Measuring the Total Factor Productivity of Government Trading Enterprises

STEERING COMMITTEE ON NATIONAL PERFORMANCE MONITORING OF GOVERNMENT TRADING ENTERPRISES

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PREFACE

Recently there has been general recognition that achieving an effectively performing public sector is an essential part of Australia's micro-economic reform agenda. The supply of major service inputs by government trading enterprises (GTEs) has a large impact on the competitiveness of Australian industry.

The objective of a national performance monitoring system is to provide an information base on the performance of GTEs. As experience is gained in compiling relevant, consistent data it will be possible for managements and shareholding governments to track the improvement in GTE performance, as reflected in the chosen indicators.

Performance monitoring also provides GTE managers with a useful management tool. In many of the industries where GTEs operate there is little direct competition in either output or input markets. An appropriate set of performance indicators can be an ideal tool for promoting so-called 'yardstick competition'.

The Steering Committee on National Performance Monitoring of GTEs, established by the July 1991 Special Premiers' Conference, is currently assembling a range of performance indicators for many major Commonwealth, State and Territory GTEs. To date this process has concentrated on the more readily available financial indicators and indicators of partial productivity and service quality. There is general recognition, however, that to obtain a comprehensive picture of GTE performance it is useful also to compile economic indicators such as total factor productivity and the economic rate of return. These indicators are more difficult to produce but encompass all of the GTE's operations.

The Steering Committee has prepared this paper to promote a better understanding of the steps involved in calculating and interpreting the total factor productivity measure. It provides an illustration of how to calculate this indicator for a typical GTE and presents several case study applications. In all, six GTEs have been used as case studies. These are: the Australian National Railways Commission, the State Rail Authority of NSW, Melbourne Water, the Port of Brisbane Authority, Pacific Power and Australia Post. Two of the case studies were prepared by the GTEs themselves with some assistance from the Steering Committee's secretariat (provided by the Industry Commission). Another two were prepared by Industry Commission staff with input from the GTEs. The remaining two were prepared for the GTEs by external consultants.

The experience with the case studies indicates that preparation of total factor productivity indicators is practicable, given an appropriate data base. The quality of capital data in particular remains a problem in some instances. However, most GTEs are in the process of having thorough valuations made of their assets and the accuracy of available data is expected to improve markedly in the next few years. The case studies included in this paper illustrate that a good start often can be made on calculating total factor productivity indexes with data that is currently available.

It is hoped the material contained in this paper will encourage more GTEs to become familiar with the technique and to initiate their own total factor productivity studies.

The Steering Committee wishes to thank the six case study GTEs and the staff involved for their co-operation and the helpful spirit in which they approached the exercise. Thanks are also due to the members of the technical sub-committee who reviewed the papers prior to publication.

Preparation of the paper was co-ordinated by Denis Lawrence of the Industry Commission with assistance from Ruth Thomson and Alan Avanzado.

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PART A

TOTAL FACTOR PRODUCTIVITY

1 TOTAL FACTOR PRODUCTIVITY — A USEFUL INDICATOR OF OVERALL ECONOMIC PERFORMANCE*

1.1 Performance indicators

Following the July 1991 Special Premiers Conference, the government created a Steering Committee to develop a national performance monitoring scheme for government trading enterprises (GTEs). The aim of this scheme is to lay the foundation for a better understanding of GTE performance. This is an important prerequisite before the success or otherwise of various reform initiatives can be judged.

The performance indicators being considered by the Steering Committee can be divided into three categories: financial, non-financial and economic. Financial indicators cover a range of accounting measures normally found in annual reports. Non-financial indicators cover measures of service quality and partial productivity. The two major economic performance indicators under consideration are total factor productivity (TFP) and the economic rate of return (ERR). These indicators help management gauge how well the organisation is performing overall. They can provide information on how the GTE is performing through time and how well it is performing relative to its peer enterprises. This information can be used to determine areas requiring improvement, as well as helping to determine appropriate pricing and investment policies.

This chapter explains briefly the concept of the TFP indicator and how it can be used by management. The following chapter discusses the technical aspects of calculating TFP along with the data required and some illustrative examples.

1.2 What is productivity?

Productivity is a measure of the physical output produced from the use of a given quantity of inputs. All enterprises use a range of inputs including labour, capital, land, fuel, materials and services. If the enterprise is not using its inputs as efficiently as possible then there is scope to

* Prepared by staff in the Industry Commission's Economic Studies Branch.

lower costs and increase profitability through productivity improvements. This may come about through the use of better quality inputs including a better trained workforce, adoption of technological advances, removal of restrictive work practices and other forms of waste, and better management through a more efficient organisational and institutional structure.

In practice, productivity is measured by expressing output as a ratio of inputs used. There are two types of productivity measures: total factor productivity and partial factor productivity. TFP measures total output relative to all inputs used. Output can be increased by using more inputs, making better use of the current level of inputs and by exploiting economies of scale. The TFP index measures the impact of all the factors effecting growth in output other than changes in input levels. Partial factor productivity (PFP) measures one or more outputs relative to one particular input (eg. labour productivity is the ratio of output to labour input).

1.3 The need for a 'total' productivity measure

Partial productivity measures are widely used as they are simple to calculate. However, partial factor productivity measures should be interpreted with caution.

By concentrating on the productivity of one particular input a misleading impression of overall performance may result. Take, for example, a railway whose productivity is being measured by the number of passenger journeys per employee (ie. the partial productivity of labour). A ten-year comparison of the results may indicate substantial productivity gains during the last four years. The source of these gains may be due to increased output or a decrease in labour input or a combination of both. Assuming that output increased by investing in faster and bigger trains (ie. more frequent services and more seating capacity during peak hours) while keeping the number of employees constant, the observed improvement in labour productivity has most likely been achieved at the expense of a deterioration in the partial productivity of capital. To assess whether the railway has become more efficient overall we need to measure output relative to both labour and capital inputs. Only by using a measure of total factor productivity can the true picture of performance be obtained.

Similarly, we need to be wary of setting performance targets in terms of partial productivity measures. Managers can often meet the specified target by simply using more of the inputs not included in the measure (eg. by substituting capital for labour if a labour productivity target was set). The net result overall may be a worsening of performance.

1.4 TFP and economic efficiency

An enterprise must be economically efficient to obtain the highest possible level of profitability . There are two aspects of economic efficiency. The first involves ensuring that the maximum output possible is produced from the given quantity of inputs available. This is known as technical efficiency. Assuming that inputs are all being used as productively as possible given current technology levels, the second aspect of economic efficiency involves combining those inputs in combinations which minimise costs given current input prices. This is known as allocative efficiency.

TFP is the best overall indicator of technical efficiency. It is a holistic measure which takes all inputs into account, thus avoiding problems of changing input composition associated with using partial productivity measures. Attaining high levels of technical efficiency and hence high levels of TFP is a prerequisite for an enterprise to maximise its profits. If the inputs available are not being used as efficiently as possible then profits can be increased by attaining higher levels of output from those inputs. It should be noted, however, that while being technically efficient is a prerequisite for profit maximisation it does not guarantee it. To provide a service at least cost the enterprise has to be allocatively efficient as well.

TFP indices calculated for one enterprise through time provide information on how its TFP has grown. However, information on TFP growth rates gives no indication of how close the enterprise is to being as technically efficient as possible or on how technically efficient it is relative to its peers. To obtain this information we need to know the enterprise's TFP levels as well as growth rates. This information can be obtained by extending measurement to look at a number of GTEs providing similar services through time and calculating multi-lateral TFP indices which give information on both TFP levels and growth rates (see Lawrence, Swan and Zeitsch (1991a,b)). The multilateral TFP technique provides a ready means of benchmarking enterprises both domestically and relative to international best practice.

1.5 TFP and microeconomic reform

Monitoring the TFP performance of government trading enterprises provides a ready means of gauging how successful GTE reforms have been. TFP changes show whether key government supplied services are being produced with relatively fewer inputs. By improving levels of technical efficiency in service provision, the cost of providing these services can be reduced and the resources tied up in those industries freed for use in other parts of the economy. This leads to improved competitiveness and improved domestic living standards.

Given its holistic nature TFP measurement provides a sure way of assessing whether reforms have been successful. As noted above, the use of partial productivity targets can provide managers with scope to achieve those targets by increasing the use of other inputs, perhaps leading to an overall worsening of economic performance. Only by monitoring TFP, can we identify whether overall performance is improving.

1.6 How can TFP be used by GTE managers?

Just as TFP measurement provides governments as owners of GTEs with a ready means of assessing the overall performance of those enterprises and whether reforms are in fact being successful, it also provides GTE managers with a useful management tool. In many of the industries where GTEs operate there is little direct competition in either output or input markets. By providing a means of comparing levels of technical efficiency, TFP measurement is an ideal tool for promoting so-called 'yardstick competition'. This can most obviously occur in terms of overall performance between similar GTEs. By providing a means of comparing performance between similar GTEs in different States, or in different countries, TFP monitoring can promote attainment of best practice. Comparing TFP levels between similar enterprises will provide information on who is the best performer. This then prompts management in the other GTEs to ask why the best performer is outperforming them. To find the answer to this question GTEs may have to engage in more detailed benchmarking exercises. This will enable them to identify the techniques being used by other GTEs and assess whether those techniques could usefully be used in their own operations to improve performance. A first step towards finding out why TFP levels differ between similar enterprises is to compare the partial productivity levels of the various inputs being used. This will provide a focus for further investigations on those inputs which appear to be a problem for the particular GTE concerned.

There is often little competition within particular GTEs for the provision of various services. Extending TFP measurement downwards through the enterprise from major business units right through to a relatively disaggregated level provides a ready means of promoting internal 'yardstick competition'. For instance, comparing TFP levels between individual power stations within the electricity industry, or between particular mail centres within the postal service will provide a form of competition between those business units which is otherwise absent. It provides a focus for workers in those business units to take pride in achievements, meet specified goals and outperform their counterparts. This can be used by management as a means of improving overall economic efficiency, involving employees to a greater extent and promoting participation of employees in putting forward ideas on how to improve performance. Many GTEs have already moved in this direction and are well advanced in calculating TFP at a relatively disaggregated level.

1.7 How accurate are TFP results?

Estimates of the TFP of an enterprise are only as good as the data used to calculate it. Both the quality and consistency of data affect the results. Most firms have a diverse range of outputs (eg. railways operations will provide both passenger and freight services) and an even more diverse range of inputs (eg. fuel, labour, materials and capital). An indexing procedure is used to add these diverse outputs and inputs together. This procedure uses the shares in total costs or revenues of each input or output, respectively, to derive weighted total quantity indexes for inputs and outputs.

In order to obtain an accurate picture of the enterprise, it is important that the data chosen accurately reflects the true use of inputs, production of outputs and level of service. For example, the use of persons employed may over- or under-estimate labour inputs if the number of hours worked by staff varies considerably from year to year. In such a case every effort should be made to obtain an hours worked series.

One of the main problems in undertaking productivity studies is obtaining accurate estimates of capital inputs. Being durable, capital inputs are consumed in production over many years rather than just the year in which they are purchased. Most information available on investment and capital stocks is, however, in historical cost terms which needs to be corrected for the effects of inflation, the difference between economic and accounting depreciation, effects of technological obsolescence, etc. Ideally, a thorough valuation of all the GTE's assets at current market prices is required for an accurate estimate of the GTE's total economic costs. The first step in obtaining such a valuation is to compile a register of all the assets held by the GTE. Following this, reputable valuers should be employed to assess the current market value of the assets. For those assets which cannot be valued directly (eg. due to thinness or non-existence of the market), approximations could be made based on the discounted cash flow of expected future production from the asset. Armed with this information, it is possible to form estimates of the quantity of capital employed by the GTE and its annual user cost.

While it is desirable to obtain the maximum degree of accuracy with respect to all outputs and inputs, the most critical data in calculating TFP will relate to the major outputs and inputs. This is because these outputs and inputs carry the highest weight in calculating the TFP index. Naturally, what is the most important output and input will vary from industry to industry.

TFP is more difficult to measure than conventional performance indicators. This is because it relies heavily on the availability of consistent data which accurately reflects the true nature of the business. In the past there has often been little, if any, emphasis on obtaining and reporting this information for GTEs. However, as we move towards greater corporatisation, more emphasis is being placed on obtaining and reporting this type of information which is crucial to the running of an efficient business. By its nature, the process will become more refined and sophisticated as better data become available and those undertaking the measurement gain more experience. The evidence to date indicates that most GTEs can calculate TFP using information currently available. Given the overall importance of microeconomic reform to the economy and the important role which TFP monitoring can play in this process, every emphasis should be placed on improving the quality and consistency of the data available on GTEs, both at an aggregate level for the GTE as a whole and at a disaggregated business unit level within each GTE.

1.8 Conclusions

The measurement of TFP gives managers a guide to the overall performance of their enterprise from one year to the next. It enables targets to be set for productivity growth and its progress to be monitored. This provides governments as owners of GTEs with a ready means of guaging the success of reform efforts. It provides GTE managers with useful information on how their enterprise is performing overall and on how it is performing relative to its peers. TFP measurement thus provides a ready means of 'benchmarking' the enterprise's overall performance relative to other enterprises supplying the same output. Finding out why TFP levels differ between enterprises will involve examining partial productivity measures to find out which inputs appear to be a problem for the enterprise concerned. More detailed benchmarking exercises between GTEs and private sector organisations may then be necessary to identify specific options for improving productivity performance. Similarly, extending TFP measurement down to the disaggregated business unit level within each GTE provides a ready means of promoting yardstick competition within the GTE and hence a means of improving its overall performance.

These attributes of TFP make it a very useful indicator of overall economic performance. It provides much information which cannot be obtained from either accounting or non-financial indicators. Extending the performance monitoring framework to include TFP indicators should be considered an important priority.

2 A TECHNICAL GUIDE TO CALCULATING TOTAL FACTOR PRODUCTIVITY*

2.1 Methodology

The aim of this chapter is to provide a simple illustration of the steps involved in calculating total factor productivity (TFP) for a representative government trading enterprise (GTE). The approach uses readily available information from the GTE's annual reports, supplemented by additional information on the valuation of capital stocks. The mathematical equations used in calculating TFP and related concepts, including the capital stock, depreciation and the user cost of capital are presented. These are explained with step by step examples which the reader can follow and adapt to calculate TFP for most GTEs.

2.1.1 Calculating TFP

Mathematically, TFP is defined as:

$$TFP = \frac{Q}{I}, \quad (1)$$

where

Q is the quantity of outputs, and
I is the quantity of inputs.

Most firms have a diverse range of outputs (eg. railways often provide both passenger and freight services) and an even more diverse range of inputs (eg. fuel, labour, materials and capital). Calculating TFP requires a means of adding together these diverse output and input quantities into measures of total output and total input quantity. The different types of outputs and inputs cannot be simply added (eg. it is not meaningful to add the number of employees to the number of litres of fuel consumed). Index number theory is used to overcome this problem.

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* Prepared by staff in the Industry Commission's Economic Studies Branch.

The Tornqvist index method is commonly used to calculate a TFP index. It cumulates through time a weighted sum of the rates of change of the component output or input quantities. The Tornqvist TFP index is defined in log-change form as:

$$\ln\left(\frac{TFP_t}{TFP_{t-1}}\right) = \sum_i \frac{1}{2}\left(R_{it} + R_{it-1}\right)\ln\left(\frac{Y_{it}}{Y_{it-1}}\right) - \sum_j \frac{1}{2}\left(S_{jt} + S_{jt-1}\right)\ln\left(\frac{X_{jt}}{X_{jt-1}}\right) \quad (2)$$

where t and t-1 are adjacent observations, there are i outputs, (Y), j inputs, (X), the Rs are output revenue shares, the Ss are input cost shares and ln is the natural logarithm operator.

This indexing procedure possesses a number of desirable technical properties which make it very suitable for calculating TFP. It avoids the traditional index number problem by using moving averages as weights and is consistent in aggregation in the sense that a Tornqvist index of Tornqvist indexes is approximately equal to a Tornqvist index of all the individual items. A more detailed explanation and discussion of these properties can be found in Industry Commission (1990) and Lawrence, Swan and Zeitsch (1991a,b).

Before calculating TFP it is necessary to ensure that appropriate and accurate data are available for the GTE.

2.1.2 Outputs and inputs

The most important aspect of calculating TFP is obtaining consistent and reliable sets of value and quantity data. If quantity data are not available, price data or an indicative price index are required. Variations in accounting methods from year to year and from one organisation to another often make it difficult to obtain consistent data. This is compounded by accounting methods that value assets at original or historic cost which does not give a true picture of the current worth of the organisation's assets.

Many GTEs have recognised that good information is a critical element in calculating performance indicators and are now improving their data collection and reporting methods. Most GTEs now periodically revalue some or all of their capital stock to reflect current or replacement values. It is becoming easier to use the data supplied in GTE annual reports to estimate TFP.

When choosing measures for outputs it is important to ensure that the GTE's major operations are accurately reflected (eg. railways carry passengers and freight hence we need measures of these two major output categories). When choosing input measures it is important to accurately reflect the level of utilisation of the input, if possible. For example, persons employed is not the best measure of the quantity of labour as it does not incorporate the number of hours each person worked. A better measure is total person hours. However, such data are not always available so the former may have to be used, based on the assumption that each person works the same number of hours each period. At a more basic level it is necessary to ensure that the number of part-time employees is converted to a full-time equivalent measure.

A fictitious government rail authority known as Choochoo Railways has been used to illustrate the type of data required to calculate TFP and possible sources for these data. In this example, Choochoo Railways is assumed to produce two outputs (freight and passenger travel) using three broad input types (labour, capital and other inputs). In some cases, direct measures of the value and quantity of these variables may be available. In other cases, only value information may be available and one may have to resort to the use of a price index to approximate the price faced by Choochoo. Using the identity; value = price x quantity; an implicit quantity can then be derived by deflating the value by an appropriate price index. The required output and input variables are as follows:

Output variables

Passenger revenue

Passenger kilometres travelled

Freight revenue

Net tonne kilometres of freight carried

Input variables

Labour costs (wages and salaries plus oncosts)

Number of operating and maintenance employees

Annual user cost of capital (VAUC)

Quantity of capital stock

Other costs

Price index for other costs

The specification of the variables is usually constrained by the data contained in Annual Reports and other supplementary sources. Most of the required information can be found in Annual Reports. For illustrative purposes Choochoo's income and expenditure statement for 1989–90 is reproduced in Table 2.1. In this example the minor outputs of retail and catering, rent and other income are excluded for simplicity. This is equivalent to assuming that the output of these items moves in line with that of freight and passengers.

Table 2.1: **Income and expenditure statement for year ended 30 June 1990**

		Choochoo Railways $000
	Income	
1	Freight services	1 298 980
2	Passenger services	79 810
3	Retail and catering	20 565
4	Interest	21 005
5	Rent	12 955
6	Asset sales	4 358
7	Other	7 732
8	Redundancy grant	4 940
9	Total	1 450 345
	Expenditure	
10	Operations	471 880
11	Salaries and wages	780 120
12	General charges	24 265
13	Redundancy payments	4 940
14	Audit fee	199
15	Board member's emoluments	46
16	Depreciation	83 733
17	Assets written off or sold	30 814
18	Amortisation of loan discounts	2 161
19	Interest and other loan charges	1 504
20	Leasing charges	2 906
21	Total	1 402 568

Source: Choochoo Railways 1990.

The variables passenger and freight revenue and labour cost for example can be taken straight from Table 2.1 (items 1, 2 and 11). Details of net tonne kilometres travelled and the number of staff are usually also available from Annual Reports. Other costs are derived as a residual after subtracting labour costs from total economic expenses. Economic expenses are obtained from Table 2.1 by deducting depreciation, interest expenses and other capital charges from total operating expenditure (item 21 less items 16, 19, 17 and 18).

Some of the desired quantity variables may have to be approximated using information from alternative sources. For example, the passenger kilometres variable may have to be derived for Choochoo Railways if the only information available from its Annual Reports were the number of passenger journeys. Additional information on the average distance travelled by Choochoo's passengers could perhaps be obtained from secondary sources and combined with the number of passenger journeys to obtain an estimate for the variable passenger kilometres.

Other variables such as the capital stock and user cost of capital cannot simply be taken from the Annual Report and have to be estimated using available data. The following sections illustrate how the capital stock and the user cost of capital can be calculated.

2.1.3 Capital stock

Capital inputs are different from other inputs in that only a fraction of the input is used each year to produce outputs. To obtain the contribution of capital it is, therefore, necessary to estimate the service flow derived each year from the capital stock. For simplicity, the quantity of this service flow is usually assumed to be directly proportional to the quantity of the capital stock.

The Industry Commission (1990) used the following method to obtain estimates of the quantity of the capital stock through time. It is a variant of the Perpetual Inventory Method (PIM) and relies on the availability of at least one reliable estimate of the current or market value of the GTE's capital stock. If a reliable current valuation is not available but a sufficiently long series for investment expenditure is available the conventional perpetual inventory method can also be used to generate estimates of capital stocks. Where disaggregated investment data is available it may also be possible to link the assumed length of life to the actual length of life observed for individual investments.

The Industry Commission method consists of updating and backdating the reliable point estimate of the current value of capital stocks by annual investment (net additions to capital taken from the assets and liabilities statement) and depreciation series to obtain a time series of current cost estimates of the capital stock:

$$K_{nt} = K_{nt-1}(1 - \delta_n) + I_{nt} \tag{3}$$

or equivalently,

$$K_{nt-1} = \frac{K_{nt} - I_{nt}}{(1 - \delta_n)} \text{ ; and} \tag{4}$$

$$K_t = \sum_n K_{nt}$$

where

K_{nt} is the capital stock, of type n, in constant prices in period t,

I_{nt} is net investment (including sales of assets) on capital of type n in constant prices in period t, and

δ_n is the economic rate of depreciation on capital stock of type n (see section 1.5).

The following example shows how to estimate the real value of capital stock for Choochoo in one year given that we know the value for another year. In terms of the data in Table 2.2, we can calculate capital stocks for 1979–80 or 1980–81 using equations 3 and 4 and assuming a declining balance rate of depreciation of 6 per cent. From equation 3:

$$K_{80-81} = 2542.16(1 - 0.06) + 187.14$$

$$= 2576.77, \text{ and from equation 4}$$

$$K_{79-80} = \frac{2576.77 - 187.14}{(1 - 0.06)}$$

$$= 2542.16$$

To obtain a series of capital stocks, suppose that the current value of capital assets for Choochoo Railways for the year 1978–79 has been estimated by the Choochoo Foundation as $1393 million. Using the Australian Bureau of Statistics (ABS) implicit price deflator for public fixed capital expenditure this converts to a real value of $2473.8 million in 1984–85 prices. Information on investment in fixed assets (or capital expenditure) can be obtained from Annual Reports. The series used in Table 2.2, column 2 consists of net additions of new and used fixed capital assets. Equation 3 is used to obtain a real capital stock time series (Table 2.2, column 6). The real capital stock series is then used as a measure of the quantity of capital input.

Using the real value of the capital stock to reflect the quantity of capital implicitly assumes that the assets are utilised at a constant rate. Typically assets are utilised less intensively during recessions and more intensively in boom times. For example, some locomotives may be taken out of service during extended periods of low demand and maintained, refurbished or stored until demand increases. By assuming the locomotives have the same utilisation each year, the capital stock may be over-estimated and consequently TFP underestimated in periods of recession. It is possible to overcome this problem by using physical units to reflect the quantity of capital stock (eg. track kilometres and the number of locomotives and rolling stock in service). However, this measure assumes that all assets are of a similar quality and age and will not include smaller assets which may be quite significant in total.

Table 2.2: **Estimating the quantity of capital stocks for Choochoo Railways**

Year	*Nominal investment $m*	*Price index*[a]	*Real investment* I_t	*Real depreciation* $K_{t-1}*0.06$	*Real capital stock*[b]
1978–79	133	0.563	236.23	142.83	2 473.82[c]
1979–80	137	0.632	216.77	148.43	2 542.16
1980–81	131	0.700	187.14	152.53	2 576.77
1981–82	216	0.782	276.21	154.61	2 698.38
1982–83	371	0.891	416.39	161.90	2 952.87
1983–84	307	0.940	326.60	177.17	3 102.29
1984–85	237	1.000	237.00	186.14	3 153.15
1985–86	377	1.084	347.79	189.19	3 311.75
1986–87	431	1.181	365.25	198.70	3 477.99
1987–88	332	1.265	262.45	208.68	3 531.76
1988–89	248	1.335	185.77	211.91	3 505.62
1989–90	251	1.412	177.76	210.34	3 473.05

a Implicit price deflator for public enterprise fixed capital expenditure, ABS, Cat. No. 5204.0.
b Real Capital Stock =(K_{t-1}*0.94) + I_t.
c Choochoo Foundation estimated value of capital stocks for 1978–79 ($1393 million) converted to 1984–85 constant prices.

2.1.4 Depreciation

Depreciation is the reduction in the value of an asset due to wear and tear or technological obsolescence. It represents the consumption or use of capital each year. In this way it is like any normal cost of running a business and should be included as a cost when calculating profit. The true amount of depreciation can only be accurately measured at the end of an asset's life (ie. *ex post*). Depreciation is usually approximated through time by either the declining balance or straight line method. The declining balance method assumes depreciation is a given proportion of the remaining value of the asset. The straight-line method divides the original value of the asset by its length of life to give an equal dollar amount each year.

When dealing with many assets of different vintages, calculating total depreciation can become very complex. To overcome this problem the Industry Commission (1990) used the implied declining balance depreciation rate (δ) that equates the present value of a declining balance depreciation charge to the present value of an 'L' year straight line depreciation charge reflecting zero residual value, for alternative subjective discount rates.

At the nominal discount rate r and the declining balance depreciation rate δ, the present value of the flow of depreciation is:

$$PV = \int_0^\infty \delta e^{-(r+\delta)t} = \frac{\delta}{(r+\delta)} \qquad (5)$$

For straight line depreciation over L years it is:

$$PV' = \frac{1}{L}\sum_{h=1}^{L}\frac{1}{(1+r)^h} = \frac{1}{L}\left\{\frac{(1+r)^L-1}{r(1+r)^L}\right\} \qquad (6)$$

Given r and L we solve for δ in:

$$PV = PV'$$

ie. $$\frac{\delta}{(r+\delta)} = \frac{1}{L}\left\{\frac{(1+r)^L-1}{r(1+r)^L}\right\}$$

For example with nominal discount rate r=0.1 and lifetime L=10 years

then: $\delta = 15.94\%$.

2.1.5 User cost of capital

The cost or annual user charge of capital is made up of two components. The first component is depreciation on the current value of capital stock (nominal value of assets) and is given by:

$$\delta P_{nt} K_{nt},$$

where δ is the declining balance depreciation rate, P_{nt} is the price of a physical unit of capital stock in each year, and K_{nt} is the physical quantity of capital stock in each year.

