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Measuring New Zealand's Productivity

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TREASURY WORKING PAPER

99/5

Measuring New Zealand's Productivity

Erwin Diewert and Denis Lawrence

ABSTRACT

This report was prepared for the Department of Labour, Reserve Bank of New Zealand and Treasury by Dr Denis Lawrence (Tasman Asia Pacific) and Professor Erwin Diewert (University of British Columbia) under contract. The authors examine New Zealand's market sector productivity performance using two databases. One has been prepared by the authors and contains a large number of input and output variables for the period 1972 to 1998. The second database involves data provided to the authors by officials and allows estimates to be prepared for 20 individual market sectors over the period 1978 to 1998.

The authors provide estimates of New Zealand's total factor, labour and capital productivity, using an index number based methodology. They carry out many sensitivity tests relating to different input, output and functional form specifications. Labour input specifications are found to be important. The results are compared with Australian and OECD estimates and tested for structural breaks over time. Other recent New Zealand contributions to productivity literature are reviewed and statistical measurement problems are discussed. The data and techniques used are fully documented.

Disclaimer: The views expressed are those of the author(s) and do not necessarily reflect the views of the New Zealand Treasury. The Treasury takes no responsibility for any errors or omissions in, or for the correctness of, the information contained in these working papers.

DIEWERT ENTERPRISES LTD

**MEASURING NEW ZEALAND'S
PRODUCTIVITY**

by

Dr Denis Lawrence

and

Professor Erwin Diewert

**Report prepared for the Department of Labour,
Reserve Bank of New Zealand and The Treasury**

MARCH 1999

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EXECUTIVE SUMMARY

The Department of Labour, the Reserve Bank of New Zealand and The Treasury have commissioned Diewert Enterprises to examine New Zealand's recent productivity performance.

The previous literature on New Zealand's measured productivity experience uses a variety of data, estimation methods, time periods and choices of break points between pre and post reform periods. The consensus of previous research has been that productivity growth in New Zealand over the second half of this century has been comparatively lacklustre. Given this poor performance, productivity might well have been expected to show a lift in its average growth rate following the reform process. Previous empirical tests of this hypothesis, however, have produced mixed results.

Objectives of the study

The primary objectives of this study have been to try and establish the facts, as well as possible, on New Zealand's productivity performance over the last 20 years and to assess the importance of potential sources of measurement error. To do this we have used two principal data sources:

- the detailed Diewert–Lawrence database of the New Zealand economy which contains consistent series on a total of 62 outputs and inputs valued at producers' prices covering the March years 1972 to 1998; and
- an official database assembled by the Department of Labour, the Reserve Bank and the Treasury to facilitate detailed sensitivity analyses of alternative data sources and specifications covering the March years 1978 to 1998.

