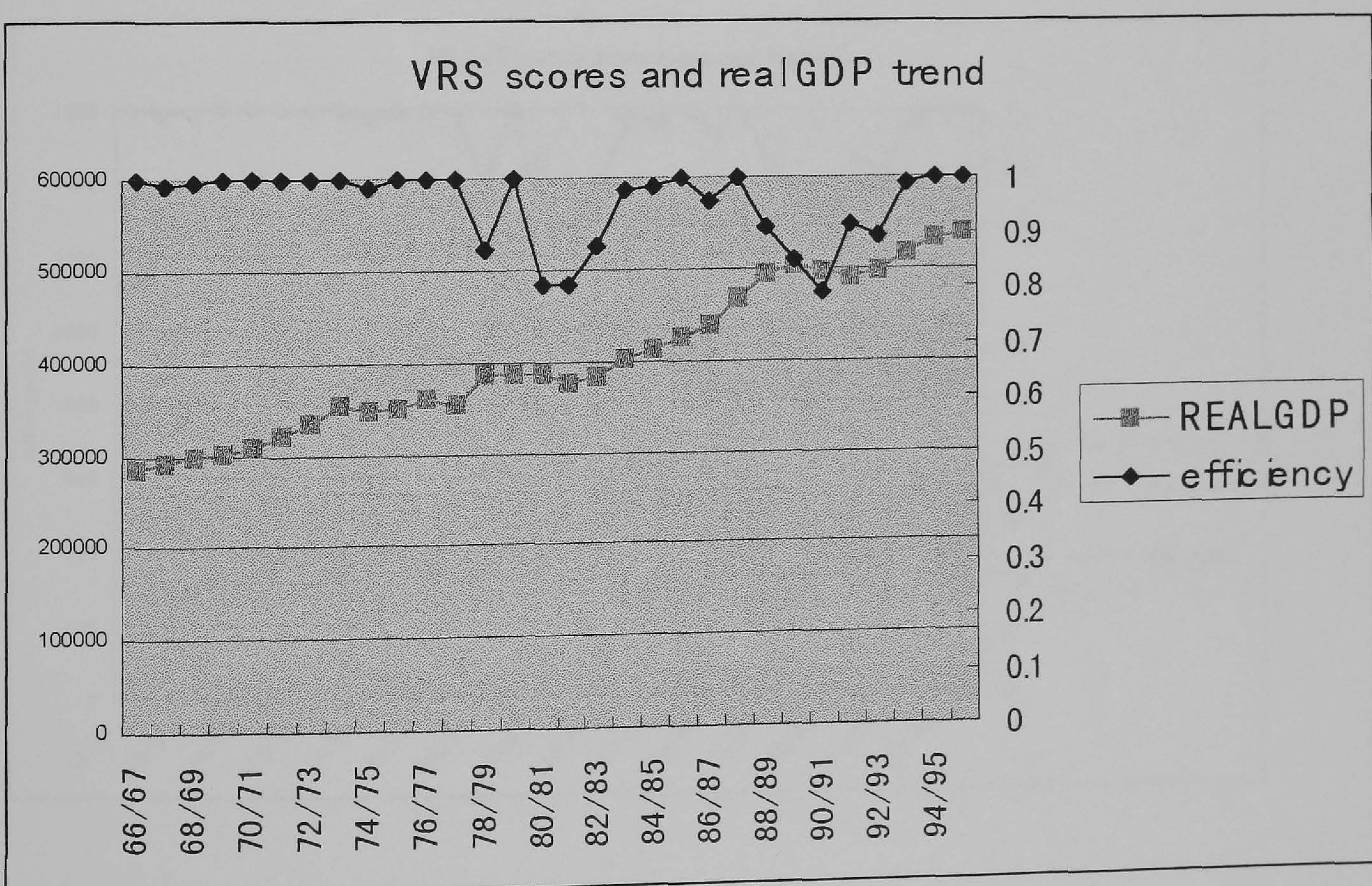


Figure 6-8 efficiency scores and real GDP growth rate