The second component is the opportunity cost of the current value of the capital stock which is given by:

$$\left(g - dP_{nt}/P_{nt}\right)P_{nt}K_{nt},$$

where g is the nominal opportunity cost of holding capital and dP_{nt}/P_{nt} is the annual rate of change in the nominal price of capital. The term in brackets can be interpreted as the commonly used approximation for real interest rates (nominal rate of interest minus the rate of inflation).

Combining the two components, the formula for the annual user charge is:

$$VAUC = \left(\delta_n + g - dP_{nt}/P_{nt}\right)P_{nt}K_{nt} \tag{7}$$

where VAUC is the value of the annual user cost of capital.

Choochoo's annual user charge for capital is derived in Table 2.3. Since Choochoo Railways is a government trading enterprise, the ten year government bond rate was used to approximate the net cost of financing a dollar's worth of capital.

Table 2.3: **Estimating the annual user charge for capital (VAUC)[a]**

Year	*g*	*δ + g*	*Price index*[b]	*dP/P*	*Nominal value of capital stock*	*VAUC*[c]
1980–81	0.132	0.192	0.700	0.11	1 803.74	145.00
1981–82	0.164	0.224	0.782	0.11	2 110.14	231.51
1982–83	0.149	0.209	0.891	0.14	2 631.00	177.53
1983–84	0.138	0.198	0.940	0.06	2 916.15	412.11
1984–85	0.135	0.195	1.000	0.06	3 153.15	413.60
1985–86	0.130	0.190	1.04	0.08	3 589.94	393.10
1986–87	0.128	0.188	1.181	0.09	4 104.39	387.79
1987–88	0.120	0.180	1.265	0.07	4 468.05	484.22
1988–89	0.135	0.195	1.335	0.06	4 680.37	653.68
1989–90	0.133	0.193	1.412	0.06	4 904.31	663.66

a When data is available on more than one type of asset class an aggregate capital quantity and price series can be found by using the indexing procedure discussed in section 2.1.1.
b Implicit price deflator for public enterprise fixed capital expenditure (ABS, Cat. no. 5204.0).
c Calculated using equation 7.

2.1.6 The complete data set for Choochoo railways

The complete price and quantity data used to calculate TFP for the period 1980–81 to 1989–90 are presented in Table 2.4.

Table 2.4: **Data used for calculating total factor productivity**

A. Output variables:

	Freight		*Passenger*	
Year	*($m)*	*(net tonne kilometres)*	*($m)*	*(Passenger-km)*
1980–81	532.12	16 470	26.75	1 105
1981–82	656.25	17 469	32.77	1 159
1982–83	691.85	17 561	37.06	1 157
1983–84	849.80	19 273	43.33	1 231
1984–85	1 038.55	22 765	46.59	1 192
1985–86	1 106.47	24 455	52.30	1 206
1986–87	1 161.68	24 933	59.81	1 278
1987–88	1 114.20	24 880	74.07	1 305
1988–89	1 253.18	25 765	83.93	1 353
1989–90	1 298.98	27 451	79.81	1 236

(Continued on next page)

Table 2.4: **Data used for calculating total factor productivity** *(continued)*

B. Input variables:

	Labour		*Other inputs*		*Capital inputs*	
Year	*($m)*	*(No. of staff)*	*($m)*	*(Quantity[a])*	*($m[b])*	*(Quantity[c])*
1980–81	481.25	342 67	191.04	157.50	145.00	2 473.82
1981–82	575.70	341 80	221.90	162.75	231.51	2 542.16
1982–83	628.96	343 34	263.03	173.69	177.53	2 576.77
1983–84	674.18	336 92	297.42	182.26	412.11	2 698.38
1984–85	708.48	327 55	328.21	186.91	413.60	2 952.87
1985–86	736.69	322 46	368.64	195.11	393.10	3 102.29
1986–87	745.14	306 70	402.54	198.42	387.79	3 153.15
1987–88	729.43	286 37	438.26	203.55	484.22	3 311.75
1988–89	754.78	270 86	436.82	190.33	653.68	3 477.99
1989–90	780.12	263 25	471.88	192.89	663.66	3 531.76

a Implicit quantity derived by deflating the value by the ABS price index for public enterprise transport equipment.
b The value of capital inputs is the user cost of capital derived in Table 2.3.
c The quantity of capital input is approximated by the real capital stock derived in Table 2.2.

2.2 Some illustrative results

The TFP index can be calculated from the data listed in Table 2.4 using equation 2. The indexing formula can be implemented easily using an econometrics package such as SHAZAM or can be programmed using a standard spreadsheet package. In the case of Choochoo Railways, the estimated output, input and TFP indexes are shown in Table 2.5.

Table 2.5: **Output, input and TFP indexes[a]**

Year	*Output Index*	*Input Index*	*TFP Index*
1980–81	1.00	1.00	1.00
1981–82	1.06	1.02	1.04
1982–83	1.07	1.05	1.01
1983–84	1.17	1.06	1.10
1984–85	1.37	1.06	1.29
1985–86	1.46	1.08	1.36
1986–87	1.50	1.07	1.40
1987–88	1.49	1.05	1.43
1988–89	1.55	1.00	1.54
1989–90	1.63	0.99	1.65

a The indexes for output, inputs and TFP have been set to one in the first year.

For 1982 the output index was estimated in the following way:

$$\ln\left(\frac{Y_{81-82}}{Y_{80-81}}\right)=\frac{1}{2}\left\{\left[\left(\frac{656.25}{689.02}+\frac{532.12}{558.87}\right)\ln\left(\frac{17469}{16470}\right)\right]+\left[\left(\frac{32.77}{689.02}+\frac{26.75}{558.87}\right)\ln\left(\frac{1159}{1105}\right)\right]\right\}=0.058$$

Taking the antilog of this we obtain a value of 1.058 for the ratio of the output index in 1980–81 to that in 1981–82. Since the index is being set equal to 1.0 in 1980–81, its value in 1981–82 will be 1.0 x 1.058 = 1.06. Similarly, the ratio of output in 1982–83 to that in 1981–82 between is 1.009 leading to an index value in 1982–83 of (1.06 x 1.009) = 1.07 and so on.

It can be seen from Table 2.5 that between 1982–83 and 1987–88 output grew largely due to improved productivity rather than increased use of inputs. Furthermore, the share of TFP in total output growth has increased with time. This can be seen more clearly by decomposing the growth in output into that due to growth in inputs and that due to growth in TFP.

TFP as defined in equation (1) can be expressed in growth terms as:

$$T\dot{F}P=\dot{Q}-\dot{I} \tag{8}$$

where

$T\dot{F}P$ is the growth in TFP,

$\dot{Q}$ is the growth in total output, and

$\dot{I}$ is the growth in total inputs,

or alternatively:

$$\dot{Q}=T\dot{F}P+\dot{I}$$

The trend growth rate, over a number of periods, of output, input and TFP can be found by regressing the natural logarithm of these variables against time and a constant term. Trend growth rates for the 3 indexes and the contribution of TFP to output growth are presented in Table 2.6 for the whole period and 2 sub-periods.

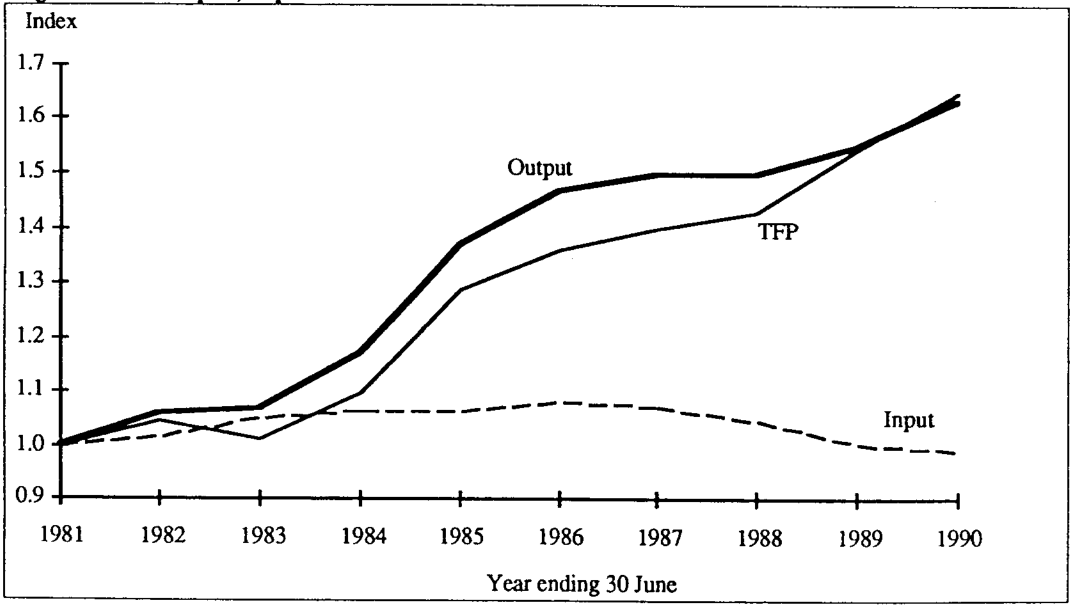
Table 2.6: **Contribution of growth in total factor productivity and input use to growth in output**

Period	*Trend growth in output % pa*	*Trend growth in input % pa*	*Trend growth in TFP % pa*	*Contribution of TFP to output growth %*
1980–81 to 1989–90	5.8	–0.1	5.9	102
1980–81 to 1984–85	7.2	1.7	5.5	76
1985–86 to 1989–90	2.5	–2.3	4.8	192

Trend output growth for the period 1980–81 to 1989–90 was 5.8 per cent per year with total factor productivity contributing 102 per cent of the growth. Between 1981 and 1985, trend output growth was 7.2 per cent a year with TFP growth accounting for 76 per cent of this. For the last five years Choochoo's productivity growth fell to 4.8 per cent. However, while output growth fell to 2.5 per cent input use actually declined at an annual rate of 2.3 per cent. TFP growth was thus contributing more than 100 per cent to output growth as it more than offset the reduction in input use.

The output, input and total factor productivity indexes for Choochoo Railways are graphed in Figure 2.1. TFP fell substantially in the third year reported due largely to reduced output associated with the recession of 1982–83.

Figure 2.1: **Output, input and TFP indexes**



2.3 Summary

The various steps involved in calculating TFP for a representative GTE have been illustrated in this chapter. While this approach will be generally applicable to most GTEs, the availability of data and the characteristics of the service provided by particular GTEs will necessitate case by case modifications to the procedure. The issues of most concern will typically be the availability and reliability of estimates of the current market value of capital assets and the choice of an appropriate rate of economic depreciation of these assets. In other cases, choosing appropriate variables to capture all aspects of the quantity and quality of a GTE's outputs may pose special problems.

PART B

TOTAL FACTOR PRODUCTIVITY CASE STUDIES

3 BACKGROUND

3.1 Previous TFP studies

The preparation of economic indicators for GTEs in Australia was first undertaken in a comprehensive fashion for the Industries Assistance Commission inquiry into Government (Non-tax) Charges (IAC 1989). In that inquiry TFP indexes were constructed for each of the State electricity systems and for the five major rail systems. Subsequent analysis has tended to concentrate on GTEs involved in the energy, transport and communications fields.

In 1990 the Industry Commission published an Information Paper presenting economic indicators for a range of GTEs. The methodology used was explained in detail and this formed the basis for most subsequent studies looking at the performance of single GTEs.

The Bureau of Transport and Communications Economics has also examined the productivity performance of Australian National railways in detail (BTCE 1991), while Telecom has undertaken in-house studies of its TFP performance (Smith and Fedderson 1989).

TFP indices calculated for one enterprise through time provide information on how its TFP has grown. However, information on TFP growth rates gives no indication of how close the enterprise is to being as technically efficient as possible or on how technically efficient it is relative to its peers. To obtain this information we need to know the enterprise's TFP levels as well as growth rates. This information can be obtained by looking at a number of GTEs through time and calculating multi-lateral TFP indices which give information on both TFP levels and growth rates. This technique provides a ready means of benchmarking enterprises both domestically and relative to international best practice.

Lawrence, Swan and Zeitsch (1991a,b) calculated multi-lateral TFP indices for the electricity supply industries in each of the five mainland States. This study utilised the methodology of Caves, Christensen and Diewert (1982), allowing TFP levels as well as growth rates to be compared for the period 1975–76 to 1989–90.

The Industry Commission (1991) has also applied this methodology to examine the comparative productivity performance of the five major railway systems. An adjustment procedure was also applied in this study to ensure that like was being compared with like since the composition of railway system output has an important bearing on productivity performance. Passenger operations are more input intensive and hence systems with a high proportion of passenger output will be disadvantaged in TFP comparisons. This adjustment was made by the use of regression analysis.

The most recent development in productivity measurement of GTEs has been the inclusion of overseas GTEs in multilateral TFP analysis. Swan Consultants (Canberra) Pty Ltd (1991) benchmarked the TFP performance of the Australian electricity supply industry against that of the investor-owned electric utilities in the United States. This approach enables the performance gap between Australian GTEs and international best practice to be established.

Table 3.1: **Recent GTE productivity studies and the indicators reported**

	Study	*Coverage*	*Time period*	*Indicators reported*
1.	Swan Consultants (Canberra) Pty Ltd (1991)	Australian and United States electricity systems	1975–76 to 1989–90	Multilateral Total Factor Productivity (MTFP)
2.	Lawrence, Swan and Zeitsch (1991a, 1991b)	State electricity systems (mainland States)	1975–76 to 1989–90	MTFP
3.	Industry Commission (1991)	Railway systems	1980–81 to 1989–90	MTFP and Real Rate of Return (RROR)
4.	Bureau of Transport and Communications Economics (1991)	AN railways	1979–80 to 1987–88	Total Factor Productivity (TFP)
5.	Industry Commission (1990)	Australia Post	1975–76 to 1987–88	TFP and RROR
		Qantas Airways		TFP and RROR
		Telecom Australia		TFP and RROR
		Australian National Line		RROR
		Australian Water Industry	1987-88	RROR
6.	Smith and Fedderson (1989)	Telecom	1975–76 to 1987–88	TFP
7.	Industries Assistance Commission (1989)	State electricity systems	1975–76 to 1987–88	TFP
		Railway systems	1978–79 to 1986–87	TFP

The major GTE productivity studies that have been completed recently and their coverage are listed in Table 3.1. As well as measurement techniques becoming more sophisticated through time it should also be noted that the quality of GTE data is progressively being improved. Most GTEs are currently undertaking or plan to commence thorough commercial valuations of their assets. Previous TFP studies along with the case studies included in this paper illustrate that a good start can be made on calculating TFP indexes with data that is currently available. Experience has also shown that commencing work on calculating GTE performance itself serves to identify gaps in data availability and accuracy and initiate action to improve the data available.

A natural progression in the evolution of economic performance indicator studies is as follows:

1. basic financial ratios and TFP estimates are derived from GTE annual reports. These estimates are easy to prepare but need to be treated with caution due to their reliance on historic cost capital values;

2. more reliable estimates of capital variables are formed. Ideally, a complete valuation of current assets is carried out. Alternatively, if a previous current value estimate is available this can be extended forwards and backwards using the perpetual inventory method (Industry Commission 1990). If no current valuation information is available, the approach of Swan (1990a, b) can be used to form estimates of annual user charges based on past investment series and length of life assumptions;

3. TFP and real rate of return indicators are compiled for each GTE using the capital values derived in (2). In the case of TFP, series derived for one GTE through time give information on TFP growth rates but not on TFP levels which indicate how efficient it is relative to its peers;

4. multilateral TFP series are formed to provide information on TFP levels as well as growth rates. This technique is particularly suitable to those cases where the same service is provided by different GTEs in different States (eg. electricity and railways). More generally, the technique provides a ready means of 'benchmarking' Australian GTEs against international best practice;

5. the indicators are further refined as superior data becomes available and/or errors in previously published series are detected and corrected; and,

6. adjustment procedures are developed which ensure that like is being compared with like. The effects of extraneous influences such as geography and topography are removed.

3.2 The case studies

To demonstrate some practical applications of TFP measurement, six GTEs were nominated as case studies. These are: the Australian National Railways Commission, the State Rail Authority of NSW, Melbourne Water, the Port of Brisbane Authority, Pacific Power and Australia Post.

The studies of Australian National and Pacific Power were prepared by the GTEs themselves with some assistance from the Steering Committee's secretariat (provided by the Industry Commission). The studies of the State Rail Authority of NSW and Melbourne Water were prepared by Industry Commission staff with some input from the GTEs, while those of the Port of Brisbane Authority and Australia Post were prepared by external consultants (State government and private sector, respectively).

All six case studies examine the respective GTEs in isolation. They thus calculate traditional TFP indexes which provide information on the growth rate of TFP for that GTE. Four of the case studies closely follow the Industry Commission method of preparing data and calculating TFP outlined in the preceding chapter. The studies of the Port of Brisbane Authority and Pacific Power adopt somewhat different approaches to the construction of capital data. In both these cases no current valuations of the GTE's assets were available but long time series of detailed investment data were available. In the case of Pacific Power information was also available on the commissioning and decommissioning dates of major assets. Given the long lead times in constructing electricity generation assets, Pacific Power also included interest during construction in the starting capital cost of major investments using a method similar to that of Swan (1990a). Both the Pacific Power and the Port of Brisbane Authority studies believed that straight line depreciation represented a more accurate representation of capital decay in those industries than the declining balance method used in the Industry Commission model.

Having derived estimates of the capital stock, both these studies go on to calculate annual user charges for capital on a similar basis to that of the Industry Commission although it should be noted that the Port of Brisbane Authority study adopts a wider definition of the term 'economic depreciation'. It incorporates both the depreciation term and the capital gains component identified separately in the Industry Commission model.

Another minor difference between the Port of Brisbane Authority and the other studies is that the PBA study treats internal capital development work undertaken by the Authority as output. This treatment was adopted as the inputs relating to internal capital construction work undertaken by the PBA could not be separately identified. The PBA inputs categories therefore include both inputs into operations as well as inputs into internal capital development work. On the other hand, the Industry Commission model excludes capital development work undertaken by enterprises from output while also excluding the inputs used to produce these capital goods.

In spite of these minor differences in approach to the treatment of capital, the six studies broadly follow the model set out by the Industry Commission. Its implementation has proven to be quite practicable. Even in those cases where available capital data is relatively crude a useful start has been made. Measurement will be progressively refined as better information becomes available.

4 TOTAL FACTOR PRODUCTIVITY OF AUSTRALIAN NATIONAL: 1979–80 to 1990–91*

For more than a decade now, Australian National (AN) has been engaged in a program of restructuring which has touched all parts of the organisation. The objectives of this program have been to develop an efficient, strongly commercial organisation which places emphasis on customer service and bottom line results. In order to monitor the results of this program, AN recently embarked on a project to develop an internal system of Key Performance Indicators. One of the indicators selected for measurement, on an annual basis, was AN's Total Factor Productivity. AN's experience to date with this indicator indicates that internal measurement is entirely practicable.

4.1 Summary

The use of so-called "economic indicators" is **one** useful way in which the performance of productive units in society may be assessed. This is particularly the case for public sector organisations which may not be subject to the normal efficiency mechanisms of the private sector, such as price competition and capital rationing by capital markets. One such "economic indicator" is an index of Total Factor Productivity (TFP) or Multifactor Productivity (MFP) as it is sometimes called.

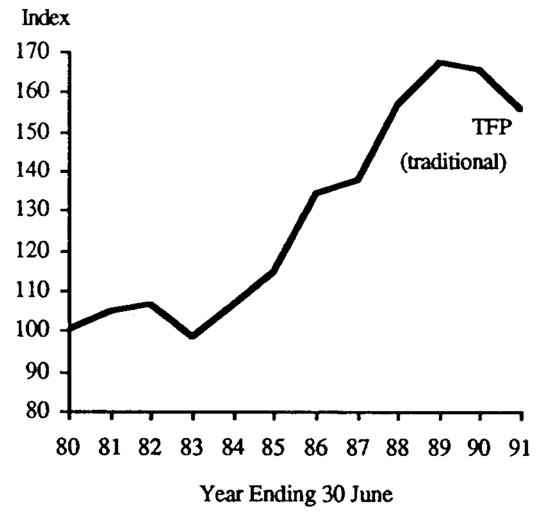
Total Factor Productivity measures attempt to relate changes in total output to changes in all (or most) of the major factors of production. As such, TFP measures provide better information about efficiency changes in an organisation than do so-called "partial productivity measures" such as labour productivity.

Australian National has developed a model, similar to that previously developed by the Bureau of Transport and Communications Economics (BTCE 1991) and the Industry Commission (1991), for the purpose of estimating the growth of AN's Total Factor Productivity over time.

Figure 4.1 shows an index of AN's TFP for the period 1979–80 to 1990–91, **derived from this model**. This index is the so-called "traditional" TFP index that has in the past, been used by the Industry Commission for reviewing GTE performance.

* This case study was prepared by the Corporate Strategy Department of Australian National.

Figure 4.1: **Total factor productivity of Australian National**



The index indicates that TFP within AN grew strongly for most of the period between 1979–80 and 1988–89. The poor result in 1982–83 was due to the coexistence of recession and drought in that year. In the period since 1988–89 the index has moved downward strongly, in response to the severity of the current recession.

The measured compound rate of growth of this index over the period 1979–80 to 1989–90 (without adjustment for variations in input intensity) was 4 per cent. The measured compound rate of growth between peaks of the growth cycle, where capacity utilisation can be assumed to be at a maximum, was 5.8 per cent between 1981–82 and 1985–86 and was 7.5 per cent between 1985–86 and 1988–89.

AN's high measured rate of TFP growth during the period (relative to other economy-wide TFP estimates) can be attributed to improvements in technical efficiency **and** to the productive effects of technological progress. However, TFP growth due to improved technical efficiency almost certainly exceeded that due to technological progress.

TFP growth rates for any organisation in a mature industry cannot remain high (ie. greater than 4–5 per cent) indefinitely. Outside of periods of unusual rates of technological change within the industry, high rates of TFP growth are usually associated with the transition from inefficient operations (i.e. a low TFP base) to more efficient operations (i.e. a higher level of TFP).

AN has not yet exhausted the potential to shed surplus resources, as part of its restructuring program. Accordingly relatively high TFP growth rates **would** have been expected to prevail **in the short term** beyond 1989–90, were it not for the severity of the current recession and the consequent dramatic fall in capacity utilisation. However, even in the absence of the recession, as the level of surplus resources is progressively decreased, AN's TFP growth rate should approach a rate nearer to that of the private sector as a whole (i.e. 1–2 per cent).

In the process of constructing an aggregate index of inputs to AN's production process, six types of inputs have been distinguished; three are "capital" inputs and three are "non-capital" inputs. The input groups selected are as follows.

Non-Capital Inputs	Capital Inputs
— labour	— land, buildings/structures and perway
— fuel	— plant and equipment
— "other inputs"	— rollingstock

The three capital inputs groups set out above have been used to construct a time series index for the size of AN's capital stock from 1979–80 to 1990–91. However, this index relies heavily on **preliminary** estimates of the value of the capital stock as at 30 June 1990. These estimates were obtained from AN's current revaluation exercise, which is due for completion in 1994.

The estimated index of AN's capital stock has remained within a band of 10 index points of its value at 30 June 1989–90 throughout the period 1979–80 to 1990–91. The precise path of AN's capital stock index over the period 1979–80 to 1990–91 would **appear** to be the result of four major influences, as set out below:

— the construction of the standard gauge Central Australian Railway;

— the gauge conversion of the Adelaide-Crystal Brook line;

— a period of rationalisation of the capital stock as part of AN's strategy to achieve break even in the profit and loss account; and,

— a period of historically high capital expenditures since about 1987.

AN's index of labour inputs has declined continuously over the period 1979–80 to 1990–91 while the quantity index of "Other Inputs" has declined strongly over the period 1979–80 to 1990–91. Over the study period, AN's fuel quantity index has moved mainly in line with the freight traffic task, as was to be expected.

4.2 Background

Objective comparisons between the performance of commercial organisations are usually undertaken via the use of various Key Performance Indicators (KPIs). These indicators can be grouped under three headings;

— accounting indicators,

— economic indicators, and

— non-financial indicators.

Under the heading of "economic indicators", the two most widely used measures are;

— Total Factor Productivity (TFP) (also called Multifactor Productivity); and,

— Real Rate of Return (RRR) (i.e. the real economic return on assets employed).

Measures of "partial" factor productivity are fairly widely known. These include labour productivity (ie. output/labour input) and capital productivity (output/capital input). However, partial productivity measures are ambiguous indicators and increases in these ratios may not always be the result of overall productive improvements in an organisation.

In contrast, the Total Factor Productivity measure presents better information about the productive path of an organisation, since it covers all (or most) factor inputs. TFP is measured as a **ratio** of an index of total output to an index of total inputs;

$$\text{TFP} = \frac{\text{Index of total output (a quantity measure)}}{\text{Index of total inputs (a quantity measure)}}.$$

TFP measures have been in the past produced with various "adjustments" to try and improve general aspects of the measure or to "tailor" the index for the input usage characteristics of a particular organisation being reported on. The latter exercise was done in the BTCE study, where an adjustment was made for the effects of "surplus" labour inputs being present within AN over the period 1979–80 to 1987–88.

However, in Australian studies, the main emphasis has been on the so–called "traditional measure" of TFP. This is simply a TFP index without any of the specific adjustments mentioned earlier. This result can probably be attributed to a desire to ensure a consistent indexing methodology, where the performance of a number of organisations was being examined.

The TFP index was initially developed to measure the rate of change of technological progress over time for organisations at the micro level and at the macro level for the economy as a whole. However, by nature of its construction, as well as measuring the productive effects of technological change, the index also captures changes in technical efficiency within an organisation.

To restate, the rate of change of TFP, as measured by the traditional index measures the rate of change of organisational productivity which is the **combined result** of changes in the technology of the production function and changes in the technical efficiency of operations. As a result, for any organisation which is already "technically efficient" the rate of change of TFP will equate to the rate of change of technological progress.

While technically superior to measures of partial productivity, the calculation of a TFP measure is more complex, since it requires a precise indexing technique.

AN has been involved with TFP measurement practices for a number of years now. This involvement initially occurred via providing data and other assistance to external agencies completing TFP studies on AN. These studies were undertaken by the BTCE in 1991 and by the Industry Commission as part of its various inquiries into Rail Transport. Such studies have provided invaluable information on the effects of AN's restructuring program.