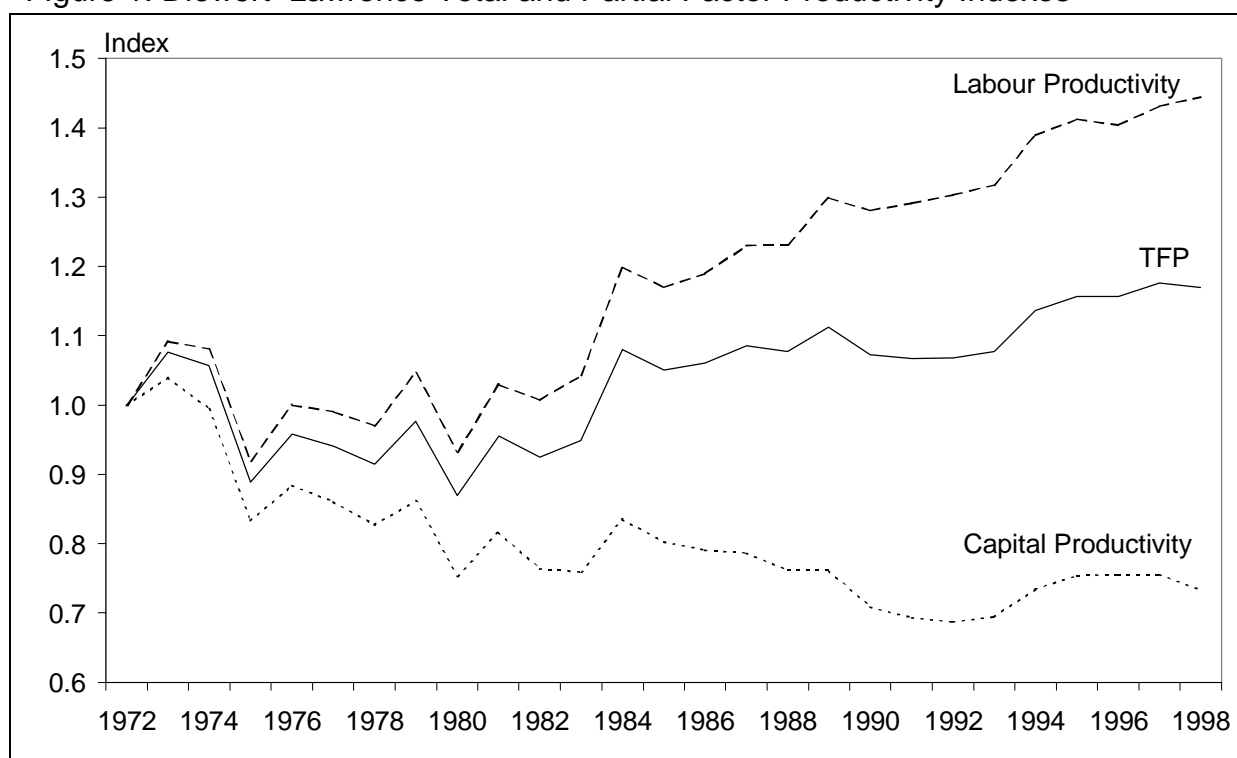
We use the index number approach to measuring productivity throughout this report. A total factor productivity (TFP) index is generally defined as the ratio of an index of output growth divided by an index of input growth. Outputs refer to the total quantities of all outputs produced by the production sector and inputs are the total quantities of all inputs utilised by the same production sector over two accounting periods. The index number approach can be readily linked to the traditional growth accounting approach which has been more commonly used in New Zealand (see chapters 2 and 6).

Diewert–Lawrence TFP estimates

The Diewert–Lawrence TFP index is presented in figure 1 along with labour and capital partial productivity indexes. For the decade from 1972 onwards, TFP performance was poor

coinciding with the period of high assistance to industry and a relatively rigid economy. TFP suffered a 16 per cent fall in 1975 due to a combination of reduced output and increased input usage. TFP levels then fluctuated for several years and the economy was not to regain its 1972 productivity level until 1984. TFP again suffered a sharp fall in 1980 with a large reduction in the output of government consumption of intermediates combined with a surge in imports and virtually no change in the output of consumption and investment goods. TFP levels then recovered strongly in 1984 with good across the board growth in the output of consumption and investment goods and exports and only modest growth in input usage. However, between 1984 and 1993 the TFP level again changed little. Output growth was variable and matched fairly evenly by input growth. Another surge in productivity in 1994 of 6 per cent has been supported by TFP growth of around 2 per cent in 1995 and 1997. TFP fell by 0.5 per cent in 1998 due to a reduction in total output.