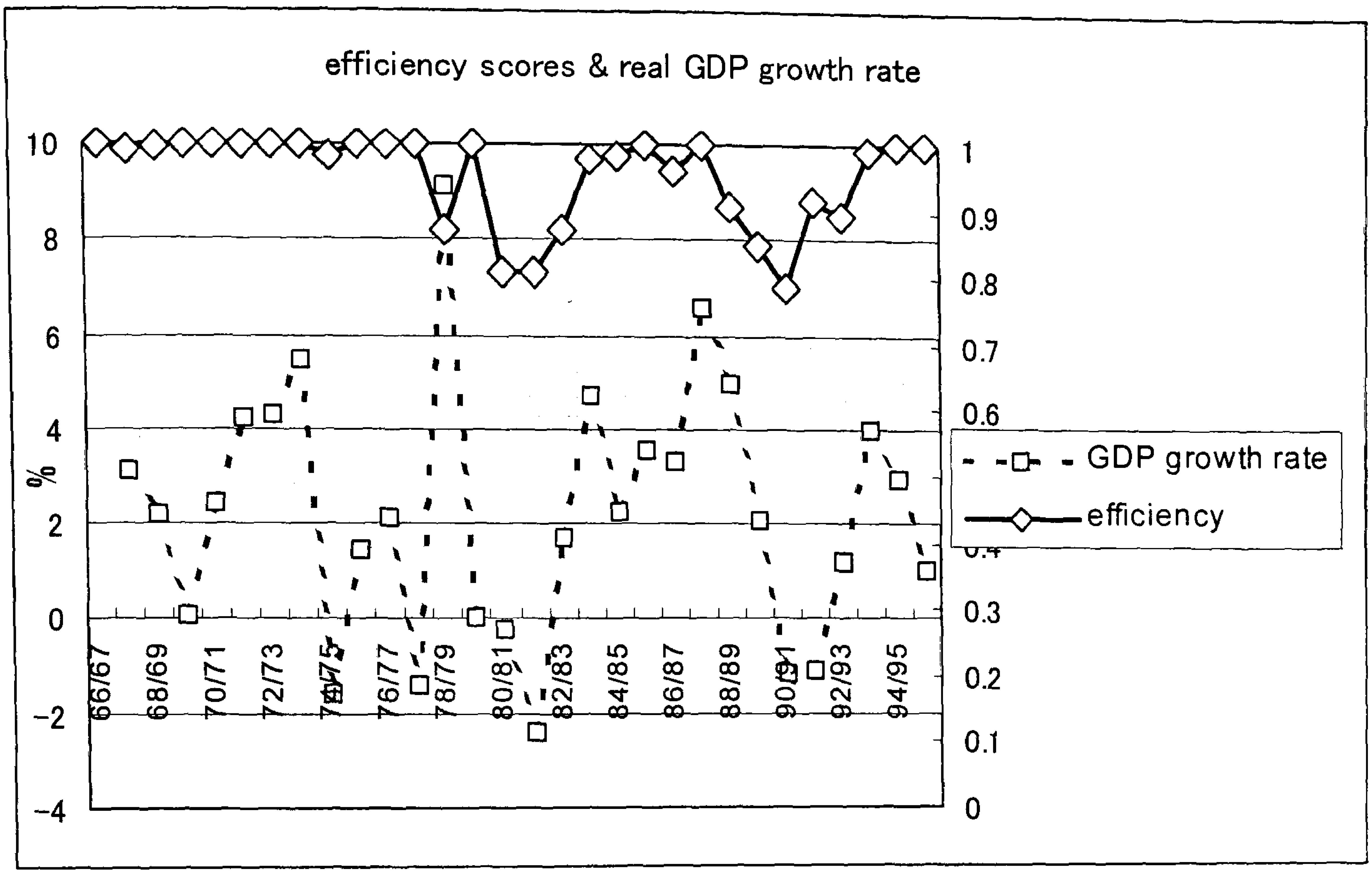
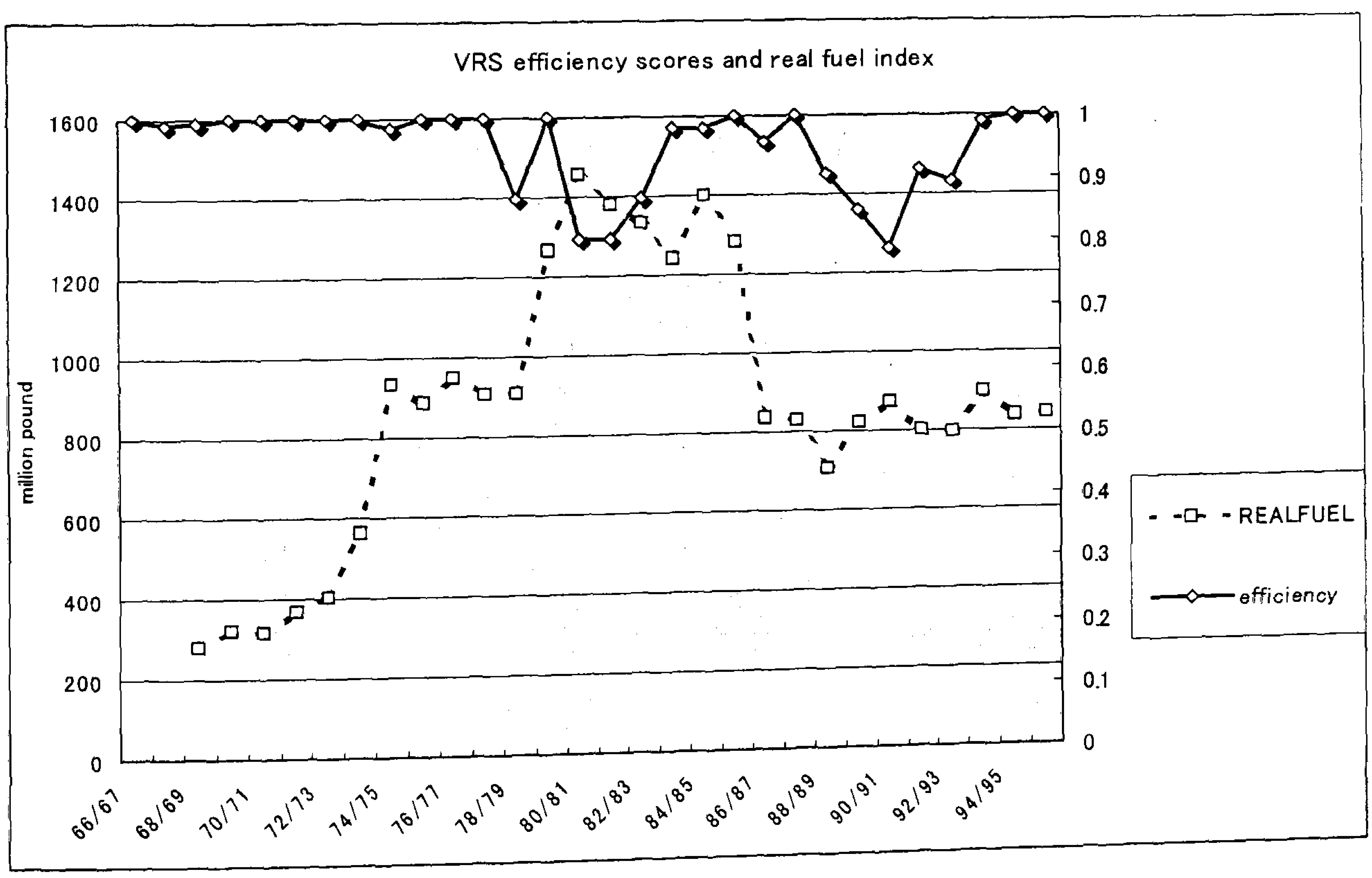