However, AN also believes that it is most desirable for the organisation to be able to monitor this index on a continuous basis using internal resources. AN also believes that the internal preparation of TFP estimates, within Industry Commission guidelines, is regarded as being entirely practicable.

The benefits to AN from an "in house" model can be summarised as follows:

- TFP estimates produced by AN staff could potentially achieve greater accuracy, by continuing to refine data inputs;
- AN will prepare its own TFP estimates on an annual basis, rather than relying on irregular studies by outside agencies. This benefit would be maximised by remaining within the generally accepted IC/BTCE methodology;
- Preparing TFP estimates internally will complement AN's existing procedures for calculating partial productivity measures, and will improve management familiarity with the information content of the index; and,

— TFP estimates produced internally will be available for inclusion in AN's Annual Reports and Corporate Plans.

4.3 Measuring AN's aggregate output

In the preceding section it was observed that the TFP index is a ratio of an index of total organisational output and an index of multiple factor inputs. In this section the construction of AN's **output index** is described. Results from the model are then presented and reviewed.

4.3.1 AN's output index: construction

The output index used is a **Tornqvist** Index. It is also a **quantity** index and not a value index. A full description of the construction of this index can be found in BTCE (1991) or Industry Commission (1990), however the basic formulation used is as follows.

Starting with the continuous rate of growth in output (Q);

$$\log Q = \log(Q_t/Q_{t-1})$$

$$= (1/2) * \sum_{j=1}^{n} (S_{jt} + S_{jt-1}) * \log(Q_{jt}/Q_{jt-1})$$

$$= A$$

The output index is then given by rearrangement as follows:

$$Q_t = Q_{t-1} * \text{Antilog}(A)$$

where:

Q_t is an index of total output produced in period t;

S_{jt} is the revenue share of output j in total revenue, in period t;

Q_{jt} is the quantity of output j produced in period t, and,

n is the number of separately identified outputs.

A detailed understanding of the previous formulation is not essential. However, the overall result is that the indexing procedure attempts to overcome the "aggregate output" problem of summing "apples" and "oranges". It does this by setting the aggregate output quantity (i.e the index) to a value of 100 in the base year. The value of the index in the next year is then calculated by multiplying the value in the base year (ie. 100) by a growth factor. This growth factor is a "weighted" average of the individual changes in the quantities of the three component outputs produced by AN. The "weights" used in this formulation are the revenue shares.

Via this procedure the index effectively gives greatest weight to changes in the quantities of those outputs which account for the most significant share of AN's annual total revenue.

It should also be noted that in calculating the revenue shares for "weighting purposes", explicit CSO payments have been **included** as a revenue component, and are in no way distinguished from other revenue sources. This procedure was also used by Brunker and Chapman (BTCE 1991).

Explicit payments for CSO services have been identified in AN Annual Reports since 1985–86. Prior to this period, payments to AN by the Commonwealth government included an implicit CSO component. Following the BTCE methodology, the size of these payments in the years 1979–80 to 1984–85 were imputed by:

> "...multiplying the unsupplemented revenue (from Tasrail services and from passenger services respectively) for that year by the ratio of CSO payment to revenue (unsupplemented) for the relevant service in the year 1985–86" (BTCE 1991, p 68).

As with the BTCE study, AN's TFP model distinguishes three categories of output. These are:

— mainland freight services, measured in net-tonne-kilometres (NTKs);

— Tasrail freight services, measured in net-tonne-kilometres (NTKs); and

— passenger services, measured in passenger-train-kilometres (PTKs).

By comparison, the Industry Commission TFP study of rail distinguished only two types of system output, freight services and passenger services.

NTK data is available for the whole of the study period and this is an appropriate **unit** of output for freight services. Both the BTCE and the Industry Commission used NTKs as the unit of output for freight services.

In the case of passenger services, the Industry Commission used passenger-kilometres as the unit of output. Where system data on this basis was not available (as in the case of AN) this figure was estimated by ... "multiplying the number of urban and country passenger journeys by the respective average journey distances obtained from the Commonwealth Grants Commission (CGC 1988)".

Given the lack of a data series for AN passenger-kilometres, and the uncertain accuracy of alternate estimation methods, it was decided to make use of "passenger-train-kilometres", for which a data series was available. The BTCE study also used this unit.

In reviewing the adequacy of passenger-train-kilometres as an output measure, the BTCE concluded that:

> "...AN is required by legislation to provide certain passenger services regardless of the level of passenger demand. As such, it may be viewed as having entered into a contractual agreement with the Commonwealth government to provide a given level of passenger services. Whether or not that level constitutes an over provision is of importance from a national welfare viewpoint, but it is not relevant to the question of how efficiently that contractual arrangement is fulfilled. These considerations, together with a lack of origin-destination data, provide some justification for the measure." (BTCE 1991, p 67)

4.3.2 Results obtained from the model

Figure 4.2: **Index of aggregate output for AN**

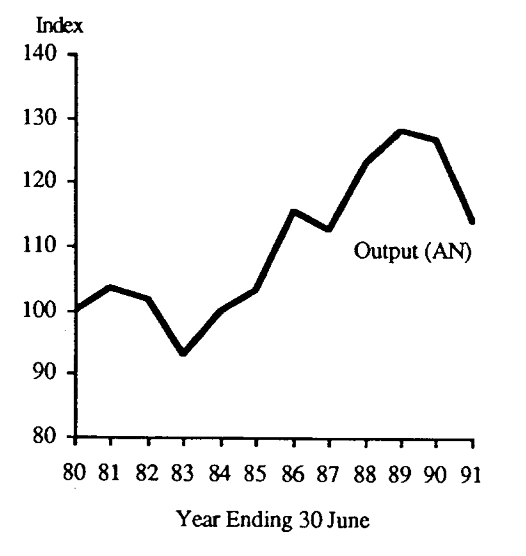


Figure 4.2 shows AN's aggregate output index as derived from the AN TFP model. Data relevant to the output index is contained in the AN data set at the end of this document.

Figure 4.3 shows three separate output indices. These are:

— AN's output index;

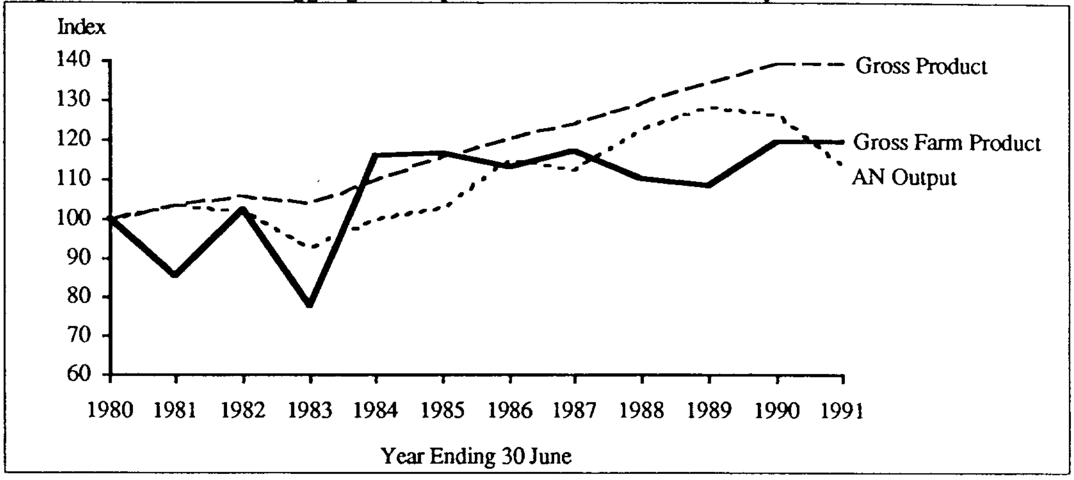
— the gross product index for the market sector of the economy; and

— the gross farm product index for the economy.

From this graph it can be seen that throughout the period 1979–80 to 1989–

90, AN's output index tracked the index for gross product of the economy, as would be expected for a major transport operator. In the early part of the period AN's output was also strongly affected by the output of the rural economy, with the result that the coincidence of recession and drought in 1982–83 caused AN's output to fall significantly in one year. Toward the end of the study period AN's output index tracked the Gross Product index more closely, as the importance of grain hauling within AN diminished.

Figure 4.3: **Index of aggregate output for AN and the economy**



The graph of AN's output index also indicates the dramatic effect on AN of the current recession. As indicated therein, by 1990–91, AN's output index had fallen back to its level of 1986–87, and was only about twelve index points above the level achieved in 1979–80.

4.4 Measuring AN's aggregate inputs

In the process of constructing an aggregate index of inputs to AN's production process, six types of inputs have been distinguished; three are "capital" inputs and three are "non-capital" inputs. For each of these, a "quantity series" and a "value series" has been estimated. The input groups selected are as follows;

Non-Capital Inputs	Capital Inputs
— labour	— land, buildings/structures and perway
— fuel	— plant and equipment
— "other inputs"	— rollingstock

"Quantity" estimates for the "non-capital" inputs were derived mainly from data contained in AN's Annual Reports. "Value" data were obtained from the financial statements also reported in the Annual Reports.

In the case of AN's capital inputs, for reasons stated previously, accounting based data is not relevant, so a modelling exercise was undertaken to obtain suitable quantity and value estimates.

The aggregate input index used is also a **Tornqvist** Index. As with the aggregate output index, the input index is a **quantity** index and not a value index. The basic formulation used is as follows.

Starting with the continuous rate of growth in aggregate input (I):

$$\log I = \log(I_t/I_{t-1})$$

$$= (1/2) * \sum_{i=1}^{m} (C_{it} + C_{it-1}) * \log(I_{it}/I_{it-1})$$

$$= B$$

The input index is then given by rearrangement as follows:

$$I_t = I_{t-1} * \text{Antilog}(B)$$

where:

I_t is an index of aggregate input used in period t;

C_{it} is the cost share of input j in total cost, in period t;

I_{it} is the quantity of input j used in period t; and,

m is the number of separately identified inputs.

4.4.1 Labour

The relevant input here is defined to be that amount of labour which is used during the year for **operational and maintenance purposes.**

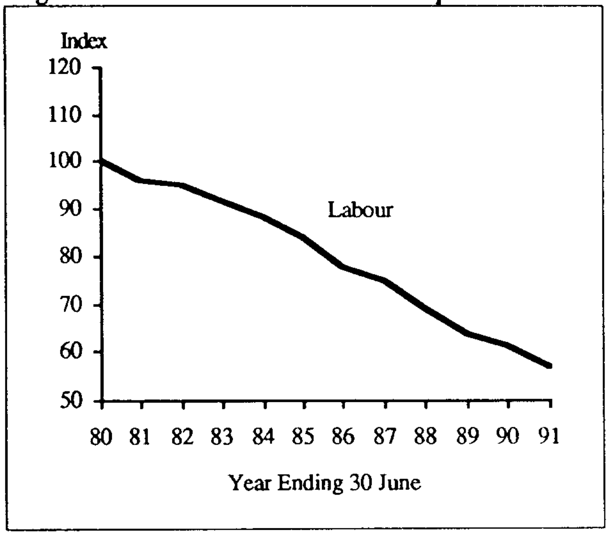
The most suitable **quantity** measure for labour inputs is **total hours worked.** Unfortunately AN does not have an accurate series for total hours going back to 1979–80. One possible way around this problem is to use the average annual employment of full time staff as the labour input measure; excluding those "made available" to STA. This has the disadvantage that it does not capture variations in the intensity of use of the labour force. Both the BTCE and Industry Commission TFP studies were forced to rely on employee numbers as the relevant input measure, in the absence of better data.

At this point in time, the AN model has also used 30 June levels of full time staff as the labour quantity measure. Future work within AN will be directed at improving upon this input measure.

For some GTEs, the labour measure reported in the Annual Report will correspond to the organisation's labour input for "operational and maintenance" purposes. This would be the case where the GTE in question purchased all items of capital stock from outside suppliers rather than constructing them using internal resources.

In contrast, many GTE's (eg. those in the transport, communication, water supply and electricity generation industries) construct much of their capital stock internally, using significant amounts of labour in the process. In any TFP study dealing with such an organisation, an attempt should be made to exclude from the measure of labour input used, that component of total labour which is used to produce the capital stock. If this is not done, the labour quantity measure will obviously involve an element of double counting of inputs, since the labour component of capital goods produced internally is already included in the estimate of the volume of the capital stock. Obviously the degree of any distortion caused by this problem will depend on the proportion of the total capital stock which is constructed internally.

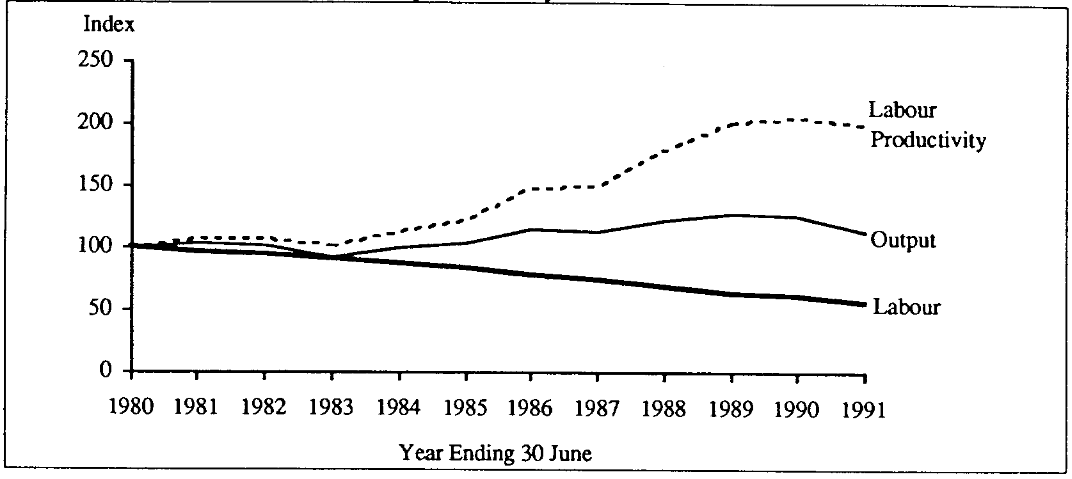
Figure 4.4: **Index of AN labour inputs**



In the present study no attempt has been made to "net out" labour inputs used to produce capital goods, as no consistent series was available covering the entire study period. Again, future TFP modelling work within AN will be directed at attempts to overcome this problem.

Figure 4.4 shows AN's labour input quantity index. The path of the index shows the effects on the labour force of AN's progressive restructuring process. Numbers of full time employees fell each year over the period, with the result that the 1990–91 workforce was less than 60 per cent of its size in 1979–80. The positive effects of this process on labour productivity can also be seen in Figure 4.5. Labour productivity did however move downward between 1981–82 and 1982–83 and again beyond 1988–89.

Figure 4.5: **Index of AN labour productivity**

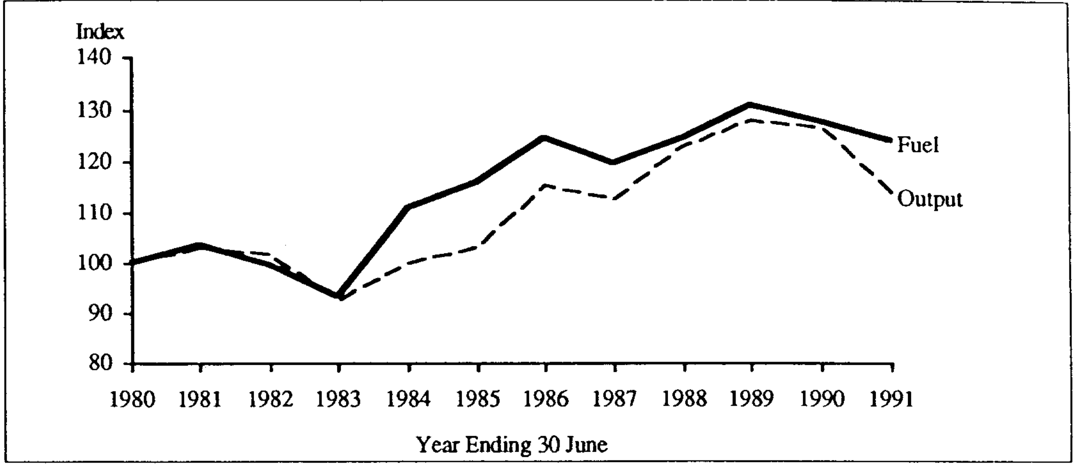


Downward movements of the labour productivity index during the period were due to falling labour utilisation in times of recession. This is itself the result of AN's employment policy as a GTE, and because of the nature of the rail transport business, where specific employee skills must be retained throughout the business cycle. The latter feature is common to most large manufacturing/service providing organisations, both in the public and private sectors.

4.4.2 Fuel

Figure 4.6 shows AN's fuel quantity input index together with the aggregate output index. From the graph it can be seen that fuel inputs moved mainly in line with the traffic task over the period.

Figure 4.6: **Indexes of AN output and fuel input**



Fuel usage is the result of a multitude of factors, many of which are changing independently of each other. However, allowing for variations in the traffic task, the two major factors which are believed to have affected fuel usage most were significant increases in train maximum speeds and changes to wagon technology.

Between 1979–80 and 1990–91, the maximum speeds of AN's trains increased by between 30–40 kilometres per hour. Over this time, locomotive fuel consumption would have increased more than in proportion to the increase in speed.

Improvements in wagon technology over the period resulted in the introduction of new lighter wagons (ie. improvements in net-to-tare ratios). In isolation to other factors, this would have resulted in less fuel usage for the same traffic task.

4.4.3 Other (non-capital) inputs

In the present study two non-capital inputs (ie. labour and fuel) are separately identified and price/quantity data estimated, with the remaining non-capital inputs grouped together and reported as an "other inputs" category. An implicit quantity series was then derived by dividing the real expenditure series for "other inputs" by a price index series. The index used for this purpose was the implicit price deflator for non-farm gross domestic product. The "other inputs" expenditure series was derived by subtracting from the annual operating expenditure figure (in the profit and loss statement) costs relating to:

— fuel and labour;

— accounting based capital costs; and

— employee special redundancy costs, after 30 June 1989 (these were reported as Abnormal Items in earlier years).

The accounting treatment of AN's employee redundancy costs over time highlights the fact that any financial accounting differences which affect items reported under the operating expenditure category, will as a result, affect the quantity series for "other inputs". Thus a potential exists for distortions in the TFP estimates where expenditure data are accessed from the annual reports of target organisations without careful review. **This is particularly important where the TFP indices of different organisations are being compared.**

In the recent Rail Transport Report, the Industry Commission commented on this feature of the usual data sources by noting that:

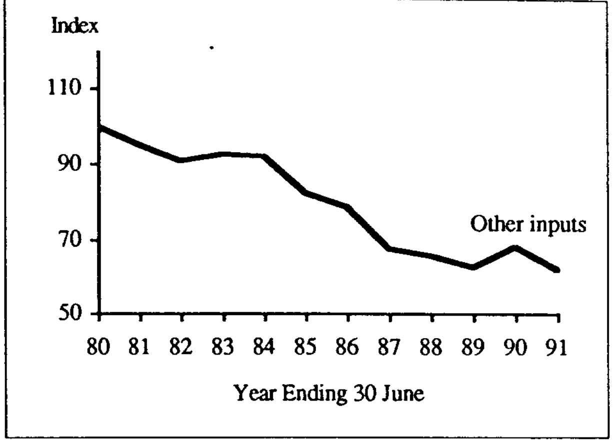
> "The Principal data sources used in this study for outputs and non-capital inputs are annual reports of the various railway authorities. The information presented in these reports has been prepared according to a variety of accounting rather than economic conventions and often lacks the degree of detail required, particularly for calculation of TFP indices" (IC 1991, Appendix E, p 43).

Telecom, in their own TFP study, have also shown an awareness of the need for care in this area, by noting that:

> "Changes in accounting procedures can create difficulties for the measurement of changes [in] input quantities and hence productivity. For example, the estimation of the quantities of inputs may be distorted when an item is changed from being regarded as capital to being treated as an expense. An accounting change results in a biased measure of TFP growth in the year of the change, and counteracting biases in other years. Unfortunately, it has not been possible to adjust for accounting changes because of insufficient information" (Telecom 1989, p 6).

Figure 4.7 shows an index for AN's "other inputs" category. It is apparent from the graph that "other input" usage fell by almost forty index points over the period.

Figure 4.7: **Index of AN "other inputs"**



4.4.4 Capital

The modelling of AN's capital inputs presents a greater technical problem than for non-capital inputs. This results from the fact that information on the value of the capital stock contained in AN's Balance Sheet cannot be used for this purpose, since asset values derived from historical cost accounting methods distort the true economic value of such assets.

The **appropriate** input measure here is the "flow of capital services" per period. Unfortunately the service **flow** cannot be measured directly and a measure of the capital **stock** is normally used instead.

This raises the problem of just what measure of the capital stock is appropriate. In this respect it would be most desirable to use a measure which reflects the physical "service potential" of the capital stock. Again this objective is not directly measurable and it is common practice to rely on a measure of the economic value for the capital stock (ie. gross economic capital stock, net economic capital stock, or some weighted average of the former). The measure of capital stock used in the Corporate Strategy model is defined to be an index of the constant price value of AN's capital stock, as installed, net of estimated accumulated depreciation of capital.

Prior to proceeding with the discussion, it is instructive to briefly touch on the differences between a physical measure of service potential and an economic value for a capital item. The ABS has summarised the issue succinctly by concluding:

> "An asset which is near the end of its life has a low economic value, but it can still be quite productive: an extreme example is a light bulb" (ABS 1990, p. 7).

In addition, by selecting the **net capital stock** as the capital measure for the model, we are in fact assuming that AN's assets decline in productive efficiency at the same rate as they decline in economic value. Again as the ABS has observed (ABS 1990, p. 7), ... "this is not really the case, particularly for buildings and structures".

Previously it has been stated that AN's TFP model distinguishes three types of capital inputs. These are:

— land, buildings/structures and perway,

— plant and equipment, and

— rollingstock.

Following normal practice in TFP studies, the AN model uses a Perpetual Inventory Method (PIM) to estimate the discounted replacement values of particular capital categories. This result follows from the fact that information on the value of the capital stock contained in AN's Balance Sheet (ie. the carrying amount) cannot be used for this purpose. Balance Sheet values are derived from historical cost accounting methods which distort the true economic value of capital assets.

The method uses data on capital "flows" and an estimate of the value of each category of capital item, **at a particular point in time**, to generate a time series for the value of each capital category. The capital "flows" incorporated in the PIM are a consequence of the following;

— capital acquisitions,

— capital disposals,

— the rate of economic depreciation, and

— the rate of capital price inflation.

In application the PIM is a simple mathematical-economic algorithm. The formula used for estimating the value of the capital stock in period (t) is as follows:

$$K_t = [K_{t-1} * (1-d)] + I_t - D_t$$

where K_t = real value of capital stock at the end of period (t);

d = real rate of economic depreciation;

I_t = real value of additions to the capital stock in period (t); and,

D_t = real value of asset disposals in period (t).

In this study, the geometric rate of depreciation (d) used in the previous formula was derived by equating the present value of the flow of geometric depreciation amounts with the present value of the flow of straight line depreciation amounts. Given the nominal discount rate and an asset class lifetime, the two present value expressions can be used to solve for (d). The results of this exercise are set out in the Appendix on the data set.

Information on capital additions/disposals is thus required and is normally obtained from the Annual Reports of the target organisation, or from the ABS. In the case of AN's model, this information was obtained from the Annual Reports. The other essential piece of information is a point estimate of the value of the capital stock, to start the PIM iterations.

In previous studies of AN's TFP, point estimates of the value of the capital stock have been derived from various "desk based" estimation methods, rather than from a proper revaluation exercise. In this study, the point estimate used is for the value of the capital stock as at 30 June 1990 and is derived from AN's revaluation project which provides estimates for discounted replacement values. Because this valuation is a **preliminary** figure only, some comment is required as to its derivation.

AN's current revaluation exercise is due for completion in 1994. In arriving at figures for the value of the capital stock, as at 30 June 1990, the following points should be noted;

— AN has not yet completed the revaluation of its land holdings, and the component for land contained in the data set provided herein is a preliminary **estimate** only; and,

— no precise figures are yet available for AN's CSO assets. Accordingly, estimates here were derived by assuming that the ratio of asset value (discounted replacement cost) to accounting carrying value found for a particular asset class on the mainland also applied for the CSO assets.

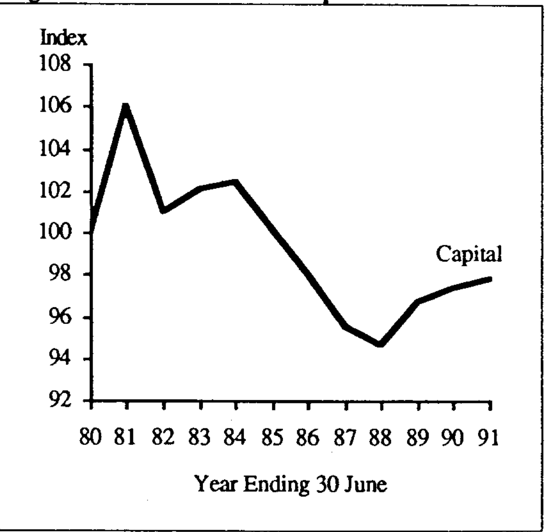
The three capital categories cited above were selected as follows. First, these were the categories used by the BTCE in their report on AN; but were no doubt selected because they correspond to the capital categories reported historically in AN's annual reports. In contrast the Industry Commission used only a single capital category in the PIM runs performed for the Rail Transport report. This has the benefit of simplicity, particularly since the Commission used ABS investment data for their PIM and the ABS data does not distinguish capital sub-groups.

If a single capital category had been used in the AN model, this would have meant that AN data on capital acquisitions/disposals (from the Annual Reports) broken down into the above capital sub-groups, would not have been utilised. In this event, the model must use a single rate of economic depreciation for all capital assets and this is less desirable. Also, if a single capital category had been used, the PIM model would not then generate estimates of the changing mix of AN's capital stock over time. This information may be of significant value to AN management, given the cost variations involved in holding different types of capital assets.

It should also be noted that the PIM model deals exclusively with AN's **owned capital stock.** Capital items obtained by AN via leasing (eg. AN's EL Class Locomotives) and hire contracts (certain mobile plant and equipment) are not accounted for as production inputs by the PIM model. At this point in time, the value of these inputs is measured as the sum of the annual lease payments made and is picked up in the "other inputs" category, as derived from AN's profit and loss statement.

Three separate capital stock series were derived, one for each of the capital categories previously identified. The results of this exercise are set out in the data set tables contained in Appendix 4.1, while the aggregate capital stock index is shown in Figure 4.8.