Figure 1: Diewert–Lawrence Total and Partial Factor Productivity Indexes

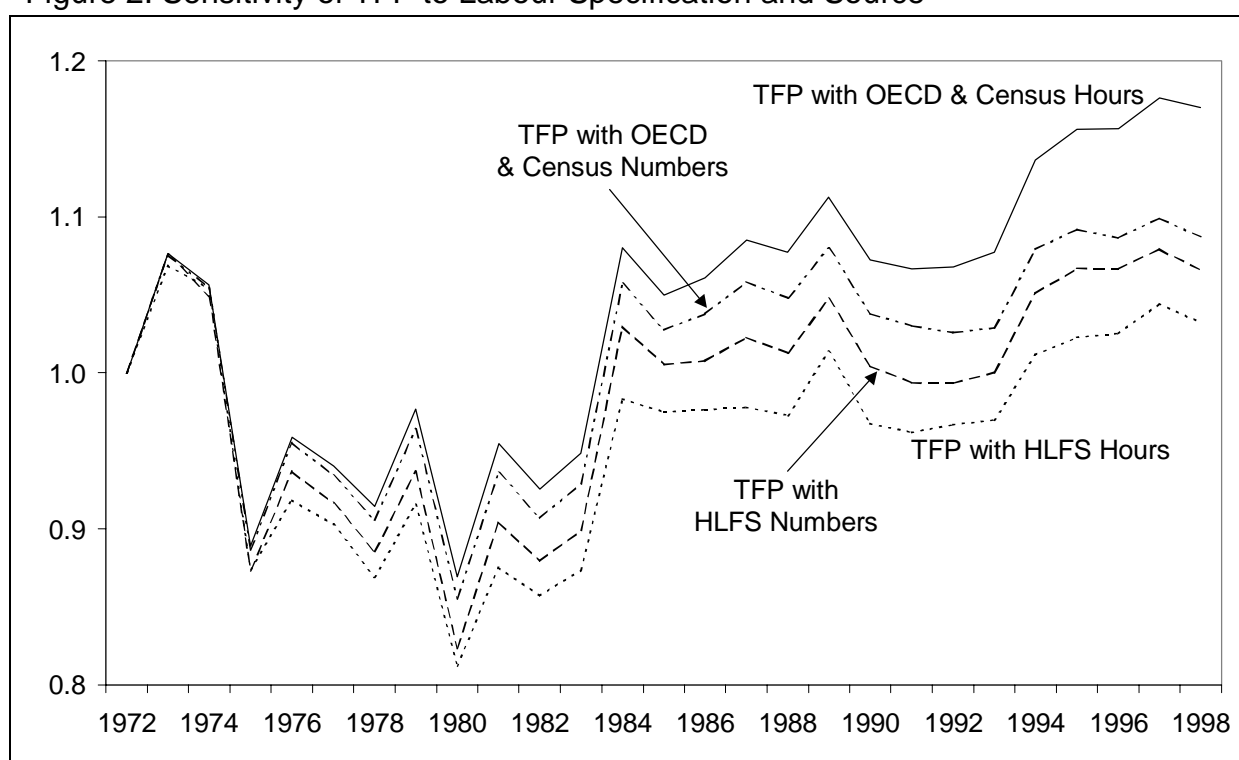


After more than two and a half decades New Zealand's TFP level is still less than 20 per cent higher than it was in 1972. The trend annual rate of TFP increase has been only 0.81 per cent. Over this period labour partial productivity has consistently grown faster than TFP while capital partial productivity has generally fallen reflecting the increasing capital intensity of production. Labour productivity grew at a trend annual growth rate of 1.66 per cent while capital productivity declined at a trend annual rate of 1.13 per cent over the period 1972–98.

Labour inputs sensitivity analysis

The detail included in the Diewert–Lawrence database permits us to carry out a number of sensitivity analyses to input specification and data sources. In figure 2 we present alternative TFP indexes using hours and numbers employed measures of total labour input using two sources – the combination of SNZ Census information and OECD labour data used in the Diewert–Lawrence database and the SNZ Household Labour Force Survey (HLFS). In principle the labour hours measure should be a better measure of labour input than the number employed as it allows for changes in hours worked per person employed over time.