Figure 6-9 efficiency scores and real fuel index



The efficiency scores after privatisation (from 1987/88 to 1995/96) do not seem to show any appreciable productivity improvement of BAA compared to the scores in the period between 1966/67 and 1986/87. However, the results show that there is a close relationship between the efficiency score's trend and the factors related to the business cycle of the airline industry, particularly after the late '70s. The tendency for low efficiency scores during the recession period, around the time of oil crisis and the Gulf War can be seen from the figures above. The correlation between the efficiency scores and these environment changes, which are mainly outside the control of airport management, such as recession, oil crisis and wars make it difficult to tease out whether or not the efficiency scores are due to the change in ownership of the airports and other economic constraints. Yet, after taking the Gulf War (from 1990/91 to 1991/92) and the Lockerbie terrorist bomb on Pan Am (1988/89) (because of which BAA had to increase the number of security staff) into consideration, the continuous inefficient scores from 1988/88 to 1993/94 do not seem to support the hypothesis that the productivity would rise as a consequence of privatisation.

During the period of nationalisation, it seems that over-staffing which is normally pointed out as a specific problem of a nationalised industry was not the issue in the case of the airports under the then British Airports Authority, apart from the years 1973 and 1974. This is because an airport in operation is capital intensive and a problem if any would be that of capacity adjustment when the demand declines due to the bulkiness of investment.

The result seems to show that productive efficiency during the period from 1983/84 to 1986/87 had been improved compared to the period from 1981/81 to 1982/83. The period between 1983/84 and 1986/87 was when a different new financial target had been placed on the then nationalised British Airports Authority, i.e., the financial target in which the passenger numbers growth rate was incorporated. However, during this period, there were roughly three major factors which might have been influencing performance, but outside the control of the airport operator: (1) the economy was recovering from recession, (2) fuel prices were reducing and (3) the liberalisation of the airline industry within Europe had begun. As to the last point (3), firstly there were bilateral agreements settled in this period between the UK Government and many other European nations aimed at liberalising air transport (e.g., with Luxembourg, Belgium and Switzerland, West Germany and the Netherlands in the period from 1984 to 1985). Thus during this period the then British Airports Authority, particularly with regard to Heathrow and Gatwick, may have become more eager to attract business as international hub airports inside Europe. Secondly, in 1985 domestic air fares in the UK were liberalised. Because of this the competition on scheduled domestic trunk routes inside the UK had the effect of constantly increasing ATM numbers (as a result the passenger numbers especially in 1984/85 had drastically increased by 11% in total for the then British Airports Authority). Therefore it is rather inconclusive as to how the new annual financial target during the period from 83/84 to 86/87 might have worked as an incentive towards productive efficiency.

After regulatory reform the years which scored as efficient in my measurement were only three out of the nine years after privatisation. As seen from the figures above, the efficiency scores had continued dropping since the year following 1987 when BAA was privatised, for three years in a row until 1991. The efficiency scores calculated by DEA are regarded as a combination of both cost-reduction improvement and improvement of the investment level. Thus the questions to be raised from the result are:

(1) As to the cost-reduction effort, is the difference between b and a, i.e., the marginal cost to the managers of inputting cost-reduction activity x, significantly large or ignorably marginal?

(2) If the investment level has not been optimal as predicted after privatisation, what factors, other than the airline industry's demand fluctuation, were considered to cause the investment inefficiency?

The efficiency scores had been gradually lowered since 1988/89 for three years in a row until 1991. The result of the slightly improved efficiency score for the year 1991/92 might have been linked to the form of price regulation at BAA's London airports. The second quinquennium was to be started from 1992/93. The MMC's investigation and the formal announcement by the CAA regarding the value of X in each year during the second quinquennium period between 1992/93 and 1996/97 had finished in early 1991. The management knew the following five year period's X values already in the year 1991/92. They knew that the values of X were going to be larger (especially for 1992/93 and 1993/94) than those in the first quinquennium. BAA seemed to be adjusting its inputs in this year in preparation for the tighter X of 8 in the following two years, although it is not clear whether the improved efficiency scores in the years 1993, 1994 and 1995 are reflected in the tightening of the X values. The result of the 1991 efficiency target inputs suggests that the contribution of the inefficient level of staff costs was greater than the inefficient level of capital employed. In 1991 a new terminal at Stansted was opened and BAA might have been suffering an over-capacity problem due to the Gulf War and slow economic growth. Adjusting the staff costs is easier than adjusting the capital stock level. Thus the result of the efficiency in the year 1991/92 might have been evidence that management was influenced by the review where the CAA announced tighter X values in the second quinquennium. If the main cause of the efficiency improvement during the year 1991/92 was expectation of the tighter price regulation, the possible answers to the questions above could be as follows:

(1) As to the cost-reduction effort, the marginal cost to the managers to reduce costs, *a*, would not be substantially larger than *b*, implying that the pressure from the capital market by itself did not reduce managerial slack which might have existed during the period of the first quinquennium. However, it is not certain whether the slack was mainly caused by the lack of competition among airports or by the first quinquennium's X being too leniently set.