Figure 4.8: **Index of AN capital stock**

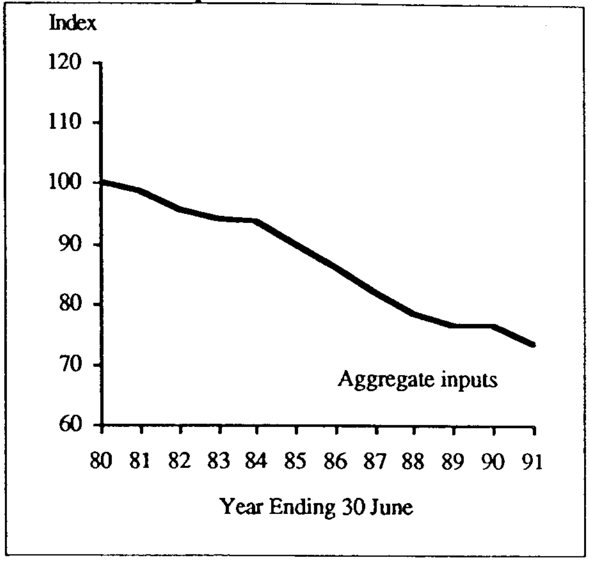


As indicated previously, for each of the inputs included in this study, a quantity series and a value (or cost) series has been derived. The value series represents the annual cost of providing the input. In the case of capital inputs, a cost series has been derived for each asset class, by multiplying the real value of the capital stock in that class, by an index of the economic rental price of capital. The expression used to calculate the economic rental price is set out in Table 4.10, together with a rental price series for each of the three capital classes used.

4.4.5 AN aggregate inputs index

Figure 4.9 shows AN's aggregate inputs index for the period 1979–80 to 1990–91. From the graph it can be seen that over the period of this study, aggregate inputs, as reflected by this index, fell by more than twenty five per cent. This result also occurred at a time when output showed a trend increase.

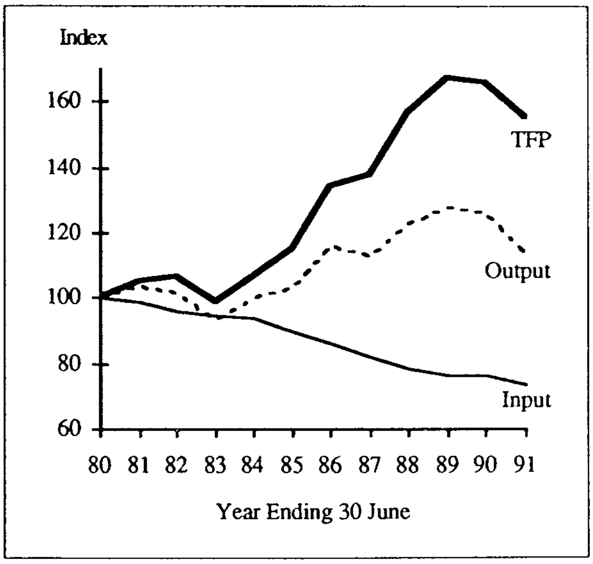
Figure 4.9: **Index of AN aggregate inputs**



4.5 AN index of total factor productivity

Figure 4.10 shows AN's indexes for Inputs, Output and TFP for the period 1979–80 to 1990–91, as derived from AN's model. This is the traditional TFP index, with no adjustments for the effects of surplus labour or for variations in capital or labour intensities. The graph would indicate that AN's measured level of TFP grew strongly over most of the period from 1979–80 to 1988–89. The downturn of the index in 1982–83 was in response to a severe demand downturn due to recession and drought. In particular, the drought had a major adverse effect on AN output, as at that time grain haulage was a significant component of the traffic task.

Figure 4.10: **Indexes of AN output, input and TFP**



Over the period 1979–80 to 1990–91 the compound rate of growth of the index was 4 per cent, more than double the rate recorded for the "market sector" of the Australian economy as a whole. However, as previously noted, for reasons of varying factor utilisation, this figure is not particularly meaningful. A better guide is obtained by examining the growth rate between peaks of the growth cycle. The results of that exercise are set out below.

Period	Compound growth rate
1981–82 to 1985–86	5.8 per cent
1985–86 to 1988–89	7.5 per cent

As indicated previously, the Industry Commission (1991) and the BTCE (1991) also recently conducted independent studies into AN's Total Factor Productivity. The BTCE study covered the period 1979–80 to 1987–88 and estimated the average compound rate of TFP growth over this period to be 5.1 per cent. For the purposes of direct comparison, the growth rate estimated by AN's model over this particular period is 5.7 per cent. The Industry Commission Rail Transport Report covered the period 1980–81 to 1988–89, and estimated the compound growth rate during this period to be 5.7 per cent. The comparable figure from the AN model is 5.8 per cent.

These growth rates are high and can be attributed to both **efficiency gains** (the effect of labour reductions and internal reorganisation within AN) as well as to the effects of **technological progress.**

Over this whole period AN's index of labour input moved downward strongly, and was a major influence on the size of the aggregate inputs index. Given that it is unlikely that the rate of change of technological progress within AN during the period exceeded that recorded for the private sector as a whole (1–2 per cent), then it can be concluded that input **efficiency gains** were the major reason for the high compound growth rate of the TFP index over the period 1979–80 to 1988–89.

Given that the TFP index is a ratio of aggregate output to aggregate input, the traditional index will always be sensitive to the business cycle. Accordingly since 1989–90 AN's TFP index has declined, as output has fallen faster than aggregate inputs, due to the current recession. The size of the movement in the TFP index for any business organisation will vary with the magnitude of the economic contraction, with the capital and labour retention policies of the organisation and with the nature of the production function.

In the case of capital, the degree of "underutilisation" during recession will normally be greater than that for labour, as adjustment of the capital stock may not be economically desirable or quickly achievable. In the case of labour inputs, GTE employers have traditionally not "hired and fired" in response solely to the business cycle. Given AN's status as a capital intensive GTE, and for the reasons cited above, downward movements in the TFP index can be expected to be significant in a deep recession. The track of the index post 1988–89 seems to confirm this view.

Downward movements of the TFP index in periods of recession are to be expected and are not necessarily a "bad report" on AN. As stated previously, estimates of TFP growth rates should be made over long periods of time, **and between peaks of the TFP index, where the degree of capital and labour intensity is approximately similar.**

Beyond the current recession, AN's TFP index will not, over the longer term, **continue** to show the same rate of growth as exhibited between 1979–80 to 1988–89. The rate of change of the TFP index for any organisation recording continuing efficiency improvements over time must eventually move toward the average rate of change of technological progress in it's particular industry, as other factors leading to high growth rates are "boiled out". Accordingly, assuming "more of the same" management policies within AN, the future rate of growth of the index is expected to be between 1 and 2 per cent per annum.

APPENDIX 4.1: DATA SET

Table 4.1: **AN output quantities**

Year	Mainland Freight ('000 NTKs)	Tasrail Freight ('000 NTKs)	Passenger ('000 PTKs)
1979–80	5 235 000	383 000	2 924
1980–81	5 331 000	420 000	3 057
1981–82	5 356 000	375 000	2 992
1982–83	4 967 000	381 000	2 395
1983–84	5 511 000	401 000	2 355
1984–85	5 867 000	403 000	2 188
1985–86	6 679 000	402 000	2 486
1986–87	6 445 000	429 000	2 381
1987–88	7 192 000	455 000	2 439
1988–89	7 618 000	459 000	2 397
1989–90	7 699 000	413 000	2 316
1990–91	7 420 000	369 000	1 664

Note: NTKs are net-tonne-kilometers. PTKs are passenger-train-kilometers.
Source: AN.

Table 4.2: **AN output revenues, inclusive of CSO payments**

Year	Mainland Freight ($'000)	Tasrail Freight ($'000)	Passenger Movements ($'000)	Total Adjusted Revenue ($'000)
1979–80	119 014	25 200	30 617	174 831
1980–81	136 005	28 500	37 269	201 774
1981–82	151 214	28 200	40 900	220 314
1982–83	144 273	30 200	43 733	218 206
1983–84	174 798	31 400	47 460	253 658
1984–85	196 798	34 000	48 440	279 238
1985–86	219 045	36 700	57 956	313 701
1986–87	215 697	40 200	54 912	310 809
1987–88	236 882	42 318	56 100	335 300
1988–89	256 859	38 398	63 236	358 493
1989–90	255 631	43 852	74 424	373 907
1990–91	250 060	43 334	78 853	372 247

Note: Current dollars.
Source: AN.

Table 4.3: **AN non-capital inputs, quantity terms**

Year	*Labour (persons)*	*Fuel (litres)*	*Other (1989–90 constant dollars)*
1979–80	10 481	77 380 000	119 113
1980–81	10 071	80 148 000	112 939
1981–82	9 941	77 105 000	108 263
1982–83	9 575	72 129 000	110 210
1983–84	9 252	85 868 000	109 292
1984–85	8 799	89 706 000	97 594
1985–86	8 127	96 312 000	93 178
1986–87	7 838	92 519 000	80 054
1987–88	7 198	96 435 000	77 716
1988–89	6 648	101 327 000	74 147
1989–90	6 432	98 874 000	80 826
1990–91	5 965	96 016 000	73 172

Source: AN.

Table 4.4: **Deflator for "other inputs"**

	Other	
Year	*(1)*	*(2)*
1979–80	64.60	45.30
1980–81	71.50	50.14
1981–82	79.60	55.82
1982–83	88.40	61.99
1983–84	94.50	66.27
1984–85	100.00	70.13
1985–86	107.00	75.04
1986–87	115.00	80.65
1987–88	123.40	86.54
1988–89	134.60	94.39
1989–90	142.60	100.00
1990–91	148.60	104.21

Source: Australian Bureau of Statistics (1991), Cat No. 5204.0.
Notes: 1. Implicit price deflator nonfarm GDP; base year 1984–85.
2. (1) rebased for 1989–90.

Table 4.5: **AN non-capital inputs, value terms**

Year	*Labour ($'000)*	*Fuel ($'000)*	*Other ($'000)*
1979–80	137 267	13 975	53 96
1980–81	148 345	20 748	56 628
1981–82	165 932	21 727	60 433
1982–83	178 584	26 490	68 321
1983–84	186 577	32 186	72 427
1984–85	187 480	34 946	68 439
1985–86	203 091	39 094	69 916
1986–87	207 018	38 637	64 560
1987–88	205 660	41 658	67 252
1988–89	216 840	39 155	69 987
1989–90	222 322	42 855	80 826
1990–91	212 627	44 190	76 251

Note: Current dollars.
Source: AN

Table 4.6: **Geometric rates of depreciation for capital stock series**

Type	*Land, Buildings and Perway*	*Plant and Equipment*	*Rollingstock*
Economic Life (L), years	50	20	20
Nominal discount rate (r)	0.10	0.10	0.10
P.V.*	0.20	0.43	0.43
Geometric rate of depreciation (d)	0.02	0.07	0.07

Notes:
1. Values for (d) used in PIM iterations.
2. Method is to use the present value of the flow of depreciation to solve for (d), given the economic life and the nominal discount rate.
3. P.V.* = Present Value for straight line depreciation over L years.

Table 4.7: Capital expenditure deflators

Year	*Land, Buildings and Perway (1)*	*Plant and Equipment (2)*	*Rollingstock (3)*	*PGFCE (4)*
1978–79	55.30	67.50	67.50	56.30
1979–80	61.70	74.30	74.30	63.00
1980–81	69.50	80.60	80.60	69.80
1981–82	78.60	86.10	86.10	78.10
1982–83	89.30	94.30	94.30	88.90
1983–84	94.60	98.50	98.50	93.90
1984–85	100.00	100.00	100.00	100.00
1985–86	111.00	113.00	113.00	108.80
1986–87	119.60	124.20	124.20	117.80
1987–88	127.60	125.40	125.40	127.20
1988–89	136.90	121.00	121.00	136.60
1989–90	147.70	122.70	122.70	145.20
1990–91	150.30	121.90	121.90	

Source: ABS, Cat.No. 5204.0, base year = 1984–85.
Notes: 1. Implicit price deflator, private non-dwelling construction.
2. Implicit price deflator, private equipment.
3. Implicit price deflator, private equipment.
4. Implicit price deflator, public gross fixed capital expenditure.

Table 4.8 AN real value of owned capital stock

Year	*Land, Buildings and Perway ($'000)*	*Plant and Equipment ($'000)*	*Rollingstock ($'000)*	*TOTAL ($'000)*
1979–80	1 858 037.64	94 057.08	332 306.65	2 284 401.37
1980–81	2 101 034.59	93 927.08	308 491.05	2 503 452.73
1981–82	2 059 364.50	89 764.23	285 626.19	2 434 754.92
1982–83	2 118 357.26	93 270.55	269 265.14	2 480 892.95
1983–84	2 117 624.82	91 837.26	275 134.43	2 484 596.51
1984–85	2 095 680.31	90 120.02	261 495.31	2 447 295.64
1985–86	2 069 494.23	89 616.73	251 587.66	2 410 698.62
1986–87	2 034 867.29	88 773.10	239 735.81	2 363 376.19
1987–88	2 017 626.27	89 652.73	235 834.32	2 343 113.33
1988–89	1 998 344.78	98 762.09	252 513.93	2 349 620.80
1989–90	2 011 753.00	100 495.00	251 850.00	2 364 098.00
1990–91	2 018 801.57	107 653.71	242 662.08	2 369 117.36

Source: AN capital stock at replacement cost, calculated by PIM.
AN base year (1989–90) asset values; all other data from AN.
Notes: 1. Constant 1989–90 dollars.

Table 4.9: **AN nominal value of owned capital stock**

Year	*Land, Buildings and Perway ($'000)*	*Plant and Equipment ($'000)*	*Rollingstock ($'000)*	*TOTAL ($'000)*
1979–80	776 174.15	56 955.51	201 225.62	1 034 355.28
1980–81	988 638.49	61 699.45	202 643.68	1 252 981.61
1981–82	1 095 910.97	62 988.59	200 427.18	1 359 326.74
1982–83	1 280 767.12	71 682.26	206 941.34	1 559 390.72
1983–84	1 356 312.17	73 724.29	220 869.94	1 650 906.40
1984–85	1 418 876.31	73 447.45	213 117.61	1 705 441.37
1985–86	1 555 273.25	82 532.12	231 698.49	1 869 503.86
1986–87	1 647 732.75	89 858.34	242 666.56	1 980 257.66
1987–88	1 743 054.25	91 625.53	241 023.83	2 075 703.61
1988–89	1 852 223.43	97 393.75	249 015.37	2 198 632.54
1989–90	2 011 753.00	100 495.00	251 850.00	2 364 098.00
1990–91	2 054 339.04	106 951.81	241 079.93	2 402 370.78

Notes: 1. Calculated as NK(t) = P(t)*K(t)
Where NK(t)= Nominal value of capital stock at end of period (t)
P(t) = Capital price index in year (t)
K(t) = real value of capital stock at end of year (t)

Table 4.10: **Indices of the rental price of capital (RPC)**

Year	*Land, Buildings and Perway (x)*	*Land, Buildings and Perway (RPC)*	*Plant and Equipment (x)*	*Plant and Equipment (RPC)*	*Rollingstock (x)*	*Rollingstock (RPC)*
1979–80	0.10	0.01	0.09	0.05	0.09	0.05
1980–81	0.11	0.02	0.08	0.08	0.08	0.08
1981–82	0.12	0.03	0.06	0.12	0.06	0.12
1982–83	0.12	0.03	0.09	0.10	0.09	0.10
1983–84	0.06	0.07	0.04	0.14	0.04	0.14
1984–85	0.05	0.07	0.02	0.16	0.02	0.16
1985–86	0.10	0.05	0.12	0.09	0.12	0.09
1986–87	0.07	0.07	0.09	0.12	0.09	0.12
1987–88	0.06	0.08	0.01	0.20	0.01	0.20
1988–89	0.07	0.08	0.04	0.24	0.04	0.24
1989–90	0.07	0.08	0.01	0.19	0.01	0.19
1990–91	0.02	0.13	0.01	0.20	0.01	0.20

Notes: 1. Calculated as: RPC = [g(t) + d - dPk(t)/Pk(t)]*Pk(t), where
g = 10 year Treasury bond rate (average of quarterly rates) (proxy for nominal opportunity cost of funds employed),
d = real rate of economic depreciation.
Pk(t) = price index for asset class "k", and
x = dPk(t)/Pk(t).

5 TOTAL FACTOR PRODUCTIVITY OF THE STATE RAIL AUTHORITY (SRA) OF NEW SOUTH WALES*

5.1 Introduction

The starting point for the total factor productivity (TFP) case study of the State Rail Authority (SRA) was the Industry Commission's (1991) study of railway TFP. The data relating to SRA used in the wider study was forwarded to SRA for review. SRA subsequently provided a revised investment series which was thought to provide a more accurate profile of investment than the Australian Bureau of Statistics series used in the original study. SRA also provided a revised labour costs and quantity series and more rail specific price indexes for capital and materials have been obtained from the ABS for the current study.

SRA have provided information on their freight business unit which has allowed the Industry Commission to complete a separate TFP exercise for Freight Rail. Section 5.2 provides the analysis for the entire SRA system while section 5.3 presents that for Freight Rail.

5.2 SRA's productivity

5.2.1 Data sources for SRA

Calculation of a TFP index requires value and quantity series for each output and input. The principal data source used in this study for outputs and non-capital inputs are the annual reports of the SRA.

Railway output has been divided into two categories, freight and passengers. The quantity of freight output is measured in net tonne-kilometres while the quantity of passenger output is measured in passenger-kilometres. Where passenger-kilometre figures were unavailable they have been approximated by multiplying the number of urban and country passenger journeys by estimates of the average journey distances obtained from the Commonwealth Grants Commission (CGC 1988). Only revenue obtained directly from customers is included in this analysis. Government supplementation of SRA revenue is excluded.

* This case study was prepared by staff in the Industry Commission's Economic Studies Branch. Staff of the SRA and Freight Rail provided assistance with data.

Three input categories have been used: labour, capital and other inputs (fuel, materials and services). The quantity of labour inputs has been approximated by the number of staff employed in the system. Information on gross recurrent pay-roll costs was provided by SRA and was used to approximate total labour costs.

By subtracting total wages and salaries from the SRA's total operating costs (excluding accounting depreciation and interest costs) the value of the other inputs category was derived. This was deflated using the ABS price index for other public expenditure to derive an estimate of the implicit quantity of other inputs.

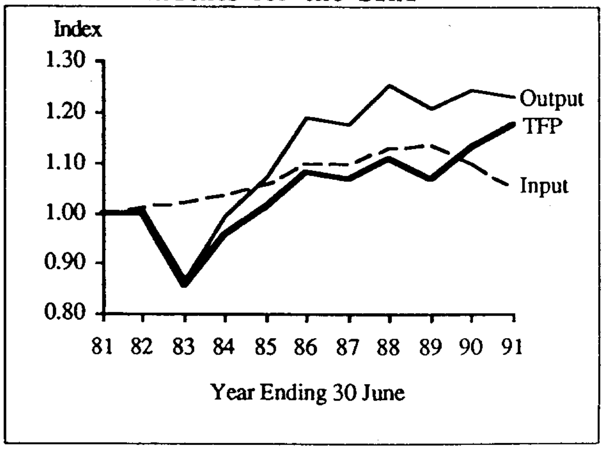
A critical part of the exercise in estimating total factor productivity is deriving estimates of the quantity of capital stock employed. Time series estimates of the economic value of SRA's fixed assets were derived from the ARRDO (1981) point estimates for 1978–79 and investment information supplied by the SRA, using the Industry Commission (1990) method. This method updates the current value point estimate by adding the investment stream in constant dollars to the point estimate after allowing for an assumed rate of depreciation. The value or annual user cost of capital inputs is derived as a proportion of the nominal capital stock allowing for depreciation, financing charges and capital gains using the Industry Commission (1990) method.

The data used in this preliminary exercise are presented in tabular form in Appendix 5.1.

5.2.2 Results for SRA

Results of the analysis are presented in Figure 5.1. For the NSW system output, input and TFP levels have increased steadily over most of the study period, except for a significant decline in output in 1982–83. The decline in 1982–83 is the result of the recession which caused demand to fall considerably. Over the very short term it is difficult to adjust input use to changes in demand and this is reflected in a significant fall in productivity.

Figure 5.1: **Output, input and TFP indexes for the SRA**



TFP then grew rapidly between 1982–83 and 1987–88 as output levels increased substantially while total input use increased only modestly. A reduction in output levels in 1988–89 combined with increased input use again caused TFP to fall.

Reforms to the SRA implemented in 1988–89 have reduced operating costs and employee numbers and increased employee productivity. After peaking at 41, 591 in 1985–86, SRA's total staff numbers have fallen by over 25 per cent in the following 5 years. In addition, management has been streamlined and many of the ancillary activities, for example printing, station retail businesses and some cleaning and maintenance services, have been put out to competitive tender or sold (IC 1991, pp. 25–6). These efficiency improvements are reflected in a reduction in total input use in 1989–90. This, combined with a recovery in output levels, has again caused TFP to increase markedly in 1989–90. TFP continued to rise in 1990–91 despite the effects of the recession which has caused a small decline in output. The recent growth in TFP is largely the result of the reduced input use associated with continuing reforms. It should be noted, however, that while there have been impressive reductions in labour usage over this period, the quantity of capital inputs has continued to increase steadily and the use of other inputs has increased markedly reflecting the greater use of contracting out.

Over the 11 year period the SRA's TFP has increased at a trend rate of growth of 2.1 per cent. This has resulted from a trend output growth rate of 3.1 per cent and a trend input growth rate of 1.0 per cent.

The TFP index can be calculated using either revenue or cost shares to aggregate the various output components together. In a competitive market where revenues and total (economic) costs will be approximately equal the use of either revenue or cost shares will make little difference. This will also be the case where there is under-recovery of costs to an equal extent between outputs. However, if levels of cost recovery differ between outputs (as is the case with rail freight and passengers), the use of cost shares instead of revenue shares may produce a different pattern of TFP results. For instance, a railway system where passenger operations were particularly important and costs of passenger operations were being under-recovered would be seen as having a lower TFP *level* when compared with other systems which were recovering costs across all their operations. In this analysis revenue shares have been used because a reliable allocation of total costs between freight and passenger operations is not yet available. It can also be argued that explicit community service obligation payments from government should be included in the calculation of revenue shares where they are available on an accurate and consistent basis through time because they make up at least part of the under-recovery of costs on certain operations. More work is required to obtain such a series for SRA. As this study looks solely at the SRA and considers only growth rates of SRA's TFP through time the use of direct revenue shares as weights will make little difference.

5.3 Freight Rail's productivity

The SRA's operations cover a wide range of activities including freight, country passenger and urban passenger services. For the last few years these three broad areas have been broken into separate business units. As a first step towards calculating TFP at the disaggregated business unit level, preliminary estimates of Freight Rail's productivity for the past four years have been made.

The time series available for the disaggregated analysis is significantly shorter than for SRA as a whole since separate accounts for the business units have only been kept since 1988–89. The main problems to overcome in the disaggregation exercise are obtaining accurate estimates of the allocation of capital stocks between the three activities and the allocation of joint costs. SRA is currently undertaking a valuation of its assets which will enable more accurate estimates of each business unit's capital stocks to be made. At this stage the nearest proxy which is available are estimates of the written down replacement cost for Freight Rail's rolling stock. These have been combined with depreciated historical cost estimates of Freight Rail's infrastructure assets to provide a starting point for the analysis. At this stage no information is available on the passenger business units' capital stocks.

5.3.1 Preliminary data sources for Freight Rail

Only four years of data are available for Freight Rail: 1988–89 to 1991–92. The figures for 1991–92 are forecasts only.

For Freight Rail one output was defined, net tonne-kilometres of freight carried. Inputs were separated into four categories: labour, fuel, capital, and other costs. Staff employed was used to approximate the quantity of labour input and fuel quantity was measured in megalitres of distillate consumed. Freight Rail also provided data on total pay-roll, redundancy and fuel costs. These were deducted from total non-capital expenditure to derive a series for other costs. The ABS price deflator for other public expenditure was used to derive an implicit quantity of other inputs.

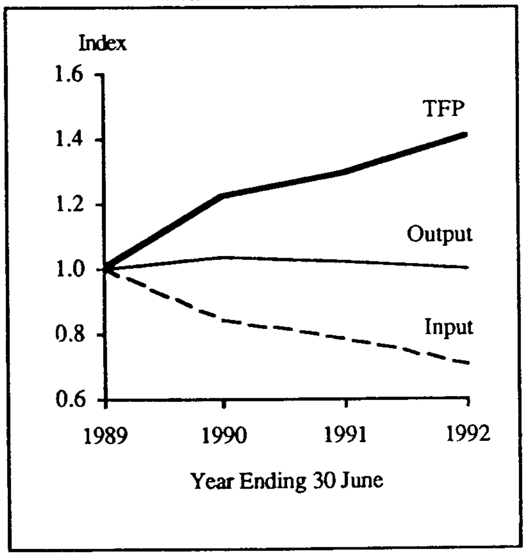
Capital assets have been divided into three categories: wagons, locomotives, and infrastructure. Freight Rail provided estimates of the written down replacement cost of wagons and locomotives in 1992. For infrastructure only a 1991 value in terms of depreciated historical cost was available. It is likely that this significantly undervalues the capital stock. However, it is the only data available at this stage.

Freight Rail also provided time series data on the number of wagons and locomotives, and total track kilometres. These physical measures can also be used as a proxy for the quantity of capital. Given the difficulty in verifying the accuracy of the written down value of the capital stock of rolling stock and the absence of any current value estimates of infrastructure, Freight Rail preferred that the quantity of capital be measured in physical units. The value of the capital stock, by asset type, was estimated by multiplying the physical quantity of capital by the ABS price index for railway rolling stock (for wagons and locomotives) and all rail capital expenditure (for infrastructure) scaled such that the value of the capital stock was equivalent to the written down value of the capital stock in 1991.

The annual user cost of each capital type was derived from the value of the capital stock allowing for depreciation, financing charges and capital gains. The Tornqvist indexing method was used to form an index of the total quantity of capital from the 3 asset categories.

The data used for the Freight Rail exercise are presented in Appendix 5.2.

Figure 5.2: **Output, input use and TFP indexes for Freight Rail**



5.3.2 Preliminary results for Freight Rail

Preliminary results of the analysis are presented in Figure 5.2. In 1989–90 TFP increased due to a small rise in output and a decline in overall input use. The fall in input use resulted from decreased use of all inputs, particularly labour and materials and services.

Growth in TFP continued to improve in 1990–91, but at a slower rate. Most inputs were reduced in 1990–91, particularly labour. However, offsetting the reduction in the use of most inputs were a small reduction in output and an increase in the use of other inputs. In 1991–92 TFP is forecast to increase more significantly, even though output is forecast to further decline due to the recession. This is a result of significant reductions in the use of all inputs.

5.4 Conclusions

The TFP analysis for SRA as a whole indicates that reforms initiated in recent years are leading to reductions in total input use and improved TFP performance. In 1990–91 total productivity improved in spite of a fall in output associated with the recession.

Freight Rail's TFP performance has also improved over the last 4 years. As more detailed valuations of SRA's assets are completed it will be possible to extend TFP measurement to the passenger business units and improve the accuracy of the Freight Rail analysis.

APPENDIX 5.1: SRA DATA

Table 5.1.1: **Estimated capital stock for the SRA**

Year	*Gross fixed capital expenditure*[a]	*Price index*[b]	*Real gross fixed capital expenditure*	*Depreciation*	*Real capital stock*	*Nominal capital stock*
1978–79	na	0.56	na	158.50	2 515.18[c]	1 399.07
1979–80	177.69	0.62	285.68	149.10	2 649.95	1 648.27
1980–81	181.24	0.70	259.19	157.30	2 750.14	1 923.04
1981–82	21.89	0.79	27.72	163.41	2 612.86	2 062.85
1982–83	189.65	0.90	211.84	155.27	2 667.92	2 388.46
1983–84	288.79	0.95	303.27	158.66	2 811.12	2 676.89
1984–85	348.54	1.00	348.54	167.34	2 990.99	2 990.99
1985–86	433.87	1.07	405.11	178.21	3 216.64	3 445.02
1986–87	472.59	1.15	409.97	191.83	3 433.61	3 958.09
1987–88	484.73	1.24	391.70	204.91	3 619.30	4 478.88
1988–89	437.53	1.32	331.65	216.12	3 733.79	4 925.80
1989–90	825.97	1.39	594.65	223.05	4 104.41	5 701.03
1990–91	504.13	1.44	349.91	245.35	4 208.06	6 062.76

Source: a. State Rail Authority - excludes depreciation.
b. ABS implicit price deflator for rail fixed capital expenditure.
c. ARRDO's estimated value of capital stocks for 1978–79($1 399.07m) converted to 1984–85 constant prices.

Table 5.1.2: **Estimated annual user charge for capital**

Year	*Government bond rate*[a]	*Depreciation plus the bond rate*	*Price of capital*	*Capital gains*	*Nominal value of capital*	*Annual user charge for capital*[b]
1980–81	0.132	0.192	0.70	0.12	1 399.07	129.43
1981–82	0.164	0.224	0.79	0.13	1 648.27	195.83
1982–83	0.149	0.209	0.90	0.13	1 923.04	178.07
1983–84	0.138	0.198	0.95	0.06	2 062.85	358.25
1984–85	0.135	0.195	1.00	0.05	2 388.46	433.26
1985–86	0.130	0.190	1.07	0.07	2 676.89	408.24
1986–87	0.128	0.188	1.15	0.08	2 990.99	442.00
1987–88	0.120	0.180	1.24	0.07	3 445.02	474.67
1988–89	0.135	0.195	1.32	0.07	3 958.09	635.13
1989–90	0.134	0.194	1.39	0.05	4 478.88	804.58
1990–91	0.112	0.172	1.44	0.04	4 925.80	813.88

Source: IC estimates.
a. Reserve Bank of Australia, *various issues.*
b. Calculated as (Bond rate + Depreciation rate - dP/P) x Nominal value of capital.

Table 5.1.3: **Value and quantity of outputs and inputs used**

	Output				*Inputs*					
	Freight[a]		*Passengers*[a]		*Labour*		*Capital*		*Other*	
Year	*$m*	*NTK (millions)*	*$m*	*PKm (millions)*	*$m*	*No.*	*$m*	*Quantity*[b]	*$m*	*Quantity*[b]
1980–81	368.46	10 600	111.25	4 504	624.60	42 583	129.43	2 750.14	234.28	326.83
1981–82	436.71	10 700	128.25	4 545	749.39	41 607	195.83	2 612.86	301.23	375.46
1982–83	438.94	9 100	143.70	4 128	787.66	40 872	178.07	2 667.92	355.42	401.03
1983–84	523.24	11 100	156.22	3 794	825.38	40 594	358.25	2 811.12	392.62	416.35
1984–85	582.71	12 300	168.08	3 750	893.97	41 423	433.26	2 990.99	409.53	409.53
1985–86	664.72	13 700	201.12	4 126	943.56	41 591	408.24	3 216.64	469.09	445.06
1986–87	663.55	13 400	223.11	4 182	954.38	40 416	442.00	3 433.61	491.75	442.93
1987–88	638.90	14 200	262.70	4 572	954.61	38 053	474.67	3 619.30	610.18	522.77
1988–89	598.00	13 900	296.94	4 243	947.93	34 970	635.13	3 733.79	720.61	578.02
1989–90	666.76	14 400	314.39	4 309	948.86	31 066	804.58	4 104.41	726.76	552.39
1990–91	696.40	14 200	329.66	4 300	917.12	28 457	813.88	4 208.06	703.39	511.03

Source: The State Rail Authority of NSW; IC estimates.
a. Revenue comprises cash fare and freight revenue from customers and excludes On-board Catering.
b. The quantity of other inputs is implicitly derived by deflating the value by a price index. The real capital stock is used as a proxy for the quantity of capital.
NTK = Net tonne kilometres PKm = Passenger kilometres.

Table 5.1.4: **Output, input and TFP indexes**

Year	*Output*	*Input*	*TFP*
1980–81	1.00	1.00	1.00
1981–82	1.01	1.01	1.00
1982–83	0.87	1.02	0.85
1983–84	0.99	1.04	0.96
1984–85	1.07	1.06	1.01
1985–86	1.19	1.10	1.08
1986–87	1.18	1.10	1.07
1987–88	1.26	1.13	1.11
1988–89	1.21	1.14	1.07
1989–90	1.25	1.10	1.13
1990–91	1.23	1.05	1.18

Source: IC estimates.

APPENDIX 5.2: FREIGHT RAIL DATA

Table 5.2.1: **Estimated value of the capital stock for Freight Rail[a] ($m)**

Year	*Wagons* *$m*	*Locomotives* *$m*	*Infrastructure* *$m*
1988–89	398.41	315.93	1 472.47
1989–90	413.56	327.95	1 584.75
1990–91	422.25	334.84	1 676.00
1991–92	422.20	334.80	1 750.60

Source: Industry Commission estimates based on capital and investment data supplied by Freight Rail.
a. The value is estimated by multiplying the ABS price indexes for rolling stock (wagons and locomotives) and rail capital expenditure (infrastructure) by the respective physical quantity in each year. The price indexes are scaled so that the values calculated for 1990–91 correspond to those supplied by Freight Rail.

Table 5.2.2: **Estimated annual user charge for capital, by asset type**

		d P / P		User cost[a]			Total
Year	*Bond rate[b]*	*Wagons & locomotives*	*Infra-structure*	*Wagons[c]* *$m*	*Locomotives[c]* *$m*	*Infrastructure[c]* *$m*	*user cost of capital*
1988–89	0.135	0.12	0.07	33.88	23.41	128.32	185.61
1989–90	0.134	0.06	0.05	59.48	42.41	154.16	256.04
1990–91	0.112	0.05	0.04	51.40	40.76	148.36	240.52
1991–92	0.101	0.02	0.02	57.17	46.26	140.97	244.41

Source: Industry Commission estimates based on data supplied by Freight Rail.
a. Calculated as (Bond rate + Depreciation rate - dP/P) * Value of capital.
b. Reserve Bank of Australia, *various issues*.
c. Based on a depreciation rate of 5.7 per cent for wagons and locomotives and 1.4 per cent for infrastructure.

Table 5.2.3: **Value and quantity of total output**

Year	*Total revenue $m[a]*	*Total quantity NTK*
1988–89	618.73	13 917.97
1989–90	691.76	14 395.39
1990–91	783.60	14 221.50
1991–92	798.98	13 924.59

Source: Data supplied by Freight Rail.
a. Revenue includes CSO payments.

Table 5.2.4: **Value and quantity of inputs used**

	Labour		*Fuel*		*Other*	
Year	*cost $m*	*quantity No.*	*cost $m*	*quantity ML*	*cost $m*	*quantity $m, const*
1988–89	531.80	16 352.00	68.61	191.01	268.47	296.41
1989–90	566.76	13 493.00	78.92	186.76	211.22	220.97
1990–91	557.61	12 471.00	79.92	172.01	208.15	208.15
1991–92	568.37	11 500.00	74.60	166.09	158.47	154.61

	Wagons		*Locomotives*		*Infrastructure*	
	cost $m	*quantity No.*	*cost $m*	*quantity No.*	*cost $m*	*quantity Track-kms*
1988–89	33.88	9 213.00	23.41	587.00	128.32	7 950.00
1989–90	59.48	8 671.00	42.41	570.00	154.16	7 912.00
1990–91	51.40	7 536.00	40.76	551.00	148.36	7 912.00
1991–92	57.17	7 479.00	46.26	558.00	140.97	7 184.00

Source: IC estimates based on data supplied by Freight Rail.

Table 5.2.5: **Output, input and TFP indexes**

Year	*Total output*	*Total input*	*TFP*
1988–89	1.00	1.00	1.00
1989–90	1.03	0.85	1.22
1990–91	1.02	0.79	1.29
1991–92	1.00	0.71	1.41

Source: IC estimates calculated using the Tornqvist method.

6 TOTAL FACTOR PRODUCTIVITY OF MELBOURNE WATER*

6.1 Introduction

Over the last few years Melbourne Water (MW) and its predecessor, the Melbourne Metropolitan Board of Works, have calculated productivity growth as the difference between the percentage increase in output (measured by properties serviced) and input (measured by the cost of operations). Since the cost of operations has a large component of labour costs, this measure is essentially one of labour productivity.

It is important, however, to assess the change in all inputs and outputs, both operating and capital, in order to make any judgements on the total productivity of MW. Total productivity measurement benefits MW as a business enterprise enabling assessments to be made of the output produced from a given stock of resources. To achieve improvements in the rate of return on assets without necessarily having to increase charges, MW will have to continue to improve productivity.

To make comparisons with other public and private organisations, it is necessary to use a productivity measure which has a degree of commonality in methodology, and that considers all resource inputs, eg. total factor productivity (TFP). TFP is a measure that has been adopted by the Victorian Department of the Treasury, the Industry Commission, the Victorian Parliament Economic and Budget Review Committee, and the Steering Committee on National Performance Monitoring of Government Trading Enterprises (GTEs).

It is not intended in this paper to explain the mathematical formulae used in calculating TFP, as the approach adopted is consistent with the methodology developed by the Industry Commission (1990). The main task is to develop input and output measures that are relevant to MW, which are sustainable and measurable over time, and which are least influenced by accounting or other artificial changes.

The development of a TFP index for MW is not only a good discipline for MW to pursue, but is a recommendation of the Victorian Economic and Budget Review Committee:

* This paper was prepared by the staff in the Industry Commission's Economic Studies Branch with input from staff of Melbourne Water. It represents the current state of development within Melbourne Water of the measurement of Total Factor Productivity. Melbourne Water is also working in conjunction with the Australian Water Resources Council on further development of TFP across the Australian Water Industry. This work will be focussing on reassessment of the capital stock.

Recommendation 6.17

That the MMBW undertake work to produce and publish Total Factor Productivity estimates in addition to its labour productivity estimates.

In addition, TFP estimates are being sought by the Department of the Treasury as part of the forecasting process leading up to the formulation of the State Budget, and by the Steering Committee on National Performance Monitoring, established by the Special Premiers Conference in July 1991.

The method for calculating TFP used by the Industry Commission is based on the development of a series for the quantity of inputs (eg. real value of the capital stock, labour hours, contract services, and real expenditure on materials and other consumables) and the value of those inputs (depreciation and holding charges, salaries expenditure, contract expenditure, and materials expenditure). The TFP model then uses this data to construct a weighted index of changes in input quantities which describes total input growth over the period selected.

Similarly, an output index is calculated using data on the output quantities and revenues for the whole of the organisation. The TFP index is then calculated by taking the ratio of the output index to the input index.

One factor which can depress both real rates of return and productivity is an obligation to provide services that would not be provided by a purely commercial enterprise, so-called community service obligations (CSOs). These obligations lower revenue received and/or raise costs, thus depressing both the measured real rate of return and productivity growth. However, more work will be needed to consider how the effects of CSOs can be identified in TFP calculations.

The key to providing continued improvements in performance is not necessarily to identify each inefficiency, rather it is to ensure that MW can operate in a competitive world, which creates incentives to seek out and remove inefficiencies, thereby providing customers with the services demanded at the lowest possible cost. Performance monitoring and TFP measurement will help MW identify progress made in improving the efficiency of its service provision.

6.2 Selecting inputs and outputs

Calculating total factor productivity requires the selection of values and volumes for each category of input and output. Five output categories and five input categories have been distinguished for MW. These are:

Outputs	Inputs
— Water supplied	— Labour
— Sewage treated	— Materials
— Trade waste agreements	— Capital stock
— Drainage services	— Contract services
— Parks services	— All other inputs

Reliable time-series data on inputs and outputs were only available for the period 1984–85 to 1990–91 and therefore the TFP study is limited to this period. The data used to calculate TFP are listed in Appendix 6.1. The following sections provide an explanation of the choice and construction of output and input variables.

6.3 Measuring outputs

Traditionally water, sewerage and drainage productivity has been based on the number of properties serviced. This assumes that the rate of demand per household remains constant. If consumption per property has been steadily increasing through time, using the number of properties will underestimate the trend change in output and, hence, underestimate TFP growth. Notwithstanding this limitation, the number of properties serviced has been used as an output measure in this study. The alternative of using volume supplied or treated is susceptible to the unnatural suppression of output during periods of water restrictions.

Water

Revenue from the supply of water to domestic customers is currently a combination of a property rate, based on the net average value (NAV) of the property being serviced, plus a water-by-measure component, dependent on the volume of water used in a year. Industrial customers are charged using a volume rate.

The volume of water services was measured by the number of properties provided with water and was valued by total income received from rates and charges levied.

Sewerage

Revenue from the collection, treatment and disposal of sewage is based on a NAV rate per property serviced and includes income from both rates and charges levied. The volume is measured by the number of properties provided with sewerage services.

Trade waste agreements

The volume is measured by the total number of Trade Waste Agreements that MW has with customers for the safe disposal of non-domestic waste water into the sewerage system. The value is the total revenue generated from these agreements.

Waterways & drainage

Revenue from the collection and disposal of stormwater is based on a NAV rate per property serviced.

The volume factor is difficult to determine, as the drainage system is essentially a transfer facility, with municipal councils providing the primary collection facilities. At this stage, the number of rateable properties is used to measure the quantity of waterway and drainage services.

Parks visits

Revenue from the provision of metropolitan parks is generated by a metropolitan improvement rate levied on properties within the metropolitan planning boundary. Parks are also provided at most major water supply reservoirs. However, these are funded from rates collected for water supply purposes.

The volume of parks output is measured by the total number of visits to MW parks. The method of measuring this volume is not altogether satisfactory as it does not account for the proportion of parks area developed or available to the public.

The value of parks output is measured by the revenue from the Metropolitan Improvement Fund (MIF) less contributions to consolidated fund for planning and the Melbourne Underground Rail Loop (MURL), and the cost of operations of reservoir parks (represented by the portion of water supply revenue contributed to reservoir parks operation and maintenance).

6.4 Measuring inputs

The input data used represent inputs to current operations only. All costs associated with works in progress are excluded as these works cannot be used to generate output. Including works in progress therefore would reduce the overall productivity of the organisation and bias the results.

Labour

The value series for labour was defined as total expenditure on labour. This includes both wage and salary expenditure and related on-costs. The quantity of labour was measured as total persons employed. Time series data on employment was only available for the years 1986–87 to 1990–91. For the earlier years it was necessary to forecast the level of employment based on the trend growth in employment between the years 1986–87 and 1989–90. Employment in the last year was excluded from the forecast because it was felt that the unusually high level of redundancies would bias the results.

The employment figure includes both part-time and full-time employees. However, part-time employees accounted for less than 1 per cent of total employment and are, therefore, unlikely to bias the quantity measure.

Materials

MW uses the term 'materials' to refer to all raw and manufactured goods purchased. This may create a problem when calculating total factor productivity because the materials used in constructing new assets are already taken into account in the capital input series. However, materials costs account for less than 10 per cent of total non-capital costs and, therefore, any double-counting is likely to be small.

The materials value series is converted to a volume series by using the Australian Bureau of Statistics' other public expenditure price deflator.

Contract services

An important input to services provided by MW is the increasing use of contractors to provide basic support services in lieu of using direct labour. MW has recently engaged contract legal services and established a major contractual arrangement with Melbourne Information Technology Services for information technology services.

The value and volume of contract services were measured in the same manner as materials and using the same price deflator.

Capital

Capital assets provide a flow of services over their working life. As such, they are different from other inputs in that only a proportion of the asset is used each year in the production of outputs. In the case of capital, it is therefore necessary to estimate the stock of capital held each year and the annual cost of using that capital.

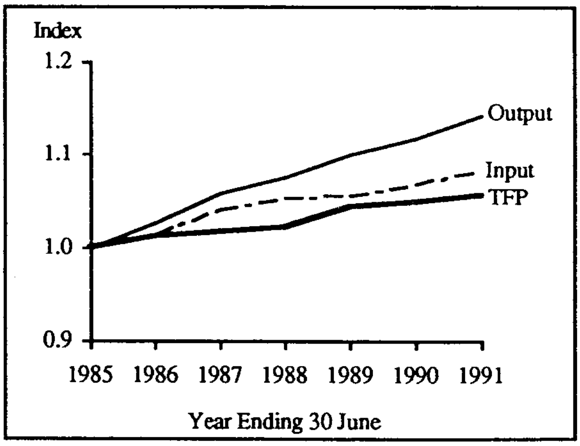
Since 1986 MW has been revaluing its capital stock to determine its market value. In 1989–90 the estimated value of capital stood at just under $8 billion. Using this figure as the base value of the capital stock, the Industry Commission (1990) method was used to update and backdate the estimated value of the capital stock. The capital was assumed to have a life of 80 years and therefore was depreciated at a declining balance rate of 1.4 per cent. The capital stock estimates were converted to 1989–90 prices using the ABS price index for water industry capital. This implicit quantity of the capital stock series was used as a proxy for the quantity of capital inputs used each year.

An annual cost of using this capital was then estimated taking into account the cost of financing the asset, the extent of depreciation on the asset due to wear and tear and the change in the value of the asset due to inflation and obsolescence.

6.5 Results

Figure 6.1 provides the preliminary results of the TFP analysis. MW's output has increased steadily over the period reflecting the growth in the number of rateable properties in line with population growth. For the period 1984–85 to 1990–91 measured output increased at a trend annual growth rate of 2.2 per cent.

Figure 6.1: **Output, input and TFP indexes of Melbourne Water**



The main means of achieving efficiency improvements in the water industry must come through improvements in management, work practices, a streamlining of investment decisions and correct price setting. MW has reduced staff significantly in the last few years in an attempt to remove inefficiencies. Increasing use is being made of contract staff to perform selected tasks. However, the observed change in input use and TFP are mainly the result of changes in MW's capital stock. The water and sewerage industry is highly capital intensive and MW is no exception with capital costs accounting for roughly 70 per cent of total cost. This means that any change in the capital stock has a marked effect on the productivity of the organisation. For instance, a small increase in the capital stock largely offsets most of the cost cutting efforts including the 22 per cent reduction in staff in the 1990–91 financial year. This highlights the importance of price setting policies to encourage correct levels of water use and to reduce future capital investment needs. It also highlights the importance of looking at an overall measure of productivity to gain an accurate picture of performance. Looking at labour productivity alone in this instance would provide a misleading impression.

For the period 1984–85 to 1990–91 the total input quantity increased at a trend annual growth rate of 1.3 per cent. The capital stock grew at a trend rate of 2.7 per cent. Labour use has declined but this has been partly offset by increases in contracting and other costs. Overall, however, TFP has increased at a trend annual growth rate of 0.9 per cent, contributing approximately 41 per cent of the observed growth in total output.

In future work it is hoped to disaggregate the output between the different types of consumers, domestic and non-domestic, and to allow for trend changes in consumption per property serviced. It is also hoped to make adjustments for CSOs, including water supplied free to crown land. As with all GTEs, it is anticipated that more accurate estimates of the capital stock employed will become available as revaluation exercises become more sophisticated and comprehensive.

APPENDIX 6.1: DATA

Table 6.1: **Estimated capital stock of MW**

Year	*Investment $m*	*Capital price index*[a]	*Depreciation $m*	*Real capital stock $m, 1989–90 prices*	*Nominal capital stock $m*
1984–85	243.20	0.72	na	6 872.85	4 948.45
1985–86	264.20	0.78	98.28	7 115.26	5 549.90
1986–87	252.20	0.83	101.75	7 316.82	6 072.96
1987–88	275.10	0.88	104.63	7 523.75	6 620.90
1988–89	269.30	0.94	107.59	7 702.85	7 240.68
1989–90	286.50	1.00	110.15	7 879.20[b]	7 879.20
1990–91	353.26	1.05	112.67	8 104.15	8 509.36

Source: MW and Industry Commission estimates.
a. ABS implicit price deflator for public gross fixed capital expenditure in the Australian water industry.
b. MW estimate of the base value capital stock.

Table 6.2: **Estimated capital annual user charge**

Year	*Bond rate*[a] *(1)*	*Depreciation plus the bond rate (2)*	*Capital gains (dP/P)*[b] *(3)*	*Nominal capital stock $m (4)*	*Annual user charge for capital $m (5)*
1984–85	0.14	0.15	0.06	4 948.45	446.52
1985–86	0.13	0.14	0.08	5 549.90	349.16
1986–87	0.13	0.13	0.06	6 072.96	426.44
1987–88	0.12	0.13	0.06	6 620.90	477.35
1988–89	0.13	0.15	0.07	7 240.68	618.49
1989–90	0.14	0.15	0.06	7 879.20	659.66
1990–91	0.12	0.13	0.05	8 509.36	674.09

Source: Industry Commission estimates.
a. Reserve Bank of Australia.
b. Proportional change in the ABS implicit price deflator for public gross fixed capital expenditure in the Australian water industry.

Note: (5) = ((2) –(3)) * (4)

Table 6.3: **Value and quantity of outputs**

	Trade waste		Water		Sewerage	
		No. of		Properties		Properties
Year	$m	agreements	$m	'000	$m	'000
1984–85	15.00	5 448	231.86	963.40	203.27	868.70
1985–86	15.41	5 431	253.86	980.10	224.06	894.10
1986–87	16.13	5 586	282.95	994.20	245.42	930.00
1987–88	21.99	5 577	321.21	1 015.40	263.35	944.00
1988–89	30.13	5 588	353.16	1 045.40	289.17	959.00
1989–90	25.56	4 864	381.86	1 067.40	302.46	980.60
1990–91	31.41	5 866	444.62	1 083.00	347.83	996.30
	Drainage		Park	Visits		Total
		Properties		visits		revenue
	$m	'000	$m	'000		$m
1984–85	35.58	786.50	23.58	3.60		509.28
1985–86	38.79	798.10	13.71	4.10		545.83
1986–87	44.14	823.10	12.08	4.70		600.72
1987–88	49.90	840.90	20.29	4.90		676.75
1988–89	53.91	872.70	21.71	5.00		748.07
1989–90	58.35	891.60	25.00	5.10		793.22
1990–91	65.44	910.40	24.85	5.30		914.16

Source: Melbourne Water.

Table 6.4: **Value and quantity of inputs**

	Labour		Materials		Contract	
		Staff		$m, 1989–90		$m, 1989–90
Year	$m	No.	$m	prices[a]	$m	prices[a]
1984–85	122.4	8 086.3	15.30	20.19	3.06	4.04
1985–86	130.14	7 839.8	16.27	20.28	3.25	4.06
1986–87	144.84	7 809.0	18.11	21.57	3.62	4.31
1987–88	161.64	7 371.0	20.21	22.61	4.04	4.52
1988–89	172.87	7 052.0	22.67	23.90	5.67	5.98
1989–90	181.96	6 878.0	23.86	23.86	2.98	2.98
1990–91	170.34	5 353.0	26.21	25.38	6.55	6.34
	Capital inputs		Other inputs			Total cost
		$m, 1989–90		$m, 1989–90		
Year	$m	prices[b]	$m	prices[a]		$m
1984–85	446.52	6 872.85	63.24	83.20		650.52
1985–86	349.16	7 115.26	67.24	83.93		566.06
1986–87	426.44	7 316.82	74.83	88.68		667.84
1987–88	477.35	7 523.75	83.51	94.14		746.75
1988–89	618.49	7 702.85	82.19	86.73		901.89
1989–90	659.66	7 879.20	89.49	89.49		957.95
1990–91	674.09	8 104.15	124.48	118.99		1 001.67

Sources: Melbourne Water and Industry Commission estimates.

a. Value deflated by ABS implicit price index for other expenditure in the public sector.

b. Value of the capital stock deflated by ABS implicit price deflator for public gross fixed capital expenditure in the Australian water industry.

Table 6.5: **Output, input and TFP indexes**

Year	*Output*	*Input*	*TFP*
1984–85	1.00	1.00	1.00
1985–86	1.03	1.02	1.01
1986–87	1.06	1.04	1.02
1987–88	1.08	1.06	1.02
1988–89	1.10	1.06	1.04
1989–90	1.12	1.07	1.05
1990–91	1.14	1.08	1.06

Source: Industry Commission estimates.

7 THE ECONOMIC PERFORMANCE OF THE PORT OF BRISBANE AUTHORITY: 1981–82 TO 1990–91*

7.1 Introduction

This chapter provides preliminary results of a study by the Queensland Government Statistician's Office (GSO) into the economic performance of the Port of Brisbane Authority (PBA).

The study was commissioned by the PBA in anticipation of performance monitoring being introduced for Government Owned Enterprises (GOEs), as outlined in the Queensland Government White Paper "Corporatisation in Queensland, Policy Guidelines" published in March 1992.

Two key measures of economic performance were compiled by the GSO, namely total factor productivity and the economic rate of return. Total factor productivity, an important indicator of economic efficiency, is an index of total output quantity to total input quantity (for more details see Industry Commission (1990)). The economic rate of return relates income to the value of the assets producing that income and is considered the best measure of overall performance.