(2) If RPI-X price regulation is in fact very similar to the rate of return regulation, there might be an incentive for 'gold plating' the cost of capital before the review, as per one of the implications shown at the end of Chapter 5. However, there is no clear evidence for inflating the cost of capital before the investigation of the MMC in 1991, and it is not conclusive whether there existed 'gold plating' as such.

6-5. Results of the panel comparison between private airports and local authority airports

Where a few very large or very small DMUs are included within a data set, it is known that they always tend to appear efficient due to the lack of available comparisons. Therefore I excluded the data for Heathrow from the panel comparison data as Heathrow is the only airport which has two runways, thus being on too large a scale to compare within the data set.

As for the privatised airports other than BAA's airports, the data for Belfast International and East Midlands was also available at the time of carrying out the calculation. Of these airports the former was sold by the Government and the latter was sold by the local authority. However, they were relatively recently privatised (1994 and 1993 respectively) so I decided not to use them and used only the privatised airports owned by BAA.

As to the local authority airports, I selected the largest three, i.e., Manchester, Birmingham and Luton. Other local authority airports are remarkably small in their operating scale, and inclusion of these small airports in the calculations would distort the results as mentioned above. Thus I selected the three largest local authority airports of comparable scale with the selected privatised airports. The airports which are included in the panel data comparison, i.e., measurement (B) are as follows:

- private airports: Gatwick, Stansted, Edinburgh, Glasgow, Aberdeen
- local authority airports: Manchester, Birmingham, Luton

The period was from 1988/89 to 1995/96 so that the panel data is made up with eight years × eight airports =64 samples. However, I have made the following three versions of the calculations:

(1) 8 years × all 8 airports = 64 samples

(2) 8 years × 7 airports (excluding Gatwick) = 56 samples

(3) 8 years × 6 airports (excluding London airports) = 48 samples

The reason for arrangement (2) is that Gatwick is a large scale airport and the inclusion of this airport might affect the result. The reason for arrangement (3) is that Gatwick and Stansted are within the London system of BAA and the inclusion of the two airports might affect the result because of (a) the location, (b) the fact that Stansted was still in the middle phase of its development at the time of calculation, and (c) the possibility of Stansted being subsidised by Heathrow and Gatwick.

The results summary tables are shown below.

Table 6-3 summary of (1)

1) total pooled data					
	mean	s.d.	min	max	sample
all 8 airports	0.82	0.15	0.363	1.000	64
5 privatised airports	0.88	0.15	0.363	1.000	40
3 local authority airports	0.73	0.09	0.594	1.000	24

2) efficiency scores separately measured: privatised & local authority					
	mean	s.d.	min	max	sample
5 privatised airports	0.88	0.15	0.363	1.000	40
3 local authority airports	0.97	0.04	0.842	1.000	24

3) policy efficiency for privatised airports vs local authority airports					
	mean	s.d.	min	max	sample
5 privatised airports	1.00	0.00	0.993	1.000	40
3 local authority airports	0.75	0.08	0.640	1.000	24

4) Mann-Whitney Test for policy efficiency				
privatised vs local authority	U=21.0	W=321.0	Z=-7.2359	P=0.0000

Table 6-4 summary of (2)

1) total pooled data					
	mean	s.d.	min	max	sample
all 7 airports	0.84	0.15	0.366	1.000	56
4 privatised airports	0.88	0.16	0.366	1.000	32
3 local authority airports	0.80	0.12	0.611	1.000	24

2) efficiency scores separately measured: privatised & local authority					
	mean	s.d.	min	max	sample
4 privatised airports	0.88	0.16	0.366	1.000	32
3 local authority airports	0.97	0.04	0.842	1.000	24

3) policy efficiency for privatised airports vs local authority airports					
	mean	s.d.	min	max	sample
4 privatised airports	1.00	0.00	1.000	1.000	32
3 local authority airports	0.82	0.13	0.666	1.000	24

4) Mann-Whitney Test for policy efficiency				
privatised vs local authority	U=99.0	W=399.0	Z=-5.5935	P=0.0000

Table 6-5 summary of (3)

1) total pooled data					
	mean	s.d.	min	max	sample
all 6 airports	0.83	0.14	0.594	1.000	48
3 privatised airports	0.92	0.10	0.687	1.000	24
3 local authority airports	0.73	0.09	0.594	1.000	24

2) efficiency scores separately measured: privatised & local authority					
	mean	s.d.	min	max	sample
3 privatised airports	0.92	0.10	0.687	1.000	24
3 local authority airports	0.97	0.04	0.842	1.000	24

3) policy efficiency for privatised airports vs local authority airports					
	mean	s.d.	min	max	sample
3 privatised airports	1.00	0.00	1.000	1.000	24
3 local authority airports	0.75	0.08	0.640	1.000	24

4) Mann-Whitney Test for policy efficiency				
privatised vs local authority	U=12.0	W=864.0	Z=-6.1408	P=0.0000

As expected, the worst scores in the pooled data in the results of both (1) and (2) were those of Stansted. The result of (3) seems to be the most reliable considering the effect of Stansted's poor scores. The sample number is 48 in the measurement (3) which is quite small, but is at least an acceptable number considering the input number × output number (=4). The efficient airports in the pooled data in (3) are as follows:

Edinburgh: 92/93, 93/94

Glasgow: 92/93*, 93/94*, 94/95*, 95/96

Aberdeen: 88/89, 92/93*, 93/94*, 94/95*

Manchester: 88/89, 94/95, 95/96

(the scores with * indicates that they were also efficient in the CRS calculation; no local authority airports were efficient under CRS assumption)