The study focussed on the 10 year period 1981–82 to 1990–91. The scope of the study was restricted to the operations of the Port of Brisbane Authority and therefore only measures the performance of this Authority, not the performance of the Port of Brisbane. All the operations of the Cairncross Dockyard have been excluded from the scope of this study. This exclusion enabled a consistent series to be produced for the study since the Cairncross Dockyard ceased operations in 1987–88.

7.2. Constructing output and input indexes

Calculation of total factor productivity requires a value and quantity series for each category of output and input and the construction of Tornqvist indexes as outlined in Industry Commission (1990, Appendix). For the PBA, fourteen output categories and six input categories have been distinguished;

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* This case study was prepared by the Queensland Government Statistician's Office for the Port of Brisbane Authority.

Outputs

- Harbour dues
  - bulk
  - containers
  - general cargo
- Berthage
- Wharfage
  - bulk
  - containers
  - general cargo
- Rent
  - leased land
  - other occupied land
  - improvements
- Services
  - dredging
  - other
- Capitalised internal development work
- Other revenue

Inputs

- Labour
- Fuel
- Other costs
- Capital
  - plant and structures
  - freehold land
  - vested land

7.3 Measuring Port of Brisbane Authority aggregate output

The value and quantity data on outputs used in the calculation of total factor productivity are shown in Table 7.1 of Appendix 7.1.

Harbour dues

Harbour dues are levied on all cargo that is moved through the Port of Brisbane. Details of revenue received, split between bulk, containers and general cargo, together with the corresponding quantities were provided by the Authority. To encourage trade the Authority has not increased the general harbour due rate since 1982–83.

Berthage

Berthage is levied by the PBA on vessels that berth at its wharves. It is levied at a dollar rate per metre per time period. Revenue from berthage together with berth hours were provided by the Authority. Ideally a quantity series of berth metre hours would have provided a better indicator but this data was not available.

Wharfage

Wharfage is charged on cargo that is moved across the Authority's wharves. Details of wharfage revenue, split between bulk, containers and general cargo, together with the appropriate quantities were provided.

Rent — leased land

This category is largely vested land leased by the Authority. Vested land is Crown land vested in the Authority. Whilst it involved no acquisition cost it was generally subject to significant reclamation costs by the PBA before it could be used. The GSO extracted details of the valuation, revenue and area of this land from the Authority's records.

Rent — other occupied land

This category covers a variety of leases for commercial and recreational boating purposes. Details of rent received and area leased were extracted from the Authority's records.

Rent — improvements

This category includes rent from the "Port Centre" office building and terminal facilities and plant at Fisherman Islands. A quantity series was derived by deflating the value series using the Australian Bureau of Statistics' (ABS) national accounts implicit price deflator for public trading enterprises, gross fixed capital expenditure, state and local, sea transport.

Services — dredging

Revenue data for this category was obtained from the Authority's annual reports. A quantity series was derived by dividing the revenue data by the hourly charge rate for the "Sir Thomas Hiley" dredge.

Services — other

The value series for this category represents revenue from maintenance, survey and other work undertaken by the Authority for outside customers. A quantity series was derived by deflating the value series by the ABS implicit price deflator for gross domestic product.

Capitalised internal development work

This category represents the cost of the PBA work in creating fixed assets. It was initially classified as expenses according to their nature, but was subsequently transferred to the appropriate asset account, via expense recovery account, shown in the Authority's Profit and Loss Statement. This development activity can be treated either as an output or excluded from output together with the associated inputs. As it was not possible to identify the associated inputs, the value of capitalised internal development work was treated as an output in this study. The value series was deflated by the implicit price deflator for public trading enterprises, gross fixed capital expenditure, state and local, sea transport, to give a quantity series.

Other revenue

The value series for this category was deflated by the implicit price deflator for gross domestic product to give a quantity series.

7.4 Measuring non-capital inputs used by the Port of Brisbane Authority

The value and quantity data on inputs used in calculating total factor productivity are shown in Table 7.2. of Appendix 7.1.

Labour

Details of wages and salaries paid together with employment levels, at 30 June each year, were furnished by the Authority. Discussions with the Authority indicated that change in employment levels usually occurred early in the financial year, and therefore the 30 June levels were accepted to be the best estimate of labour quantity for the financial year.

Fuel

The dredge "Sir Thomas Hiley" accounted for the majority of the Authority's fuel costs. Details of the quantity used or the average price paid were not readily available for the 10 year period.

An implicit quantity was derived by deflating the value series by an industrial diesel price index, excluding excise, obtained from the ABS National Accounts Section.

Other costs

This category covers the remaining economic costs of the Authority. A quantity series was obtained by dividing the value series by the ABS implicit price deflator for gross domestic product.

7.5 Capital

The Port of Brisbane Authority uses the conventional historical cost valuation of capital assets. To estimate both total factor productivity and the economic rate of return, a current market value or economic value of the capital stock is required. That is, capital valued in historical costs terms needs to be adjusted for the effects of inflation and the difference between economic and accounting depreciation.

Considerable effort was expended in this study to estimate the current value of the Authority's capital stock. Details of the methodology used are set out below.

Plant and structures

A register of major assets (an initial value of over $100,000) together with the commission date and their expected useful life was obtained from the Authority. The Authority currently depreciates plant and structures on a straight line basis reflecting their expected useful life. Analysis of the operation of the Authority indicated that straight line depreciation was appropriate, as a substantial proportion of the Authority's capital stock have long asset lives and are not often used to capacity in the early years of their lives.

The availability of the PBA data relating to individual assets with an initial value of over $100,000 allowed the calculation of an annual historical cost written down value for each asset. This measure represents the value of the individual asset in terms of commissioned year prices. This series was adjusted to current prices by inflating with an asset specific inflation rate. In this case the ABS implicit price deflator for public trading enterprises, gross fixed capital expenditure, state and local, sea transport was used. For example, for an asset commissioned in 1970–71 the written down value for 1990–91 was adjusted to 1990–91 prices in line with the movements of the deflator in this period. For some assets recent valuations were available and were incorporated in the estimates. For example, the "Port Centre" office building was valued in August 1989.

To ensure that capital inputs were matched with outputs, assets were only included from their commissioned date. Consequently, this may overstate capital inputs as, for example, a wharf may not be used to capacity until a number of years after being commissioned.

An estimate of the total current value of plant and structures was calculated by summing the current value of the Authority's individual major assets and adjusting for assets with an initial value of less than $100,000.

Freehold land

Freehold land was independently valued for the Authority in 1989–90. This valuation was indexed forward and backward by movements in the implicit price deflator for gross domestic product. The value of the Cairncross Dockyard land was excluded from this analysis as it is not used to any great extent by the Authority and its future use is to be determined by a Inter-Departmental Committee.

Vested land

Crown land that has been vested in the Authority, involves no acquisition costs and may be subsequently divested. In most cases the land requires reclamation and development. Only the value of vested land that is leased and has been valued by the Authority was included in this study. The Authority controls additional vested land which is not currently used. This encompasses land which requires reclamation as well as strategic land, some of which also requires reclamation, which is held by the PBA to ensure effective long term planning. This land was excluded as it currently does not produce outputs.

For rental determination leased vested land is valued every 3–5 years by a commercial valuer. These values were used, with estimates interpolated between valuations. For the remaining years estimates were derived, in line with movements in the implicit price deflator for gross domestic product.

The value of shipping channels and reaches development have been included in the value of plant and structures. A proportion of these development costs is also likely to be reflected in the valuation of vested land.

Quantity of capital

Capital inputs are different from other inputs in that only a fraction is used up each year to produce outputs. In the case of capital it is, therefore, necessary to estimate the service flow derived each year from the capital stock. In this study the quantity of this service flow is assumed to be directly proportional to the quantity of plant and structures, freehold land and vested land. The quantity of plant and structures was estimated by deflating the current value of capital by the implicit price deflator previously used to inflate the historical costs estimates. Hectares were used as the quantity measure for freehold and vested land.

Economic depreciation

An estimate of economic depreciation (accounting depreciation adjusted for changes in asset values), was derived as the difference between the opening and closing current value of plant and structures, adjusted for acquisition and disposal of assets. As a consequence of the long asset lives of many PBA assets and the high level of inflation in the decade to 1990–91 the estimate of economic depreciation was negative in a number of years. It should be noted that this interpretation of economic depreciation corresponds to the sum of two terms (d – dp/p) used by the Industry Commission.

User cost of capital

The value attached to the capital input is known as the annual user charge for capital (VAUC) and is derived in a manner similar to that described in Industry Commission (1990) and the formula is set out below:

VAUC = (OCOSTK * CURVK) + ECDEPN – dVLAND

where

OCOSTK	is the opportunity cost of holding capital,
CURVK	is the average value of capital stock,
ECDEPN	is the value of straight line economic depreciation (including capital gains), and
dVLAND	is the capital appreciation of land.

The derivation of the PBA's annual user charge for capital is shown in Table 7.4 of Appendix 7.1. The 10 year government bond rate was used to approximate the opportunity cost of holding capital.

7.6 Total factor productivity

Preliminary results from the study are shown in Figure 7.1.

Figure 7.1: **Ouput, input and TFP indexes for the Port of Brisbane Authority**

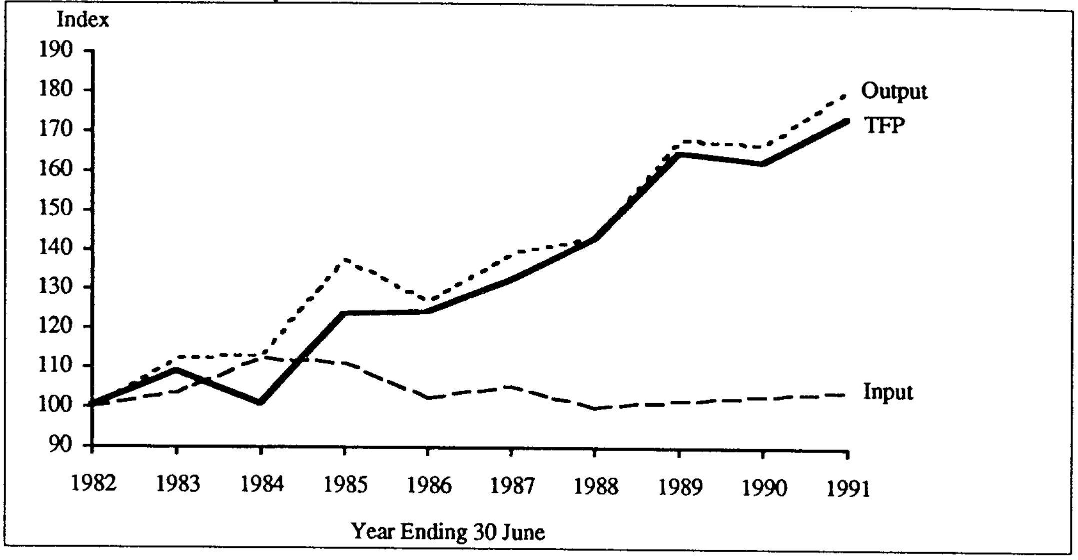

Figure 7.1 shows the output index has increased substantially in all years except 1985–86 and 1989–90. Falls in these years are largely due to a lower output of dredging services. In contrast the input usage has been relatively constant since 1985–86.

Total factor productivity of the Authority increased at an average annual trend rate of growth of 6.5 per cent largely due to a trend output growth rate of 6.2 per cent and input growth constrained to a trend rate of –0.3 per cent. The output, input and total factor productivity indexes are shown in Table 7.5 of Appendix 7.1.

7.7 Economic rate of return

The economic rate of return is defined as the ratio of the economic income to the market value of the associated capital stock at the start of the year. This definition is similar to the Industry Commission's definition of economic rate of return (referred to as real rate of return in Industry Commission (1990)), but incorporates capital gains or losses in economic income. It can be defined as:

$$ERR = ((ER - EE) - ECDEPN + dVLAND)/CURVKO,$$

where

ER	is the value of economic revenue,
EE	is the value of economic expenses,
ECDEPN	is the value of straight line economic depreciation (including capital gains),
dVLAND	is the capital appreciation of land, and
CURVKO	is the opening current value of capital stock.

Economic revenue was estimated as operating revenue less interest received and profit on disposal of assets. Likewise, interest and historic cost depreciation were deducted from the Authority's gross operating expenses to obtain economic expenses.

The nominal economic rate of return of the Authority over the 10 year period is shown in Table 7.6. of Appendix 7.1 and in Figure 7.2 below.

Figure 7.2: **Nominal economic rate of return for the Port of Brisbane Authority**

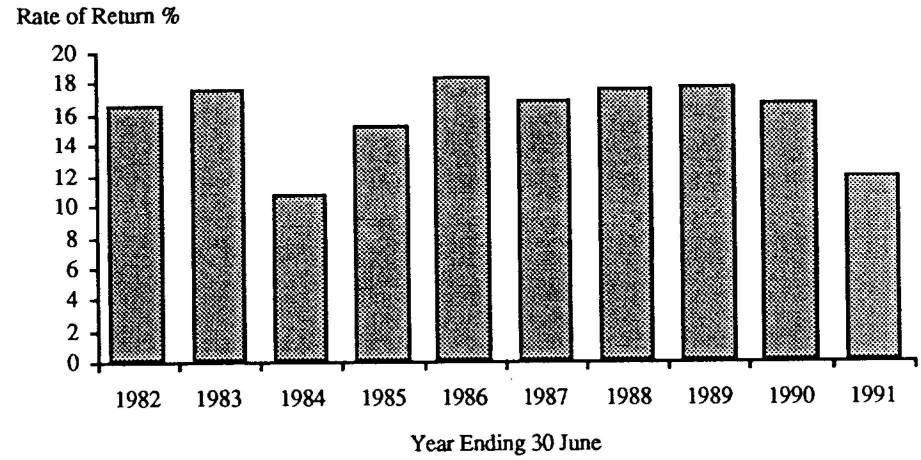

Table 7.6 of Appendix 7.1 also shows the real economic rate of return calculated by deflating the nominal economic rate of return by the Consumer Price Index (CPI).

Over the study period the Authority achieved an average annual nominal economic rate of return of 16.0 per cent with real economic rates of return averaging 7.7 per cent. Nominal rates of return above 15 per cent were achieved for all years except 1983–84 and 1990–91. The lower returns in these years were largely due to the higher opening capital stock, following the commissioning of major new assets, and higher estimates of economic depreciation due to lower levels of inflation.

7.8 Conclusion

The Port of Brisbane Authority has achieved a total factor productivity trend rate of growth of 6.5 per cent over the ten year study period. This has resulted from a trend output growth rate of 6.2 per cent and a trend input growth rate of –0.3 per cent.

The preliminary results of this study indicate the Authority's strategy of trade growth rather than profit maximisation has been effective and is reflected in an output growth rate of 6.2 per cent. One of the more important factors influencing trade growth has been the Authority's pricing policy which has seen no increase in general harbour dues since 1982–83.

The results of this strategy are also reflected in the average nominal economic rate of return achieved by the Authority (16.0 per cent) which averaged 2.4 per cent above the opportunity cost of investment, the long-term Government bond rate, over the study period.

APPENDIX 7.1: DATA

Table 7.1: **Quantity and value of outputs**

Harbour Dues

	Bulk		Containers		General cargo	
Year	*kt.*	*$'000*	*TEU's*	*$'000*	*kt.*	*$'000*
1981–82	8157.9	6846.9	88778	2415.0	684.3	1599.4
1982–83	7725.6	7089.9	99395	2860.1	643.3	1601.2
1983–84	9660.0	9199.2	96318	2821.5	329.1	1702.7
1984–85	10899.4	9610.3	98974	3026.9	374.4	1901.4
1985–86	11593.5	11068.7	102271	3233.3	502.6	1632.8
1986–87	11950.7	11893.9	104326	3368.2	233.8	888.3
1987–88	12675.4	11513.0	118581	3813.1	376.7	1359.9
1988–89	13364.8	12163.2	144964	4675.1	481.6	2150.0
1989–90	13522.6	12146.9	172251	5253.1	447.2	2122.6
1990–91	13726.5	12063.2	183380	5750.5	640.3	2286.1

	Berthage		Wharfage: Bulk		Wharfage: Containers		Wharfage: General cargo	
Year	*berth hrs*	*$'000*	*kt.*	*$'000*	*TEU's*	*$'000*	*kt.*	*$'000*
1981–82	20961	888	544	491	16957	399	0	0
1982–83	12156	569	498	496	29157	758	0	0
1983–84	13222	718	1061	1058	28993	665	0	0
1984–85	22143	1188	1510	1505	59899	1352	0	0
1985–86	20503	1157	3442	3453	65518	1584	9	16
1986–87	16353	955	3437	3945	72580	1609	15	28
1987–88	15243	932	3725	3875	82990	1930	38	70
1988–89	20783	1315	3936	4529	117313	2590	90	360
1989–90	21040	1364	3973	4369	143546	3052	54	100
1990–91	22949	1498	4470	4903	162865	3603	86	162

(continued on next page)

Table 7.1: **Quantity and value of outputs** (continued)

	Rent					
	Leased Land		*Other occupied area*		*Improvements*	
Year	*Area(ha)*	*$'000*	*Area (ha)*	*$'000*	*Quantity[a]*	*$'000*
1981–82	50.1	482.9	1.9	14.7	1791.4	1408.0
1982–83	126.1	681.9	30.8	98.4	2323.8	2056.5
1983–84	135.6	979.4	42.2	98.5	1955.4	1818.5
1984–85	134.3	1107.0	43.8	105.9	2606.3	2606.3
1985–86	138.2	1172.0	44.7	115.5	2586.3	2904.4
1986–87	157.2	1919.7	49.0	121.4	2078.5	2527.4
1987–88	165.3	2233.2	56.1	139.4	2797.8	3634.4
1988–89	175.5	2893.3	56.1	139.7	3410.5	4761.1
1989–90	184.4	3705.9	56.3	142.0	2773.4	4157.3
1990–91	185.5	4126.3	66.4	300.2	3716.3	5708.3

	Services				Capitalised internal development		Other revenue	
	Dredging		*Other*					
Year	*'000 hours*	*$'000*	*Quantity[a]*	*$'000*	*Quantity[a]*	*$'000*	*Quantity[a]*	*$'000*
1981–82	3.80	3499	683.8	548	944.2	742.1	1725.33	1382
1982–83	1.97	1930	811.0	718	4709.7	4168.1	1516.48	1342
1983–84	2.34	2661	1309.7	1239	2950.5	2744.0	1498.72	1418
1984–85	4.72	6051	1840.8	1839	1664.2	1664.2	1549.35	1548
1985–86	0.85	1140	1479.0	1581	1600.6	1797.5	1982.08	2119
1986–87	4.00	5785	437.3	502	2824.9	3435.0	1137.63	1306
1987–88	4.13	6103	774.2	960	1152.9	1497.7	749.19	929
1988–89	4.17	6155	1216.1	1649	2393.0	3340.6	832.37	1129
1989–90	3.91	5768	825.5	1183	2247.5	3369.0	965.39	1383
1990–91	5.66	8351	609.2	898	892.8	1371.4	888.20	1309

a The quantity was implicitly derived by deflating the value by a price index.

Table 7.2: **Quantity and value of inputs**

	Labour		*Fuel*		*Other Costs*	
Year	*Number of employees*	*Total S & W $'000*	*Quantity*[a]	*$'000*	*Quantity*[a]	*$'000*
1981–82	289	6054.7	1676.7	1319.1	6933.4	5553.7
1982–83	280	7489.7	1829.7	1667.2	7180.8	6355.0
1983–84	294	7866.3	1861.7	1774.4	7979.5	7548.6
1984–85	288	8756.7	2226.7	2226.7	7963.3	7955.4
1985–86	288	8801.7	2067.1	2106.7	6356.8	6795.5
1986–87	285	9356.2	2549.7	2167.2	6855.0	7869.5
1987–88	278	9642.3	2341.9	2228.5	4159.9	5158.3
1988–89	251	9228.3	1869.2	1681.2	4462.4	6050.9
1989–90	245	9584.2	2113.9	1923.2	4777.0	6845.4
1990–91	245	9926.6	1685.0	2010.7	4992.5	7359.0

	Capital					
	Plant and structures		*Freehold land*		*Vested land*	
Year	*Quantity*[a]	*VAUC $'000*	*Area (ha)*	*VAUC $'000*	*Area (ha)*	*VAUC $'000*
1981–82	88.4	7200	46.0	100	41.2	300
1982–83	90.2	6800	46.0	200	88.1	1000
1983–84	98.1	13700	46.0	200	130.9	500
1984–85	94.3	11900	46.0	400	135.0	400
1985–86	89.3	9400	46.0	200	136.3	900
1986–87	87.7	13800	50.7	300	147.7	700
1987–88	99.6	16200	50.9	400	161.3	900
1988–89	109.1	19900	50.9	300	170.4	1500
1989–90	107.8	20000	50.9	800	180.0	3300
1990–91	110.3	26800	50.9	900	185.0	5700

a The quantity was implicitly derived by deflating the value by a price index.

Table 7.3: **Estimation of the quantity of capital**

Year	*Nominal value structures and plant* $m	*Average value structures and plant* $m	*Implicit price deflator* Index	*Quantity structures and plant* 1984–85 $m	*Quantity freehold land* ha	*Quantity vested land* ha	*Average quantity vested land* ha
1980–81	67.7					32.3	
1981–82	71.2	69.5	78.6	88.4	46.0	50.1	41.2
1982–83	88.5	79.9	88.5	90.2	46.0	126.1	88.1
1983–84	93.9	91.2	93.0	98.1	46.0	135.6	130.9
1984–85	94.6	94.3	100.0	94.3	46.0	134.3	135.0
1985–86	106.0	100.3	112.3	89.3	46.0	138.2	136.3
1986–87	107.2	106.6	121.6	87.7	50.7	157.2	147.7
1987–88	151.6	129.4	129.9	99.6	50.9	165.3	161.3
1988–89	153.1	152.4	139.6	109.1	50.9	175.5	170.4
1989–90	170.0	161.6	149.9	107.8	50.9	184.4	180.0
1990–91	168.8	169.4	153.6	110.3	50.9	185.5	185.0

Table 7.4: **Estimation of annual user charge for capital (VAUC)**

	Nominal value of capital stock			*Average value of capital stock*		
Year	*Structures and plant* $m	*Freehold land* $m	*Vested land* $m	*Structures and plant* $m	*Freehold land* $m	*Vested land* $m
1980–81	67.7	2.7	5.0			
1981–82	71.2	3.0	9.2	69.5	2.9	7.1
1982–83	88.5	3.3	18.4	79.9	3.2	13.8
1983–84	93.9	3.6	25.0	91.2	3.5	21.7
1984–85	94.6	3.7	28.1	94.3	3.7	26.6
1985–86	106.0	4.0	31.6	100.3	3.9	29.9
1986–87	107.2	4.7	39.1	106.6	4.4	35.4
1987–88	151.6	8.5	43.9	129.4	6.6	41.5
1988–89	153.1	9.4	53.9	152.4	9.0	48.9
1989–90	170.0	9.9	63.3	161.6	9.7	58.6
1990–91	168.8	10.2	67.5	169.4	10.1	65.4

(continued on next page)

Table 7.4: **Estimation of annual user charge for capital (VAUC)** (continued)

		Opportunity Cost			
Year	*Govt bond rate* %	*Structures and plant* $m	*Freehold land* $m	*Vested land* $m	*Economic depreciation* $m
1981–82	15.48	10.8	0.4	1.1	-3.6
1982–83	14.43	11.5	0.5	2.0	-4.7
1983–84	13.92	12.7	0.5	3.0	1.0
1984–85	13.42	12.6	0.5	3.6	-0.7
1985–86	13.65	13.7	0.5	4.1	-4.3
1986–87	13.57	14.5	0.6	4.8	-0.7
1987–88	12.55	16.2	0.8	5.2	0.0
1988–89	12.86	19.6	1.2	6.3	0.3
1989–90	13.31	21.5	1.3	7.8	-1.5
1990–91	12.11	20.5	1.2	7.9	6.3

	Capital appreciation		Annual user charge for capital			
Year	*Freehold land* $m	*Vested land* $m	*Structures and plant* $m	*Freehold land* $m	*Vested land* $m	*Total* $m
1981–82	0.3	0.8	7.2	0.1	0.3	7.6
1982–83	0.3	1.0	6.8	0.2	1.0	8.0
1983–84	0.3	2.5	13.7	0.2	0.5	14.4
1984–85	0.1	3.2	11.9	0.4	0.4	12.7
1985–86	0.3	3.2	9.4	0.2	0.9	10.5
1986–87	0.3	4.1	13.8	0.3	0.7	14.8
1987–88	0.4	4.3	16.2	0.4	0.9	17.6
1988–89	0.9	4.8	19.9	0.3	1.5	21.6
1989–90	0.5	4.5	20.0	0.8	3.3	24.1
1990–91	0.3	2.2	26.8	0.9	5.7	33.5

VAUC = (Nominal value of average capital stock * Govt bond rate) + Economic depreciation (including capital gains) - Capital appreciation of land.

Table 7.5: **Output, input and total factor productivity indexes**

Year	Output index	Input index	Total factor productivity index
1981–82	100.0	100.0	100.0
1982–83	112.5	103.4	108.7
1983–84	113.3	112.5	100.8
1984–85	137.9	111.3	123.9
1985–86	127.4	102.8	124.0
1986–87	139.5	105.4	132.4
1987–88	143.9	100.3	143.3
1988–89	168.5	102.2	164.8
1989–90	167.2	103.0	162.3
1990–91	180.7	104.2	173.7

Table 7.6: **Estimation of the economic rate of return**

Year	Economic revenue $m	Economic expenses $m	Economic depreciation $m	Capital appreciation of land $m	Economic income $m	Opening capital stock $m	Nominal economic rate of return %	Real economic rate of return* %
1980–81	15.7	11.0						
1981–82	20.3	12.5	-3.6	1.1	12.5	75.4	16.6	5.3
1982–83	20.9	12.2	-4.7	1.3	14.7	83.4	17.6	6.0
1983–84	25.0	15.0	1.0	2.8	11.8	110.2	10.7	3.3
1984–85	32.6	18.0	-0.7	3.3	18.6	122.5	15.2	10.0
1985–86	32.1	16.8	-4.3	3.5	23.1	126.4	18.3	9.5
1986–87	34.8	15.9	-0.7	4.4	24.0	141.6	16.9	7.7
1987–88	37.4	15.5	0.0	4.7	26.6	151.0	17.6	10.0
1988–89	44.5	13.5	0.3	5.7	36.4	204.0	17.8	10.0
1989–90	44.7	15.0	-1.5	5.0	36.2	216.4	16.7	8.6
1990-91	51.0	17.9	6.3	2.5	29.3	243.2	12.0	6.8

* Deflated by the Consumer Price Index.