From the results of (3), there seems to be a significant difference between privatised airports and local authority airports in terms of efficiencies. The result showing the 'policy efficiency' for both the privatised airports group and the local authority airports group implies that on average the airports that belong to the latter group are 25% less efficient than the airports that belong to the privatised airports group. The large absolute value of Z in the Mann-Whitney test implies that the DMUs that belong to the private airports group are significantly more efficient than those which belong to the local authority airports group. The result seems to reflect the prediction that the local authority airports' productive efficiency is sacrificed because of (a) under-investment problems due to the borrowing limit constraint and (b) the larger value of β (α in Manchester's case) than a caused by the lack of access to the capital market. However, it is not conclusive whether the main cause of inefficiency of the local authority airports relative to the privatised airports is due to under-investment or less effort on the part of managers to reduce costs.

6-6. Other researchers' findings

There are three papers where productive efficiency was tested in which the UK airport industry was included. Bishop and Thompson (1992) tested the major UK regulated industries which had seen drastic ownership changes in the eighties or early '90s. The empirical findings by Bishop and Thompson are based on the method of calculating weighted indices of the growth rates of outputs and inputs, i.e., so-called total factor productivity (hereafter TFP). Their purpose was to investigate, over nine industries in aggregate, whether TFP has grown significantly faster during the '80s than during the '70s. BAA (before privatisation the then nationalised British Airports Authority) was included in the nine industries. Bishop and Thompson disaggregated the weighted index for inputs in BAA into the three components of (a) labour (23.0%), (b) capital (50.5%) and (c) other materials (26.5%). Regarding the outputs the components of the indices are (1) passenger arrivals and departures and (2) ATM. The TFP for BAA was 4.8% during the period from 1970 to 1980 and 0.3% during the period from 1980 to

1990. The labour productivity was 0.6% during the '70s and 2.7% during the '80s. Both the TFP values and the labour productivity values in the case of BAA are averaged over the relevant period but the value for each year is not shown in the paper. At least they showed that the labour productivity in BAA had grown more rapidly during the '80s than during the '70s. It is interesting that the TFP in BAA was smaller during the '80s than during the '70s. However, 1980 was long before the privatisation of BAA and the result cannot be compared with my result for productive efficiency measurement. The year 1980 was chosen by Bishop and Thompson in their investigation of the impact of privatisation over nine industries.

Boussofiane, Martin and Parker (1997) (hereafter BMP) used DEA in order to test whether the ownership changes in the major UK regulated industries had had any impact on performance. Parker (1997) also used DEA to investigate whether there was any evidence of performance improvement in the BAA after privatisation. The input data which BMP chose were (a) employee hours, (b) capital, and (c) other costs deflated by the RPI for non-food items, whilst the output data was turnover deflated by the RPI for non-food items. Parker used physical data for both inputs and outputs: (a) numbers employed, (b) capital, and (c) residual of total operating costs deflated by the RPI for the inputs, and (1) passenger numbers handled and (b) cargo and mail business for the outputs. The period for measurements of both papers is from 1979/80 to 1995/96.

The results produced by BMP and Parker are quite different as the output data the former used was pecuniary units and that of the latter was physical units. Although both papers were carried out using both CRS and VRS models, I refer only to their results using VRS for the purpose of comparability with my result of measurement (A) in section 6-4. The comparison table is shown below:

Table 6-6 three different measurements of BAA (VRS model)

year	BMP	Parker	Ito	BMP(business cycle)
79/80	1	0.98	1	1
80/81	0.94	0.95	0.81	0.95
81/82	0.95	1	0.81	1
82/83	0.97	1	0.87	1
83/84	1	1	0.98	1
84/85	1	1	0.98	1
85/86	1	1	1	1
86/87	0.99	0.97	0.96	0.98
87/88	1	1	1	0.99
88/89	1	0.89	0.91	0.99
89/90	1	0.92	0.85	0.96
90/91	1	0.81	0.79	0.86
91/92	0.93	0.81	0.92	0.86
92/93	0.89	1	0.90	1
93/94	1	0.94	0.99	1
94/95	1	1	1	1
95/96	1	1	1	1

BMP refers to the result by Boussofiane, Martin and Parker

Parker refers to the result by Parker

Ito refers to my result as to the measurement (A) in section 6-4

As a part of the analysis both BMP and Parker calculated BAA's efficiency scores adding another series of data, changes in real GDP, as an exogenous input. The purpose of this input was to capture the business cycle effect. The business cycle was assumed to be reflected by changes in real GDP. BMP's result of the calculation is shown in the last column of Table 6-6, whilst Parker chose not to report the result.

The results by both BMP and Parker confirm that there was efficiency improvement during the preparation period before privatisation where the pressure on the management was predicted, although it is still not clear whether the improvement in efficiency came from changes in the outside environment or mainly from pressure on management towards productive efficiency. All of the results confirm that there were inefficient years after privatisation. The output choice of my measurement is a mixture of pecuniary and physical data, whilst the output choice by BMP is purely pecuniary and that by Parker is purely physical. This may be the reason why any year which was measured as inefficient by either BMP or Parker was also inefficient in my measurement except for 79/80.

My results shown in Table 6-6 were extracted from the measurement (A), i.e., efficiency calculation using the data during the period between 1966/67 and 1995/96, whilst both the results of BMP and Parker were calculated from the data starting 1979/80. My result of having only 5 efficient years out of the period between 1979/80 and 1995/96, as compared to BPM's 11 efficient years and Parker's 9 efficient years, can be considered to be a reflection of the possible productivity growth which the then British Airports Authority or BAA might have seen.