8 PRODUCTIVITY OF PACIFIC POWER — PRELIMINARY RESULTS: 1978–79 TO 1990–91*

8.1 Introduction

In this chapter the Total Factor Productivity (TFP) performance of Pacific Power is presented for the period from 1978–79 to 1990–91. Earlier studies of TFP in the Australian electricity supply industry (ESI) have analysed the productive efficiency of the industry at a State system level (see for example Lawrence, Swan and Zeitsch 1991a). The contribution of the broad industry components (generation, transmission and distribution) to changes in TFP could not be determined from these studies. The current study is the first attempt at estimating changes in TFP for the combined generation and transmission activities of the NSW electricity supply industry.

The TFP measures presented below represent aggregate productivity measures for Pacific Power. However, TFP series are being estimated for each power station and for the transmission operations of Pacific Power and will be presented in future papers.

The current results should be regarded as preliminary and therefore no firm conclusions about Pacific Power's recent performance should be drawn. Particular care should be taken with the capital series, which has only recently been formed and embodies a number of assumptions which have yet to be comprehensively scrutinised.

A wide range of 'explanators' have also been collected as part of this study to explain changes in productivity over time. These will be used in further papers to examine, in detail, the sources of productivity change.

8.2 Method of analysis

Productivity refers to the efficiency with which inputs are converted to outputs. Greater efficiency in this sense is demonstrated when the quantity of inputs required to produce a unit of output declines. Put simply, productivity is measured as a ratio of an index of aggregate outputs to an index of aggregate inputs.

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* This case study was prepared by the Economics Branch of Pacific Power.

Productivity measures are typically categorised as either partial or total. This classification refers to the number of inputs related to the level of output. Total Factor Productivity is a more useful measure of productive efficiency since it relates the change in the level of **all** product outputs to the change in the quantity of **all** inputs used in the production process. Therefore, the substitution of different inputs in the production process is explicitly accounted for in a measure of TFP. This contrasts with the more traditional partial measures (eg. GWh/employee) which typically measure the ratio of a single output to a single input. Partial measures are unable to capture the trade offs from substituting factor inputs or product outputs and are therefore difficult to interpret in terms of the impact on overall performance.

Inputs are combined into single input series using the Tornqvist aggregation method (Industry Commission 1990). Broadly, an aggregate input (output) series is obtained by cumulating through time a weighted (arithmetic in this case) sum of the rates of change of the component input (output) quantities. The weights are represented by the shares of individual input (output) costs (revenues) to total input (output) expenditures (revenues).

8.3 Data sources

In this paper a single output measure, GWh Sent Out, is compared to an aggregate index of all inputs (not including Snowy inputs and outputs). Inputs have been broadly classified as fuel, labour, capital, and other materials and operating expenses.

Capital represents the largest share of input costs in this study, typically accounting for around half of all input costs. The formation of the capital consumption and cost series is perhaps the most controversial in this and all studies examining industry performance. This is particularly true for capital intensive industries, which characterise most government trading enterprises, such as electricity generation.

The quantity of capital consumed each year is calculated from the depreciation of the capital stock formed through the Perpetual Inventory Method (PIM). PIM is a technique which simulates the value of gross capital stocks over time. The gross capital stock is estimated through the cumulated value of gross fixed capital expenditure, net of the cumulated value of asset retirements. Net capital stock, used in this study, is calculated the same way except that the cumulated value of capital consumption (depreciation) is deducted from the aggregate value of capital stocks. PIM requires a series of gross fixed capital expenditure; a knowledge of the depreciation function of assets; service lives of capital; and an appropriate price index to adjust investments for price movements.

Depreciation is calculated from the stock of capital estimated at constant prices using a straight line depreciation schedule[1]. The depreciation rate is specific to each power station site and transmission asset type because of varying service lives. Depreciation costs commence in the year the last generating unit at a power station is commissioned. The rate of depreciation is calculated from an actual or assumed date of decommissioning of the last unit at a power station. Any investments at a power station after the commissioning of the last generating unit are depreciated at a rate calculated from the investment date to the decommissioning date.

Included in the capital stock are 12 coal fired power stations which were commissioned over the study period along with 5 gas turbine and 6 hydro power stations. All transmission, land, equipment, transportation capital, offices and buildings are also included in consumption and price estimates.

The opportunity cost of capital is accounted for in this study. In the case of power stations with a known investment stream the cost of 'interest during construction' is accumulated through time from the date of an initial investment in an asset to the commissioning date of the final unit at a power station. For example, if there is a 5 year lag between when the investment occurs and the commissioning of the last unit at a power station, costs in the first year of investment are compounded over 5 years and added to the starting value of capital stock. Capital costs incurred in the second year of investment are compounded over 4 years, and so on. Therefore, the starting value of the capital stock of a power station represents the cumulated value of interest during construction plus the nominal expenditures, which are then depreciated over the known or assumed life of a power station.

Interest during construction is not calculated for non-generation assets because of a lack of asset specific investment information. Non-generation assets comprise less than 30 per cent of all assets and therefore this lack of information does not significantly detract from the study.

The price of capital is formed by employing the concept of 'user cost of capital'. This price is estimated by taking the product of the nominal value of the capital stock and the sum of the nominal interest rate (10 year government bond rate) and depreciation rate, less the change in

[1] Capital expenditures were deflated by the Electricity Public Trading Enterprise Gross Fixed Capital Expenditure Equipment or Non-Dwelling Construction indices, according to the asset type. Fuel costs were deflated according to the Gross Non-Farm implicit price deflator, while labour was deflated using the ABS NSW Gas, Electricity and Water labour series. All of these indices have a 1984–85 base.

the index of capital prices. The change in the index of capital prices reflects capital gains or losses and, therefore, also technological obsolescence.

The quantity of fuel is calculated by the total energy (measured in terajoules) consumed by all power stations, including coal, oil and gas. Energy purchased from other States or private generators is included in the 'Other' input category.

Fuel expenditure is calculated from the per unit delivered coal cost for Pacific Power owned and private mines. In the case of Pacific Power's mines, coal costs reflect the costs of extraction, and therefore, may not necessarily accord to a 'market' price. This contrasts to supplies received from private coal suppliers which do reflect market prices. In 1978–79 private mines provided 57 per cent of coal delivered to power stations, the remaining proportion being supplied by Pacific Power owned mines. However, since 1982–83 Pacific Power owned mines have accounted for around 55 per cent of deliveries while the remaining quantities were supplied by privately operated mines. Pacific Power is currently evaluating proposals for the purchase of its mines which mainly comprise 8 Central Coast collieries. A decision on these evaluations is expected in the near future.

The number of full-time equivalent employees is used in this study to form the labour quantity series. Other superior series are available, based on the number of hours worked. Unfortunately, only a three year series can be established on this basis.

Labour expenditures include all wage and salary costs, allowances, superannuation, leave payments, etc. The labour costs used in this study do not match published labour costs. Over the study period there were a number of adjustments to labour provisions accounts (eg. superannuation) to offset accrued under-funding. For the purposes of this study the amount under-funded was reallocated over the labour cost series to form a series of 'true' provisions from 1973–74 to 1989–90, based on the Government Actuary's formula.

The 'Other' costs are essentially the residual of total expenditures less fuel, capital and labour expenses. A number of 'financial' transactions which were not related to the purchase or sale of goods and services have been excluded from the 'Other' costs. Most significantly, these exclusions incorporate interest and depreciation costs, dividends and other contributions.

The quantity of the 'Other' inputs cannot be estimated directly because of the wide range of inputs which comprise this category. A quantity series is indirectly determined by deflating the expenditure series, thereby eliminating any price change effects and leaving a measure of input quantity change.

8.4 Preliminary Results

The period covered in this study (1978–79 to 1990–91) was characterised by significant and rapid change. In the ten years leading up to 1978–79 electricity demand in NSW grew, on average, by 6 per cent per annum. In the two decades before this period, demand grew at an annual average of around 9 per cent. In the context of historically high demand growth and the expected 'resources boom' in the 1980s, the electricity supply industry invested heavily in larger power stations located directly on coal sources. This investment strategy was pursued to take advantage of the anticipated economies of plant size and low fuel costs.

As history revealed the much anticipated 'resources boom' failed to materialise and, combined with the general down turn in economic activity in the early 1980s, Pacific Power was left with considerable excess generating capacity.

In recent years Pacific Power has shifted its emphasis from the construction and management of capital to maximising economic efficiency. As a consequence, there has been more emphasis on the development and implementation of business objectives and strategies.

This change in direction was led by:

— the emergence of an increasingly competitive energy market;

— a fall-off in traditionally high electricity demand growth; and

— a realisation that Pacific Power's impact on the physical and social environment in which it operates should be an integral component of its decision making processes.

These shifts in the business environment required more emphasis on the achievement of productive and allocative efficiency as a policy objective.

To these ends, Pacific Power has implemented a number of reforms which positions the organisation to operate efficiently and effectively in a dynamic business environment. A central feature of these changes was the adoption of a commercially oriented and streamlined corporate structure. This structure is based upon the appointment of a business oriented Board with substantial commercial experience.

The move to a more commercial focus encompassed increased emphasis on managerial accountability, which is applied through performance agreements for senior managers.

To consolidate the gains from these managerial reforms Pacific Power has established a competitive wholesale electricity market in NSW (ELEX) which is intended to introduce the incentives to improve economic efficiency which exist within competitive markets. The basis of this wholesale market is to provide a mechanism whereby power stations bid to supply electricity into a pool and are dispatched accordingly.

Fundamental to this re-organisation is the separation of the generation, transmission and corporate functions of Pacific Power. The generation operations of Pacific Power have been broken into three separate business units, Hunter, Central Coast and Western.

The reform process has resulted in the:

— significant rationalisation of employee numbers from over 11,200 in 1983–84 to around 6,700 presently (a total fall of over 40 per cent),

— closure of economically inefficient generating plant,

— improved utilisation of capital (availability and capacity factor up by over 50 and 25 per cent, respectively, from 1978–79 to 1990–91),

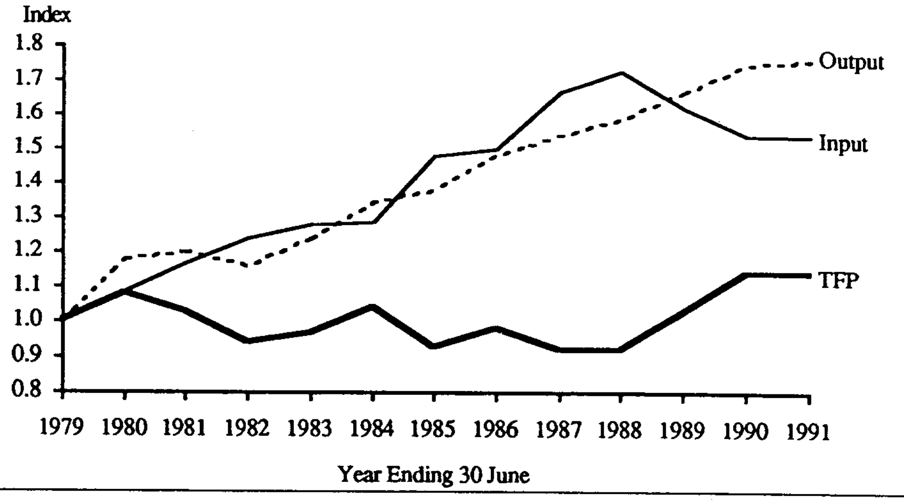
— internal funding of the Electricity Commission's capital expenditure program, and

— a 20 per cent reduction in Electricity Commission debt since it peaked in 1987–88.

With regard to the environmental and social impacts of the organisation's operations, Pacific Power has implemented a number of research programs and policies which reflect the community's concerns over these problems, and has also implemented a more efficient tariff structure.

Against this background, Pacific Power's TFP performance from 1978–79 to 1987–88 (shown in Figure 8.1 and Table 8.1) generally cycled around a flat trend. In the two years following 1987–88, when major managerial reforms were implemented, TFP increased rapidly, rising by nearly 25 per cent to 1990–91, representing an annual average increase of around 8 per cent.

Figure 8.1: **Total factor productivity of Pacific Power — 1978–79 to 1990–91**



In considering the sources of changes to TFP it is worth remembering that any decline (rise) in the most costly inputs (outputs), in terms of proportion of total costs (revenues), will have a proportionately greater impact on the TFP result. In this respect, as a percentage of total input costs, capital accounts for around 50 per cent, followed by fuel at around 25 per cent, labour around 15 per cent and 10 per cent for 'Other' inputs. Therefore, labour and 'Other' inputs require substantial improvements in productivity before there is an equivalent impact on TFP as is experienced from a small change in capital or fuel productivity.

Table 8.1: **Total and partial factor productivity indexes**

	All Inputs		*All Outputs*		*Total Factor Productivity*	
Year	*Index*	*% Change*	*Index*	*% Change*	*Index*	*% Change*
1978–79	1.00		1.00		1.00	
1979–80	1.09	8.61	1.18	17.66	1.08	8.34
1980–81	1.17	7.81	1.20	2.36	1.03	-5.06
1981–82	1.24	5.77	1.16	-3.37	0.94	-8.65
1982–83	1.28	3.21	1.24	6.13	0.97	2.83
1983–84	1.29	0.97	1.35	8.91	1.04	7.87
1984–85	1.48	14.71	1.38	2.23	0.93	-10.88
1985–86	1.50	1.54	1.48	7.28	0.98	5.65
1986–87	1.67	10.86	1.54	4.05	0.92	-6.15
1987–88	1.73	3.76	1.59	3.31	0.92	-0.43
1988–89	1.62	-6.20	1.67	4.99	1.03	11.93
1989–90	1.54	-5.37	1.75	5.35	1.14	11.33
1990–91	1.54	0.56	1.76	0.59	1.14	0.03

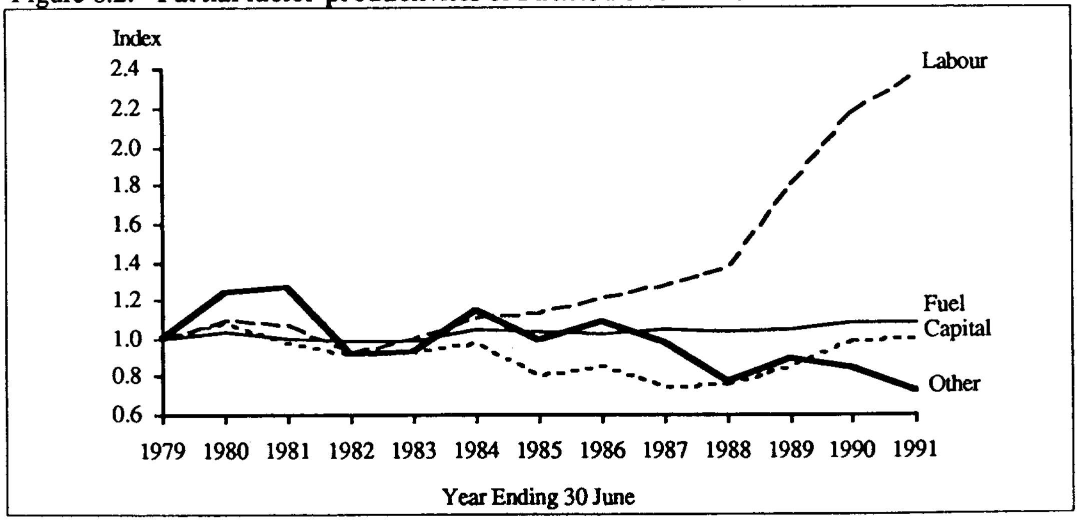
(continued on next page)

Table 8.1: **Total and partial factor productivity indexes** (continued)

	Fuel		*Labour*		*Capital*		*Other*	
Year	*Index*	*% Change*	*Index*	*% Change*	*Index*	*% Change*	*Index*	*% Change*
1978–79	1.00		1.00		1.00		1.00	
1979–80	1.03	2.54	1.09	9.03	1.08	7.83	1.24	24.37
1980–81	1.00	–2.70	1.07	–2.05	0.97	–10.51	1.26	0.98
1981–82	0.98	–2.01	0.93	–12.61	0.91	–6.02	0.91	–27.22
1982–83	0.99	1.31	1.00	7.07	0.92	1.45	0.92	0.75
1983–84	1.04	5.14	1.11	10.69	0.97	5.09	1.14	23.56
1984–85	1.03	–1.45	1.13	2.11	0.80	–17.75	0.98	–14.18
1985–86	1.02	–0.58	1.22	8.40	0.85	6.94	1.08	10.77
1986–87	1.04	1.59	1.27	3.40	0.75	–11.98	0.97	–10.45
1987-88	1.03	–0.20	1.37	7.86	0.76	1.17	0.77	–20.31
1988–89	1.04	0.20	1.81	32.74	0.85	11.64	0.89	14.96
1989–90	1.08	4.39	2.18	20.00	0.99	16.60	0.84	–5.72
1990–91	1.08	–0.66	2.37	9.18	1.00	1.65	0.72	–14.40

TFP initially rose in 1979–80, primarily as a result of a rapid rise in outputs (17.7 per cent) which offset a 8.6 per cent increase in inputs. Productivity of all inputs increased in this year with 'Other' input productivity rising by almost 25 per cent (Figure 8.2). Capital productivity improved by 8 per cent reflecting the 19 per cent rise in capacity factor and fuel productivity rose by 2.5 per cent as thermal efficiency grew by over 3 per cent.

Figure 8.2: **Partial factor productivites of Pacific Power — 1978–79 to 1990–91**



The decline of around 13 per cent in TFP in the following two years to 1981–82 is largely attributed to the combined affect of a general downturn in the economy and major plant failure at Liddell. The depressed economic conditions over this period caused an unprecedented fall in demand. Over the same period productivity in all input categories declined as economically inefficient generating plant with higher cost coal was either brought back into commission or increased output to account for the shortfall in capacity caused by major plant failure. The impact of the recommissioning of these old stations was primarily on fuel and 'Other' productivity series.

Capital productivity fell by 10 and 6 per cent in 1980–81 and 1981–82, respectively, as the impact of commissioning 2 x 660MW units at Vales Point and 1 x 500MW at Wallerawang was experienced. This adverse impact on capital productivity from large increments to generating capacity and less than anticipated load growth is evident throughout the study and is a key cause of the productivity decline which occurred from 1979–80 through to 1987–88.

The decline in capital productivity over this period was compounded by the commissioning of 12 x 25MW gas turbines to quickly meet the shortfall in generating capacity over this period. Of similar importance to TFP performance was the 5 per cent decline in fuel productivity over the same period caused by a doubling in total nominal energy costs from 1979–80 to 1981–82 with a 4 per cent increase in quantity consumed, against an overall decline in output of 1 per cent.

The 1981–82 fall in TFP preceded two years of TFP increases of 2.8 and 7.9 per cent in 1982–83 and 1983–84, respectively. These increases were a consequence of rises in the productivity of all inputs over these two years. Most significantly, labour productivity rose by nearly 20 per cent as the number of employees fell by 2.5 per cent and output rose by over 16 per cent. Fuel productivity rose as the less efficient and more expensive metropolitan power stations which were put into service to account for the shortfall in generating capacity, were progressively taken out of service. The improvement in fuel productivity also reflected an 8 per cent rise in thermal efficiency from 1981–82 to 1983–84. The decommissioning of 500MW of capacity at Pyrmont B, White Bay, Broken Hill and a Vales Point A unit caused capital productivity to rise by nearly 7 per cent over this period.

TFP experienced its largest fall over the study period in 1984–85 as aggregate inputs rose by nearly 15 per cent, compared to a rise in outputs by just over 2 per cent. This fall in productivity was largely caused by a dramatic fall of around 18 per cent in capital productivity as Eraring was being commissioned. This decline in TFP was offset, to some extent, in 1985–86 as capital and labour productivity improved. These gains were eroded in the following year as capital productivity experienced its second largest fall for the study period of 6 per cent, caused by the commissioning of Bayswater units. This decline in TFP generally continued through to 1987–88 after which productivity performance improved substantially. Between 1987–88 and 1989–90 TFP increased by around 24 per cent, the largest rise over the study period.

This dramatic turnaround in TFP performance from 1987–88 occurred at the same time as significant policy reforms were being pursued at Pacific Power. These reforms included the rationalisation of labour, capital and fuel sources. The number of employees fell by 36 per cent to 1990–91, leading to large gains in labour productivity. Approximately 1600MW of economically inefficient generating plant was retired at Broken Hill, Wangi, Tallawarra A & B, and Wallerawang A & B, leading to significant gains in TFP. These gains were supported by improvements in fuel productivity through gains in thermal efficiency.

Against these improvements in total and partial factor productivities, the performance of 'Other' inputs generally fell over the study period, which may be substantially explained by a greater proportion of works and services being externally supplied, particularly in relation to increased maintenance on older stations. The gains from improved maintenance will be experienced in the next few years as higher plant reliability and technical efficiency will facilitate better plant utilisation, thereby enhancing capital productivity.

8.5 Conclusions

Total factor productivity is presented as a more comprehensive measure of economic performance in this study. Estimates of total and partial factor productivities for the period from 1978–79 to 1990–91 show that up to 1987–88 productivity performance was poor while generating capacity was rapidly expanding and the employment of other resources rose commensurately. Clearly, the large increments to generating capacity over the study period together with the less than expected demand growth, have had a major and long term adverse impact on the productivity performance of Pacific Power.

Following the introduction of reforms which reduced the requirement for permanent labour and led to the retirement of some economically inefficient generating plant, TFP rose by 12 per cent in 1988–89 and over 11 per cent in 1989–90. In 1990–91 there was no change in TFP as marginal output growth (0.6 per cent) was offset by an equivalent rise in input use. Given normal demand growth and the marginal rise in inputs in 1990–91, TFP would have grown in the order of 5-6 per cent in 1990–91.

The key to improved TFP in the future rests on improving the efficiency of capital and fuel inputs. Capital and fuel productivity improvements will result from greater utilisation of current generating capacity at stations with low cost coal and continued retirement of economically inefficient plant. In the longer term, capital productivity growth will be determined by the economic efficiency of increments to generating and transmission capacity.

Reductions in the **number** of employees does little to improve TFP, although the way in which capital is used in conjunction with labour is pivotal to the efficiency of capital and therefore to a TFP outcome. Therefore, continuing workplace reforms are also important to sustained productivity improvements.

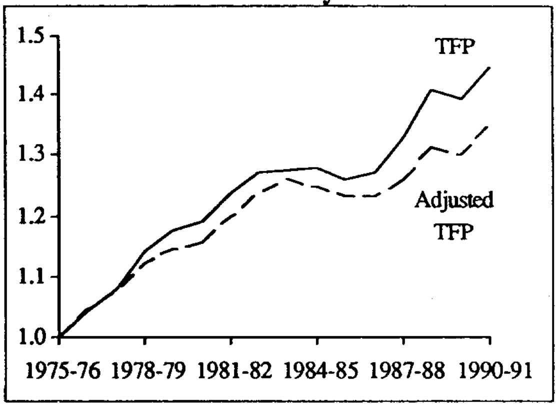
9 PERFORMANCE MEASURES FOR AUSTRALIA POST: 1975-76 TO 1990-91*

9.1 Summary

Since postal operations came under the control of the Australian Postal Commission, and more recently, the Australian Postal Corporation, productivity in postal operations has improved substantially. Today's postal operations are about 50 per cent more productive than they were in 1975-76. As a result of these gains Australia Post's real charges have fallen by 2.9 per cent per year over the study period.

Some of Australia Post's improved productivity has resulted from output growth outstripping growth in the number of delivery points serviced. Effectively, an increased quantity of mail has been delivered to each delivery point, thereby reducing per unit costs. The effect of this on productivity would need to be netted out to obtain a true indication of technical improvements achieved by Australia Post. As shown in Figure 9.1, when this was done, Australia Post's productivity rose by less but in 1990-91 was still substantially above levels recorded in 1975-76.

Figure 9.1: **Australia Post's Total Factor Productivity and Adjusted Total Factor Productivity**



Concern has also been expressed over the very low returns Australia Post has made on the substantial assets it employs. Historically, Australia Post has been constrained in its ability to earn commercial returns. Consequently, for most of the years between 1975-76 to 1990-91, it achieved a low or negative return of its capital stock. These low returns, coupled with the very high productivity growth achieved, indicates that Australia Post has been passing on most of its productivity improvement in terms of lower real changes. An exception occurred in 1990-91 when Australia Post is estimated to have achieved a real return of about 6 per cent — still below

* This case study was prepared by Swan Consultants (Canberra) Pty Ltd for Australia Post.

the 8 per cent benchmark return adopted by the Industry Commission in its 1989 analysis of certain Government Business Enterprises.

If Australia Post is to achieve higher real returns without increasing postal charges, further productivity improvements will be required. There is every indication that postal operations in Australia can become substantially more efficient than they already are.

9.2 Introduction

In 1990 the Industry Commission released an Information Paper which provided estimates of performance measures for several Government Business Enterprises (GBEs), including Australia Post (Zeitsch et al., 1990). The performance measures were calculated for the years 1975-76 to 1987-88 and included;

— real rates of return, which measure the net return to capital employed;

— total factor productivity (TFP), which measures output produced per unit of all inputs used ; and

— partial measures of the productivity of individual inputs which measure output produced per unit of the relevant input used.

In assessing the performance of those GBEs, the Industry Commission adopted as its benchmark the real rate of return on a long term government bond adjusted for a small margin of risk. Over the period 1985-86 to 1987-88 the benchmark was calculated at 8 per cent. All the GBEs studied failed to achieve the benchmark return, with Australia Post's real return averaging 1 per cent.

The GBEs studied were found to have TFP growth above the average for the Australian economy and more than half of their growth in output was achieved through productivity improvements. In Australia Post's case, over the period 1975-76 to 1987-88, 62 per cent of the growth in output was achieved through productivity improvements. The Industry Commission concluded, however, that;

> "Despite this performance over the study period, most of the GBEs earned low or negative returns on the capital they employed. This suggests that to achieve commercial rates of return without having to increase charges, the GBEs will not only have to continue to improve productivity but will have to do so at rates higher than those achieved so far" (Zeitsch et al., 1990, p. 3).

This paper provides updated estimates of the performance measures calculated by the Industry Commission.

9.3 Australia Post's TFP

The methodology used by the Industry Commission has been employed to update estimates of the outputs produced by Australia Post and the inputs used to produce these outputs. Table 9.1 provides estimates of the outputs produced by Australia Post. Australia Post handled just over 4.1 billion postal articles in 1990-91 — nearly twice the numbers handled in 1975-76. This growth contributed strongly to Australia Post's overall growth in services which is estimated to have grown by 3.7 per cent per year over the study period, that is, between 1975-76 and 1990-91.

Table 9.1: **Price and quantity of services provided by Australia Post**

	Postal articles		*Money orders*		*Agency services*		*Accommodation*		*Other*		*Total revenue*
Year	*Price*	*Quantity*	*Price*	*Quantity*	*Price*	*Quantity*	*Price*	*Rent*	*Price*	*Quantity*	
	$/article	million	$/order	'000	$/service	$'000[a]	index[b]	$'000[a]	index[b]	$'000[a]	$'000
1975–76	0.182	2 209	0.549	13 620	0.031	2 728	68.2	7 918	68.2	3 431	503 330
1976–77	0.198	2 198	0.631	10 910	0.034	3 021	76.1	6 176	76.1	4 323	552 400
1977–78	0.198	2 304	0.677	9 220	0.032	2 952	83.9	6 079	83.9	5 018	567 930
1978–79	0.211	2 505	0.556	9 770	0.033	2 788	90.8	4 846	90.8	5 187	636 690
1979–80	0.221	2 631	0.601	10 570	0.030	2 699	100.0	4 000	100.0	4 940	679 680
1980–81	0.242	2 767	0.703	11 040	0.031	2 680	109.4	4 022	109.4	4 250	768 960
1981–82	0.267	2 877	0.960	10 480	0.032	2 692	120.8	3 725	120.8	3 634	873 730
1982–83	0.296	2 944	1.052	10 030	0.033	2 768	134.7	2 970	134.7	9 993	988 840
1983–84	0.320	3 035	1.149	10 120	0.033	2 755	144.0	3 611	144.0	4 021	1 084 750
1984–85	0.343	3 148	1.141	10 460	0.033	2 819	150.1	3 997	150.1	3 977	1 199 000
1985–86	0.365	3 252	1.111	10 674	0.035	2 464	162.7	3 319	162.7	4 014	1 297 490
1986–87	0.399	3 439	1.102	11 228	0.035	2 415	177.9	3 187	177.9	3 676	1 478 850
1987–88	0.410	3 662	1.096	12 083	0.034	2 620	190.9	2 399	190.9	4 730	1 618 140
1988–89	0.420	3 916	1.310	12 820	0.033	2 665	204.9	1 889	204.9	5 476	1 764 780
1989–90	0.450	4 050	1.487	12 800	0.032	2 497	221.3	1 582	221.3	4 803	1 933 990
1990–91	0.483	4 119	1.611	13 440	0.034	2 672	233.0	1 845	233.0	6 386	2 121 640

[a] In constant 1979-80 prices. [b] Index base: 1979-80 = 100.

When updating the Industry Commission's estimates of inputs used by Australia Post, the methodology used by the Industry Commission to calculate capital stocks was revised slightly. The revised methodology involved using more up-to-date estimates of the capital stock owned by Australia Post and minor alterations to the calculation of the flow of services derived from the capital stock. These revisions are outlined in Appendix 9.1.

Table 9.2 provides estimates of the quantities and prices of inputs used by Australia Post. In total, the economic cost of producing the outputs amounted to over $2 billion in 1990-91. In that year labour costs accounted for about 60 per cent of total costs, whilst the other major inputs — capital and other inputs — accounted for about 10 and 18 per cent of total cost respectively.

Table 9.2: Price and quantity of inputs used by Australia Post

	Labour		*Capital*		*Contractor*		*Other inputs*		*Total cost*
Year	*Quantity (full-time equivalent)*	*Price (full-time equivalent)*	*Quantity*	*Price*	*Quantity*	*Price per contractor*	*Quantity*	*Price*	
	no.	$/yr	index[a]	$'000	no.	$/yr	$'000[b]	index [c]	$'000
1975–76	39 283	9 773	100.0	-13 944	4 441	7 449	61 950	68.2	445 286
1976–77	37 796	11 374	100.6	5 201	4 001	8 853	67 227	76.1	521 716
1977–78	37 798	12 305	102.2	8 296	4 017	9 826	64 613	83.9	567 262
1978–79	37 456	13 205	102.8	18 103	3 861	11 614	73 183	90.8	624 492
1979–80	37 943	14 155	103.9	11 923	3 639	14 493	73 860	100.0	676 093
1980–81	38 455	16 157	105.8	17 008	3 671	16 622	87 614	109.4	796 162
1981–82	38 032	18 285	107.5	37 127	3 671	19 066	89 139	120.8	912 986
1982–83	38 113	20 325	110.7	24 869	3 787	22 094	87 053	134.7	1 003 109
1983–84	38 516	21 591	113.9	74 380	3 790	24 533	91 472	144.0	1 141 041
1984–85	39 736	22 946	117.3	81 892	3 655	28 331	102 319	150.1	1 264 993
1985–86	40 402	24 090	118.8	30 373	3 761	29 093	116 491	162.7	1 308 322
1986–87	40 814	25 707	121.9	62 229	3 729	32 497	141 698	177.9	1 498 323
1987–88	40 641	27 834	127.9	81 884	3 858	34 430	156 606	190.9	1 667 749
1988–89	40 454	30 542	133.9	106 485	3 773	40 056	157 731	204.9	1 852 446
1989–90	41 221	32 126	141.9	102 332	3 843	41 194	176 064	221.3	2 017 385
1990–91	41 007	34 256	149.2	134 584	3 269	52 683	166 674	233.0	2 166 122

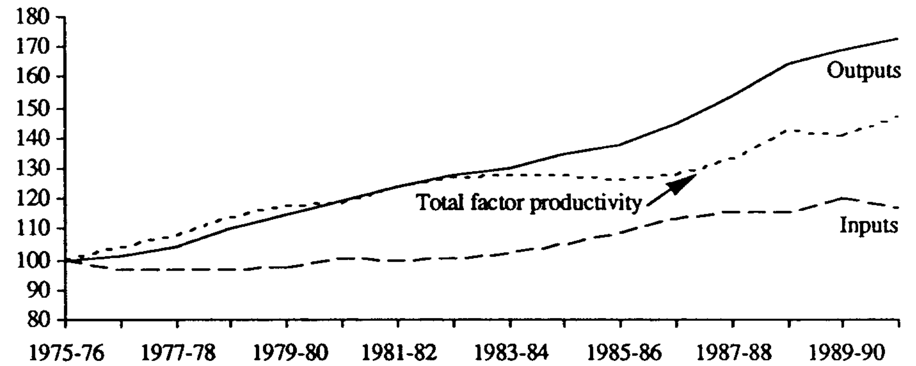
[a] Index base: 1975-76 = 100. [b] In constant 1979-80 prices. [c] Index base: 1979-80 = 100.

The price and quantity information on Australia Post's outputs given in Table 9.1 were formed into an aggregate output quantity index using the Industry Commission methodology. The price and quantity information on inputs used by Australia Post that are given in Table 9.2 were similarly aggregated to form an aggregate input quantity index. An index of Australia Post's TFP was derived by dividing the aggregate output index by the aggregate input index. The aggregate output index, aggregate input index and TFP index for Australia Post are graphed in Figure 9.2. Over the study period Australia Post's output grew by 3.7 per cent per year while input use grew by 1.5 per cent per year. Thus, as input use grew by less than output, Australia

Post's TFP increased significantly over the study period — at an estimated 2.2 per cent per year.

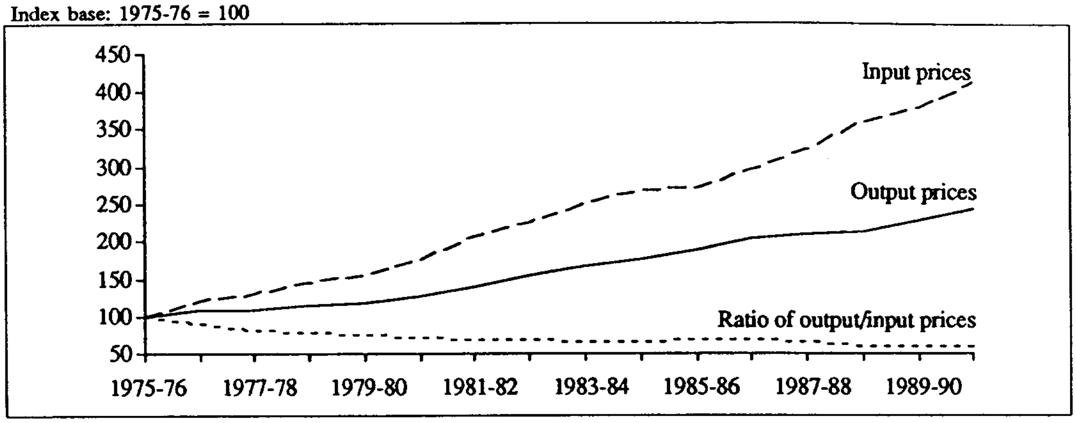
Three distinct periods of productivity growth can be seen in Figure 9.2. The strong growth period up to 1979-80 probably reflects the removal of outdated work practices that prevailed when the Australia Postal Commission took over postal operations from the old Postmasters General Department. This was followed during the mid-to-late eighties by a period of significant industrial disputation within Australia Post, when the efficient operation of the postal network was disrupted by industrial disputes and poor industrial relations. During this period substantial investments were made in mail handling equipment but the equipment was never commissioned because of union restrictions. Consequently, measured input use grew significantly and productivity remained relatively constant. With the improvement of industrial relations and the corporatisation of Australia Post in 1989, productivity growth grew significantly and peaked in 1990-91 at nearly 50 per cent above 1975-76 levels.

Figure 9.2: **Output, input use and total factor productivity of Australia Post**
Index base: 1975-76 = 100



The data which have been assembled also enable an aggregate output price index and an aggregate input price index to be calculated. This data indicates that Australia Post's charges relative to the prices paid for inputs have fallen by 2.9 per cent per year over the study period (Figure 9.3). Australia Post's real rates of return (see section 9.5) have also been low over the study period. Thus it would appear that Australia Post has been passing on to customers a large proportion of its productivity growth in terms of lower real charges.

Figure 9.3: **Output prices received and prices paid for inputs by Australia Post**
Index base: 1975-76 = 100



The strong growth in Australia Post's TFP could have resulted from a number of factors including technological improvement and changes in the market serviced by Australia Post. In the following section a methodology is developed and implemented to adjust Australia Post's TFP for changes in the market that it services.

9.4 Adjusting Australia Post's TFP for growth in the size of the network serviced

Productivity improvements as measured by TFP can result from a number of factors including; technological improvements in the way mail is handled, management-induced improvements in the way operations are carried out, and changes in the market serviced. A more densely settled geographical area, for example, would be cheaper to deliver mail to on a per unit basis than a sparsely settled area. If the market being serviced by Australia Post is changing through time, measured productivity could be affected even if there has been no underlying technical improvement in postal operations.

In Australia Post's case, over the period 1975-76 to 1990-91, output has grown by 3.7 per cent per year while delivery points have grown by 2.8 per cent per year. Effectively, the postal network has become more densely settled and more mail is being delivered to each delivery point. This could have contributed to some of the observed growth in Australia Post's productivity and if this is the case, some of the growth in TFP would have been due to factors other than technological improvements within Australia Post. To obtain a more accurate indication of technological improvements in postal operations, measured TFP needs to be adjusted for changes in the structure of the market serviced by Australia Post.

Christensen et al. (1985) derive a formula that enables growth in TFP to be split into that attributable to the true underlying growth in technological improvements, growth in output and growth in the number of delivery points in the postal network. Specifically;

$$T\dot{F}P = AT\dot{F}P + (1 - \varepsilon_y)\dot{Y} - \varepsilon_{NS}\dot{N}S \quad (1)$$

where $T\dot{F}P$ is growth in unadjusted TFP;

$AT\dot{F}P$ is growth in adjusted TFP;

$\dot{Y}$ is growth in aggregate output;

$\dot{N}S$ is growth in the size of Australia Post's network;

ε_y is the elasticity of total cost with respect to aggregate output; and

ε_{NS} is the elasticity of total cost with respect to the size of the network serviced.

To make this equation operational estimates are required of the two cost elasticities ε_y and ε_{NS}. These can be obtained by estimating Diewert's (1974) factor requirement function;

$$I = C / W = f(Y, NS, T) \quad (2)$$

where I is a measure of aggregate input use, C is total costs, W is a measure of unit input prices, Y is a measure of aggregate output, NS is the number of delivery points serviced by Australia Post, and T is time.

When estimating this model, account needs to be taken of the possibility that technological improvement in Australia Post has changed through time. As outlined in section 9.3, at least three distinct periods of technical change can be recognised;

- 1975-76 to 1979-80 — when inefficient work practices inherited from the old Postmaster General's Department were removed after the Australian Postal Commission took over postal operations in 1975-76;
- 1980-81 to 1984-85 — a period of poor industrial relations when productivity-improving capital equipment was purchased but because of industrial concerns was not installed; and
- a period between 1985-86 to 1990-91 when technical improvements were enhanced through better industrial relations and the corporatisation of Australia Post in 1989.

Following Christensen et al. (1985, p. IX-3) a logarithmic form of equation (2) is specified to account for the above institutional changes. Specifically the model estimated is given by;

$$\ln I = \sum_{i=1}^{3} \alpha_{0i} \cdot D_i + \sum_{i=1}^{3} \beta_{0i} \cdot D_i \cdot T + \varepsilon_y \cdot \ln Y + \varepsilon_{NS} \cdot \ln NS + \varepsilon \qquad (3)$$

where D_i are dummy variables corresponding to the three hypothesized periods of differential growth and the parameters ε_y and ε_{NS} measure the cost elasticities of output and delivery points respectively. This specification of changes in the structure of costs is very flexible in that both the average levels of productivity and the rate of productivity growth can differ between periods. Also, as outlined by Christensen et al. (1985, p. IX-6), various restricted versions of equation (3) can be estimated to test various hypotheses including the existence of constant returns to scale. This hypothesis was tested and could not be rejected. Consequently, various hypotheses concerning the level of technology and rates of growth of technology were tested assuming constant returns to scale prevail. The various tests undertaken are set out in Box 9.1.

Box 9.1: **Restrictions on the parameters of the factor requirement function needed to test various hypotheses**

H_1 Constant Returns to Scale ($\varepsilon_y + \varepsilon_{NS} = 1$);

H_2 Constant Returns to Scale and a common rate of technical change in all periods ($\beta_{01} = \beta_{02} = \beta_{03}$, $\varepsilon_y + \varepsilon_{NS} = 1$);

H_3 Constant Returns to Scale plus zero rates of technical change ($\beta_{01} = \beta_{02} = \beta_{03} = 0$, $\varepsilon_y + \varepsilon_{NS} = 1$); and

H_4 Constant Returns to Scale and the level of technical change are the same in all periods ($\alpha_{01} = \alpha_{02} = \alpha_{03}$, $\beta_{01} = \beta_{02} = \beta_{03} = 0$, $\varepsilon_y + \varepsilon_{NS} = 1$).

Table 9.3 sets out test statistics for the alternative hypothesis listed in Box 9.1. With constant returns to scale imposed , all restrictions on the level of technical change and rate of change of technical change were rejected. Thus it is concluded that Australia Post experienced three distinct periods during which the level of technology was different and during which the growth of technology was also different.

Table 9.3: **Test statistics associated with alternate model specifications**

Hypothesis tested	*Test statistic*[a]	*Number of degrees of freedom*	*Critical χ^2 value at the 5 per cent level of significance*
H_1: constant returns to scale	0.98	1	3.841
H_2: constant rate of technological progress + H_1	7.86	3	7.815
H_3: rate of technical change is zero + H_1	36.04	4	9.488
H_4: level of technical change is the same in all periods + H_1	49.58	6	12.592

a Log likelihood ratio test statistic calculated as, 2 log (λ_1 / λ_2), where λ_1 and λ_2 are the values of the likelihood function of the unrestricted and restricted models, respectively. This statistic is distributed as a chi-square with degrees of freedom equal to the number of independent restrictions.

The parameter estimates of the factor requirements function with constant returns to scale and differential levels and rates of change of technological growth are given in Table 9.4. The estimated model fits the data well as indicated by the R-square of 0.98. No evidence of first-order auto-correlation is evident. Constant returns to scale is imposed in the model and the elasticity of cost with respect to output is estimated at 0.6. It follows that the elasticity of cost with respect to network size is 0.4. It should be noted, however, that the estimates of the elasticities are sensitive to the specification of the periods of technical change.

Table 9.4: **Estimated parameters of Australia Post's factor requirements function with constant returns to scale imposed**

Parameter	*Parameter estimate*	*Standard error*
α_{01}	-3.816	1.955
α_{02}	-3.875	1.927
α_{03}	-3.790	1.990
β_{01}	-0.034	0.005
β_{02}	-0.021	0.004
β_{03}	-0.023	0.005
ε_y	0.589	0.213
ε_{NS}	0.411	0.213
R-square	0.98	
Durbin Watson Statistic	2.76	
Number of observations	16	

The elasticity of cost within respect to output is perhaps smaller than anticipated. Christensen et al, for example, estimated this elasticity for the United States postal system at 0.788. The smaller Australian elasticity could be due to the stronger influence of network size on costs. As Australia is more sparsely settled, a given percentage increase in the size of the network may raise costs in Australia by more than it would in the United States. With constant returns to scale imposed, a bigger elasticity of cost with respect to network size will result in a smaller elasticity of cost with respect to output.

Table 9.5: **Growth in total factor productivity, output, delivery points and in adjusted total factor productivity** (per cent)

	Growth in				
	Total Factor Productivity	*Output*	*Delivery points*	*Output per delivery point*	*Adjusted Total Factor Productivity*
1976–77	4.32	1.03	1.40	-0.37	4.48
1977–78	3.60	3.25	2.20	1.05	3.16
1978–79	5.75	6.03	3.07	2.96	4.53
1979–80	2.98	3.72	1.65	2.07	2.13
1980–81	1.09	4.29	3.79	0.50	0.88
1981–82	3.93	3.31	2.84	0.47	3.73
1982–83	2.90	3.07	4.16	-1.09	3.34
1983–84	0.38	1.98	4.65	-2.67	1.48
1984–85	0.05	3.62	1.51	2.11	-0.82
1985–86	-1.32	1.93	2.63	-0.70	-1.04
1986–87	1.16	5.12	2.81	2.30	0.21
1987–88	4.49	6.59	1.79	4.80	2.52
1988–89	6.66	6.61	2.40	4.21	4.93
1989–90	-1.09	2.79	3.66	-0.87	-0.73
1990–91	4.43	2.13	2.33	-0.20	4.51

Year-to-year growth rates in TFP, output and delivery points are given in Table 9.5. Also shown in Table 9.5 are the growth rates in adjusted TFP calculated according to equation (1). These calculations utilise the cost elasticities ε_y and ε_{NS} given in Table 9.4. As can be seen from Table 9.5, output has grown at a faster rate than has delivery points resulting in bigger mail drops at each delivery point. Thus after adjustment for growth in the size of the network, Australia Post's TFP is seen to grow by less (Figure 9.1). Nevertheless, there was still a substantial lift in productivity and in 1990-91 Australia Post's adjusted TFP was about 40 per cent higher than the levels achieved in 1975-76.

TFP is only one of a suite of measures that can be used to monitor the performance of an organisation. Financial measures are also a key measure. An organisation can take little comfort in high productivity growth if at the same time it is earning low returns on the capital it employs. In the following section, estimates are provided of the real rate of return Australia Post has earned on its capital stock.

9.5 Australia Post's real rate of return

There has been considerable debate on how to calculate an economic rate of return. (See, for example, Commonwealth Department of the Treasury 1990). The main area of debate has concerned whether to include capital gains in any rate of return measure with the conclusion seeming to be that real rates of return calculations should include capital gains.

The real rates of return calculations in this document employ the methodology developed by the Industry Commission (see Zeitsch et al. 1990, p. 60-61). They define the nominal, net of depreciation, pre-tax, earnings on capital as:

$$R_t^n = Y_t^n - E_t^n - D_t^n \qquad (5)$$

where R_t^n is the nominal earnings on invested capital in year t;

Y_t^n is the nominal economic income in year t, defined as total income less interest income and revenue from sales of assets;

E_t^n is the nominal economic expenses in year t, defined as total expenses, less interest expenses and the book depreciation charge; and

D_t^n is the nominal declining balance depreciation expense on the estimated capital stock in year t.

The real rate of return was then defined as:

$$r_t = R_t^n / (P_t K_t) * 100 \qquad (6)$$

where r_t is the real rate of return on invested capital in year t;

P_t is a price index of a unit of capital at time t; and

K_t is the value, at constant prices, of capital at the end of time period t.

Equation (6) should be extended to incorporate real capital gains made on asset holdings. However, in the current analysis, the price indexes used to construct the capital stock series are components of the consumer price index. It is therefore most unlikely that the capital data used in this analysis exhibits any significant real capital gains. Accordingly, Australia Post's real rate of return was calculated according to equation (6).

Australia Post's financial performance is summarised in Table 9.6. In 1990-91, Australia Post is estimated to have employed a capital stock valued at about $1.9 billion and the return on this capital was estimated at $111m. This represents a real return of just under 6 per cent. While this return is below the Industry Commission benchmark of 8 per cent real, it represent a substantial improvement on returns achieved by Australia Post over the previous 13 years.

The improved financial performance can be attributed to a rise in Australia Post's postal rates which are estimated to have risen from an average of 45 cents in 1989-90 to 48.3 cents in 1990-91. However, more importantly, the significant productivity improvements made by Australia

Table 9.6: **Estimated profit and rate of return earned on Australia Post's capital stock**

Year	*Economic revenues* [1][a]	*Economic costs* [2][b]	*Earnings before depreciation* [3][c]	*Pure profit* [4][d]	*Estimated nominal depreciation* [5]	*Nominal capital* [6]	*Net earnings after estimated depreciation* [7][e]	*Real rate of return* [8][f]
	$m	$m	$m	$m	$m	$m	$m	%
1975–76	503	459	44	58	7	369	37	10.08
1976–77	552	516	36	31	8	417	28	6.78
1977–78	568	559	9	1	8	457	1	0.17
1978–79	637	606	31	12	9	499	22	4.37
1979–80	680	664	16	4	10	565	6	1.06
1980–81	769	778	-9	-27	11	642	-20	-3.12
1981–82	874	873	1	-40	12	741	-12	-1.56
1982–83	989	976	13	-14	15	861	-2	-0.17
1983–84	1 085	1 056	28	-56	16	938	12	1.28
1984–85	1 199	1 169	30	-66	17	998	13	1.27
1985–86	1 297	1 272	25	-11	20	1 139	5	0.44
1986–87	1 479	1 422	56	-19	24	1 292	32	2.49
1987–88	1 618	1 563	55	-49	28	1 430	27	1.91
1988–89	1 765	1 710	55	-88	32	1 597	23	1.42
1989–90	1 934	1 872	62	-83	38	1 786	23	1.32
1990–91	2 122	1 966	156	-44	45	1 922	111	5.78

[a] Total revenue less interest revenue less book profit from the sale of assets. [b] Total cost less interest cost and book depreciation. [c] [3] = [1] – [2]. [d] [4] = [3] – cost of capital inputs. [e] [7] = [3] – [5]. [f] [8] = [7]/[6] * 100.

Post in 1990-91 were achieved through a reduction in input use which enabled net earnings after depreciation to rise dramatically. Thus, in 1990-91 Australia Post appropriated a large amount of its productivity improvement in terms of a higher real return.

While Australia Post improved its financial performance significantly in 1990-91, the achieved real rate of return of 5.8 per cent is still below the Industry Commission benchmark of 8 per cent real. Thus, further productivity improvement will be required if returns are to rise to commercial levels without increases in postal charges.

APPENDIX 9.1: CALCULATING CAPITAL INPUTS

The Industry Commission calculated the capital stock owned by Australia Post using the perpetual inventory equation;

$$K_{jt} = K_{jt-1}(1 - d_j) + I_{jt} - D_{jt} \qquad (7)$$

where K_{jt} is the end of period value at constant prices of asset class j in period t;

d_j is the declining balance rate of depreciation on asset class j;

I_{jt} is investment at constant prices in asset class j in period t; and

D_{jt} is the value at constant prices of disposals of asset class j in period t.

To make equation (7) operational, an estimate is required of the capital stock in some base year – a so-called "benchmark".

The Industry Commission used as its benchmark capital stock the Bradley Committees' August 1982 estimate of the capital employed by Australia Post (Committee of Inquiry into the Monopoly Position of the Australian Postal Commission 1982). The Committee estimated that Australia Post's assets were valued in excess of $700 million. This estimate was assumed to provide an estimate of the value of the capital stock at the end of the 1981-82 financial year. Benchmark estimates of asset values in the capital stock were estimated by the Bradley Committee using the share of these asset classes in the 1981-82 total book value of all assets. Benchmark estimates for land and buildings were derived from a recent independent valuation of Australia Post's assets. The valuation put the value of land and buildings owned by Australia Post, as at June 1989 at $1001 million and $457 million respectively (Australian Postal Corporation 1989).

Equation (7) can be used to calculate the stock of capital owned by Australia Post. The actual cost of using this capital stock for one year, assuming no tax is paid, consists of;

— the opportunity cost of the value of the capital at the start of the year; and

— the change in the value of the asset over the year. This consists of the purchase price minus the depreciated end of period value.

Thus, the user cost of the *j*th capital input in period *t* can be written as;

$$UCC_{jt} = r_t P_{jt} + P_{jt} - (1 - d_j)(1 + i_{jt})P_{jt} \qquad (8)$$

where r_t is the opportunity cost of capital in period t;

P_{jt} is the beginning period price of capital input, here approximated by a price index in period $t-1$;

d_j is the depreciation rate for asset class j in period t; and

i_{jt} is the one year inflation rate in period t for asset class j.

Equation (8) can be rearranged to put it in terms of the equation used by the Industry Commission to calculate the user cost of capital. Specifically;

$$UCC_{jt} = (r_{jt} + (1 - i_{jt})d_j - i_{jt})P_{jt} \tag{9}$$

or,

$$UCC_{jt} = ((r_{jt} - i_{jt}) + (1 - i_{jt})d_j)P_{jt} \tag{10}$$

That is, in the absence of taxation, the user cost of capital consists of two components; the real interest rate associated with holding capital ($r-i$) and an inflation adjusted depreciation rate ($(1-i)d$).

Equation (9) differs slightly from that used by the Industry Commission in that the depreciation rate used is an inflation adjusted rate and the opportunity cost and inflation rate are evaluated in terms of beginning period prices rather than end period prices. This formulation of the user cost of capital is due to Diewert (1991).

The value of the capital input is then found by multiplying the user cost of capital by the beginning period value of the capital stock in constant prices; That is;

$$CK_{jt} = UCC_t \; K_{t-1} \tag{11}$$

where CK_{jt} is the cost of using capital input in period t; and

K_{t-1} is the value of the capital stock in constant prices at the beginning of period t, which is the same as the value at the end of period t-1.

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