The target reduction ratios of inputs in order to achieve efficiency was also shown in Parker's paper. The results showed a larger target reduction rate for capital than that for employment and operating costs from 1988/89 continuously to 1991/92. Parker's results may show clearer evidence that BAA had an incentive for 'gold plating' the cost of capital after privatisation before the first regulatory review.

Notes to Chapter 6

1. The supporting hyperplane in $(s + t)$-dimensional Euclidean space given by

$-\sum_{i=1}^{s} v_i^* x_i + \sum_{j=1}^{t} w_j^* y_j + \omega^* = 0$, where the x_i and y_j are now variables. v_i^*, w_j^* and ω^* are the values of v_i, w_j and ω which maximise the objective function in the following fractional programming problem which is equivalent to the linear programming problem (6-3-P):

$$\max \quad e^0 = \frac{\sum_{j=1}^{t} w_j y_{jm_0} + \omega}{\sum_{i=1}^{s} v_i x_{im_0}}$$

$$s.t. \qquad \frac{\sum_{j=1}^{t} w_j y_{jm} + \omega}{\sum_{i=1}^{s} v_i x_{im}} \leq 1 ,$$

$$m = 1,\ldots,n; \; i = 1,\ldots,s; \; j = 1,\ldots,t; \; v_i, w_j \geq 0$$

2. This empirical analysis was carried out in 1996/97 and this is the reason why the end period of both two measurements in this chapter is 1995/96.

3. Though recent data for staff costs after privatisation was not on the annual reports of BAA, it was available to the public and was not 'classified'.

4. Charnes, Cooper and Rhodes (1981) in their 'programme follow through' concept used the

term 'programme efficiency' which has the same meaning in this chapter as 'policy efficiency'.

5. Table 6-7 below shows a comparison between the results by VRS model and the results by CRS model. Because of the reason I explained earlier in section 6-2, i.e., the DEA measurement using CRS penalises the DMUs which are operating at a non-optimal scale, many more DMUs measured with the CRS model were judged to be less efficient than in VRS model.

Table 6-7 VRS scores and CRS scores

year	VRS efficiency	CRS efficiency
66/67	1	1
67/68	0.989	0.986
68/69	0.995	0.993
69/70	1	1
70/71	1	0.978
71/72	1	1
72/73	1	1
73/74	0.999	0.978
74/75	0.984	0.955
75/76	1	0.954
76/77	1	0.95
77/78	1	0.986
78/79	0.871	0.781
79/80	1	0.706
80/81	0.808	0.67
81/82	0.808	0.694
82/83	0.873	0.736
83/84	0.98	0.872
84/85	0.982	0.934
85/86	1	0.958
86/87	0.959	0.945
87/88	1	1
88/89	0.906	0.87
89/90	0.848	0.753
90/91	0.787	0.723
91/92	0.915	0.672
92/93	0.894	0.839
93/94	0.991	0.983
94/95	1	1
95/96	1	1

Chapter 7

Conclusion

The regulatory reform of UK airports by the 1986 Act not only realised the privatisation of the then British Airports Authority, but also created local authority airports as plcs (as described in Chapter 2). The regulatory reform created a new framework for the economic regulation of the industry. As I have explained in the introduction to Chapter 1, the purpose of this thesis is to explore theoretical predictions as to whether and how there have been any efficiency changes since the regulatory reform of the UK airport industry, and to analyse how the predicted changes can be supported with evidence. In Chapter 1 I surveyed the literature on regulatory economics and the concept of positive theories, particularly in the context of public corporations. I then applied, in Chapter 3, a basic positive approach model which has been developed by Vickers and Yarrow (1988) and Rees (1984) to the different kinds of 'institutional arrangements' for the UK airports, i.e., before and after the regulatory reform of both privatised/nationalised and local authority airports. I then explored how the predictions in pricing, cost-reduction activity levels and investment levels are different to what the benchmark conditions would suggest would be achieved if total welfare maximisation had been aimed at. The financial target constraint imposed on the then nationalised British Airports Authority can be regarded as a set of incentive mechanisms, thus I have tried analysing how they might be expected to work in terms of the efficiency change outcome. The effect of the change in the form of the financial target just before the privatisation was also analysed. Taking the central government grant and the ceiling for the capital borrowed into consideration I made a variation to the basic model for the local authority airports for the period when they were directly owned and managed by the local authorities. After the regulatory reform the economic regulation framework made a clear definition between regulated revenue and unregulated revenue. Because of this in Chapter 4 I focused the predictions in line with the basic model on changes in cost-reduction activity level and investment level, and made a more specific model of the airport's price structure where price cap regulation is imposed. Both the cost-reduction activity level and investment level of BAA airports were predicted to be improved after privatisation compared to the period under nationalisation, the investment level in particular was expected to be optimum under privatisation. The local authority airports' cost-reduction activity level was also predicted to improve after they became plcs, although the cost-reduction activity level of the local authority plc airports was expected to be less than that of privatised airports. Because of the capital borrowing limit constraint the change after the regulatory reform was expected to be from a tendency of over-investment towards under-investment for the local authority airports.

I used a model in Chapter 4 based on the 'Average Revenue' form of price cap regulation. The airport charges for the 'designated' airports (Heathrow, Gatwick, Stansted and Manchester) have been regulated after the regulatory reform via a specific formula of price cap regulation. It has been pointed out in the recent literature that the outcome under the 'Average Revenue Approach' would be inefficient in the sense that the ratio of the price to the marginal cost would be higher for the service whose marginal cost is higher. The price cap regulation on the airport charges at the 'designated' airports is of a similar form to the general form of 'Average Revenue Approach', but the actual price cap constraint form is designed to limit to the capped level the total revenue from all the airport charges averaged by the passenger numbers. Other quantities such as the number of landings and takeoffs are not included in the averaging factor. I have developed a simple model to encapsulate BAA's London airports price cap regulation in Chapter 4 in order to predict the price structure change after the regulatory reform. I have then tried predicting the price rebalancing effects

(1) between peak passenger charge and off-peak passenger charge,
(2) between passenger charge and landing charge,
(3) between peak landing and off-peak landing charges,
(4) between passenger charge and unregulated service price and
(5) between landing charge and unregulated service price.

Making several assumptions, I have predicted the price ratios of the above five categories after the price cap regulation was introduced. I then compared them to the period when the airports were subject to financial target constraint under nationalisation. The direction of the changes for the ratios mentioned above respectively were predicted as follows:

(1) higher than before
(2) lower than before
(3) higher than before
(4) lower than before
(5) higher than before

In the appendices to Chapter 4 I included the predictions from the model including the demand interdependency between passenger service and landing service, and also the effect of international charge and domestic charge as a variation of the model.

In Chapter 5 I looked for any empirical evidence for the predicted rebalancing effect between different airport charges. As it was impossible to estimate the marginal cost for each airport charge, the empirical analysis was carried out in the form of price ratio change. I have used a linear time trend regression analysis using both slope dummies and intercept dummies. The analysis of the actual change in the price ratios carried out in Chapter 5 was based on the change over time, whereas the price ratio change predicted in Chapter 4 was atemporal. The results which show significantly different coefficients in both the slope and the intercept before and after the regulatory reform were considered as evidence that price ratio change existed. The airports for which the airport charge data was available were BAA's three London airports (which are subject to price cap regulation) and BAA's three Scottish airports (which are subject to no price regulation *per se*). The price ratios with which I carried out the trend analysis using the six airports' data are as follows:

- the price ratio of peak passenger charge to off-peak passenger charge
- the price ratio of peak landing charge to off-peak landing charge
- the price ratio of international passenger charge to domestic passenger charge

Of the three kinds of ratios above, only the results from the price ratio of international passenger charge to domestic passenger charge seem to support the predicted rebalancing effect for most of the airports. It was found that not only was there no clear evidence for the price ratio trends to be in the predicted direction regarding the first two categories, but also the passenger charge ratio between peak and off-peak showed that the direction of the actual price ratios were in the opposite direction in most of the BAA's London airports, i.e., there seems to have been a tendency towards the lowering of price ratio of peak passenger charge to off-peak passenger charge after the regulatory reform.

In Chapter 6 productivity efficiency measurement was carried out in order to investigate (A) whether the predicted improvement in productivity efficiency in BAA after privatisation existed and (B) whether the BAA's privatised airports are more efficient in productivity than the local authority airports. I have used the DEA method (VRS input minimisation model) and calculated technical efficiency for both measurement (A) and (B). The inputs are staff costs and capital employed, and the outputs are ATM and the commercial service revenue. As to measurement (A) I used the aggregated data for all the airports of BAA and calculation was carried out in time series. As to measurement (B) I used a technique to decompose technical efficiency measured by DEA in order to identify inefficiency that is attributable to the type of ownership. The results for measurement (A) show no appreciable improvement change in BAA's productive efficiency after privatisation. The results for measurement (B), however, showed that the airports that have been privatised were significantly more efficient than those that remain in local authority ownership.

As far as the empirical analyses in Chapter 5 and Chapter 6 are concerned, apart from the relatively convincing results of measurement (B) in Chapter 6, the results for both BAA's price rebalancing effect and BAA's productivity improvement are either opposite to the predictions or rather inconclusive. There then arises a question:

- Have there, since the regulatory reform, been any factors which the managers of BAA might have been more conscious of than the visible constraint of price regulation?

As I have already mentioned in the last section of Chapter 5, there are two important factors which BAA may have been taking into account:

(1) the process by which the maximum airport charge revenue is set, i.e., the way the value of X is set, and

(2) international obligations.

With regard to factor (1) the process of determining the X values has been closely related to the rate of return of the 'designated' airports as I mentioned in section 5-5. The price regulation of the 'designated' airports based on the 'single-till' principle means that identifying the cost of capital employed in both areas of 'air-side operations' and 'commercial-side operations' plays a significant role. As using the rate of return on capital is *de facto* the criterion in determining charging formulae, the RPI-X form of price regulation in the 'designated' airports is very similar to the rate of return regulation. Where the cost of capital plays a major role in price regulation, there is room for a regulated firm to manipulate the cost of capital, i.e., 'gold plating' of cost of capital. Although it cannot be said with certainty that there was any evidence for its 'gold plating' activity during the first quinquennium, the results of measurement (A) in Chapter 6 suggested that the possibility existed that the management of BAA can have been influenced by the regulatory review for the second quinquennium.

The results of the ratio of peak passenger charge to off-peak passenger charge (both international and domestic) suggested that the ratio at both Heathrow and Gatwick had been lowered since privatisation, which is the opposite to the prediction that was made by the model in Chapter 4 for analysing the rebalancing effect of the 'designated' airports' price cap regulation. Lowering the peak price and raising the off-peak price in an inefficient manner, i.e., setting the peak price below the marginal cost at peak period and setting the off-peak price above the marginal cost at off-peak period can be a possible behaviour of a firm regulated by rate of return regulation. This is because inflating the demand at peak period by lowering the peak price can be a strategy to expand the capital base, thereby earning the firm a larger profit. It is unfortunate that the difference between the international peak passenger charge and the international off-peak passenger charge at Heathrow was required to be phased out as per the international agreement based on the 'Exchange of Notes 1994' between the UK and the USA. Domestic passenger charge at Heathrow and international passenger charge at Gatwick and Stansted were not relevant to the issue of the international agreement. However, the peak and off-peak charge difference particularly the daily peak and off-peak difference applied for both international and domestic passengers has been gradually reduced at each BAA London airport. This tendency by itself cannot suggest that BAA had any incentive to expand its terminal capacity. There may have been actual changes in demand fluctuation between peak and off-peak periods at these airports, or even the possibility that the difference of the marginal costs of terminal services between the peak and off-peak period might have been diminishing. This price setting behaviour can also be related to the second factor mentioned above, i.e., international obligations. BAA might have feared that there could be future conflicts between airlines or other countries and BAA as to the airport charges, similar to the conflict which started in the early '80s and related to the 1983's MOU and ended with the 'Exchange of Notes 1994'. Even without any direct legal action by the airlines, the airlines can complain against a particular BAA price setting to the CAA and the CAA might decide to either intervene with the price setting policy or 'informally advise' BAA not to use a particular price setting (The CAA is mindful that any economic conditions which the CAA decides can be overridden by the Minister's directions in respect of international obligations.). The CAA seems to be conscious of the distortion in allocative efficiency caused by the 'single-till' principle[1], and it is not likely that the CAA would take actions against price differentiations which are based on the opportunity cost difference. Yet, the CAA is also the regulator of the airline industry, which might influence the CAA's behaviour.

There is another factor which is important in the reviews in so far as BAA is concerned. As an airport needs bulky investment in advance, there are problems with regard to funding investment in large terminals or runways. In the past quinquennia the funding method for future capacity expansion has always been discussed both in the case of BAA and Manchester. Particularly, a commitment problem between BAA and the CAA has been raised during the process of setting the price caps for the second quinquennium in terms of whether the Terminal 5 investment programme at Heathrow should be explicitly considered in determining the charging formulae. Though the second quinquennium was not expected to see the construction of the terminal, BAA had demanded that the CAA make a commitment in the long run to allow BAA to have a predictable income stream before it made any decision for the project. Although no such commitment was made for the second quinquennium, the contingent plans were made in setting the values of X during the third quinquennium in respect of the timing of the investment programme[2]. Thus BAA seems to have been more interested in securing the long term profit. However, the predictions from the model in Chapter 4 are based on the airport operator's objective function which is to maximise the profit at each quinquennium, i.e., short term profit. This is one of the limitations of this thesis. The analyses do not include capacity as a variable and do not cover the issue of the airport's long term profit. Also, the models in Chapter 3 and Chapter 4 are based on the comparative statics method. In order to fully analyse the dynamic aspects of the airport industry one would need to explore its strategic behaviours. The objective functions of both the government and the regulator would also need to be clearly defined, so that the strategic context could be fully analysed including the negotiation process in the reviews among the airport, the regulator, the government and the airline industry. The unique point is that an airport offers an infrastructure and needs to solve the problem of financing lumpy investment in a timely manner. This is an interesting subject for further research.

The airports policy the government announced in 1978 seems still to exist, i.e., the government's implicit policy is to keep each regional airport's given function (see Chapter 2), thus trying to avoid the situation where the airports in the UK become competitive in airport charges (As I have mentioned in Chapter 2, the government does not seem to believe the outcome and the benefit of competition among the airports in the UK (because of their natural monopolistic nature), and places a greater weight on the competition among airlines to improve the consumers' welfare.). Suppressing the competition among airports can have an effect on the airline industry's competition, i.e., where the competition among airports is not strong, the possibility of an airline company gaining a monopolistic power through dominating a hub airport can be avoided to a certain degree. On the other hand, there seems to exist competition among international airports as hub airports within Europe, particularly in the case of Heathrow and Gatwick. Although the UK airports are considered to have monopolistic power at least locally (one of the reasons for the price regulation at the 'designated' airports), if the international competition became more intense the necessity for regulating the airport charges would become weaker. This thesis does not cover the issues of international competition. However, it is worth mentioning that there is room for future research in international competition among the airports including slot problems, airports' investment decisions and the national airports policy for regional balance.

Addendum to Chapter 7

1. Incidentally, after finishing the research for this thesis, the CAA made a new move. From the year 2000 the CAA launched a series of investigations as to whether the price regulation form should be changed. It published documents mainly covering subjects such as (a) the possibility of the advantage in changing the current 'single-till' principle into a 'double-till' principle, (b) usage of incremental cost in the review and (c) changing the form of price cap from the current 'Average Revenue' approach to the 'Tariff Basket' approach. At the time of writing this thesis, the consultation with all the parties involved ongoing, and this thesis does not cover these issues. However, it is worth mentioning that the CAA is fully aware of the problems in allocative efficiency outcomes in relation to the way BAA's price level is determined.

2. The investigation mentioned in the above note 1 is basically related to the issue of securing long term investments such as for Terminal 5. The recent demand fluctuations in the airline industry (including those caused by the latest incident of the terrorist attack in the USA on September 2001) triggered the CAA to speed up the investigation, because 'encourag(ing) investment in new facilities at airports in time to satisfy demands by airport users' is one of the CAA's duties, and it is in the regulator's interest to establish ways to allow the airport industry to finance large capital programmes when the airline industry's demand is unpredictable.

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