Figure 2: Sensitivity of TFP to Labour Specification and Source

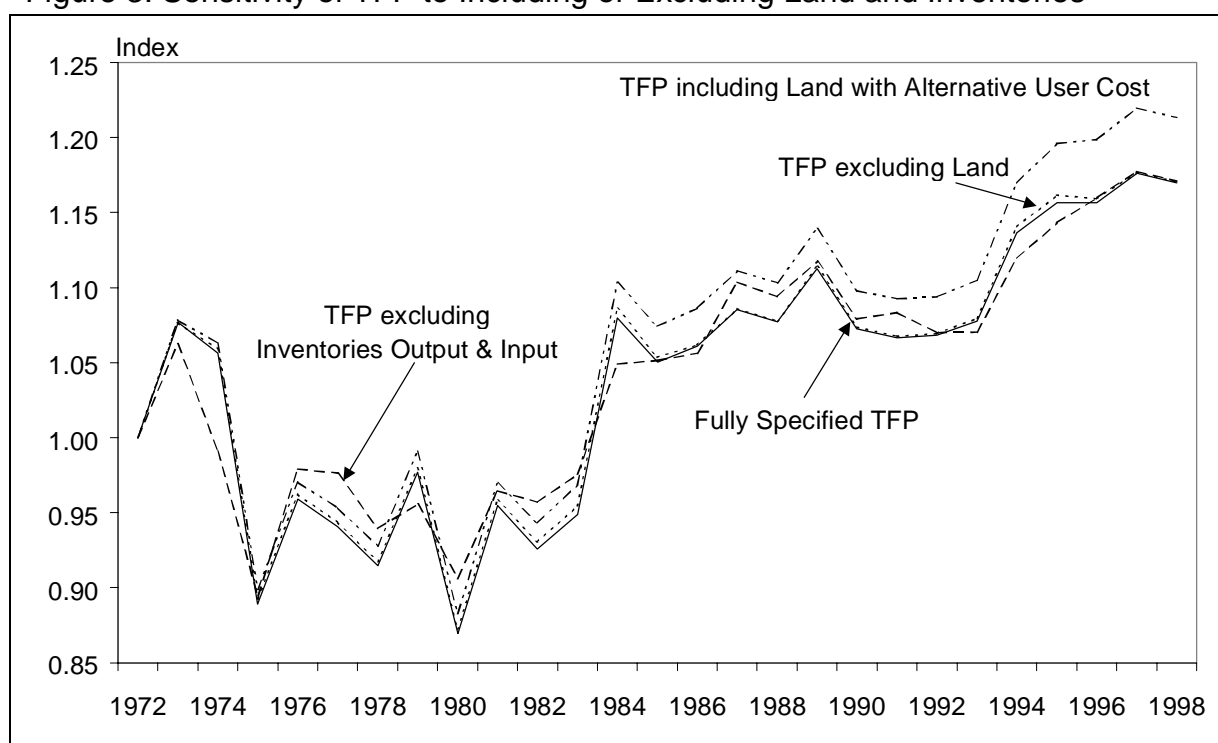


The specification of labour inputs has a major impact on TFP over the 27 year period. This is because average hours worked per person trends steadily downwards for each of the three broad occupational groups (Managers, Clerical and Production workers) contained in the Diewert–Lawrence database. Not allowing for this by simply measuring labour inputs by the number of people employed leads to an overestimate of the quantity of labour inputs with a subsequent reduction in TFP.

Some analysts, however, prefer the HLFS as a source of labour data. Using the HLFS labour hours series results in a substantial worsening in measured TFP performance. In fact, using this labour series results in TFP being only 3 per cent higher in 1998 than it was in 1972. This is because the HLFS shows the largest increase in hours worked of the alternative labour data sources. Furthermore, using the HLFS labour source, we now find the labour numbers based

TFP index lying above the HLFS hours based TFP index although still substantially below the Diewert–Lawrence hours based TFP index and somewhat below the Diewert–Lawrence labour numbers based TFP index. This is because the HLFS source implies that average hours worked per person in the labour force have increased over the first half of the time period and then remained relatively constant on average instead of having progressively decreased as implied by the Diewert–Lawrence Census based series. This example serves to highlight the importance of having accurate and consistent data on the key inputs used in the economy.

Figure 3: Sensitivity of TFP to Including or Excluding Land and Inventories



The other sensitivity analyses undertaken using the Diewert–Lawrence database result in less dramatic variations in TFP. In figure 3 we see that excluding land inputs normally results in little change in measured TFP as capital gains have largely offset the cost of holding land leading to a small weight being given to land inputs. An alternative measure of the land user cost which uses a common real interest rate across all capital components can lead to the exclusion of land having a larger impact on measured TFP. Excluding inventories from both the outputs and inputs smooths the TFP index somewhat but has little impact overall.

Diewert–Lawrence comparison with Australia

In figure 4 we compare the Diewert–Lawrence New Zealand TFP index with a similar Diewert–Lawrence index for Australia and the Australian Bureau of Statistics' 'multifactor' productivity (ABS MFP) index. Basing the three indexes in 1972, the starting year for the New Zealand series, highlights a fundamental difference between Australian and New Zealand

Figure 4: Australian and New Zealand TFP Indexes

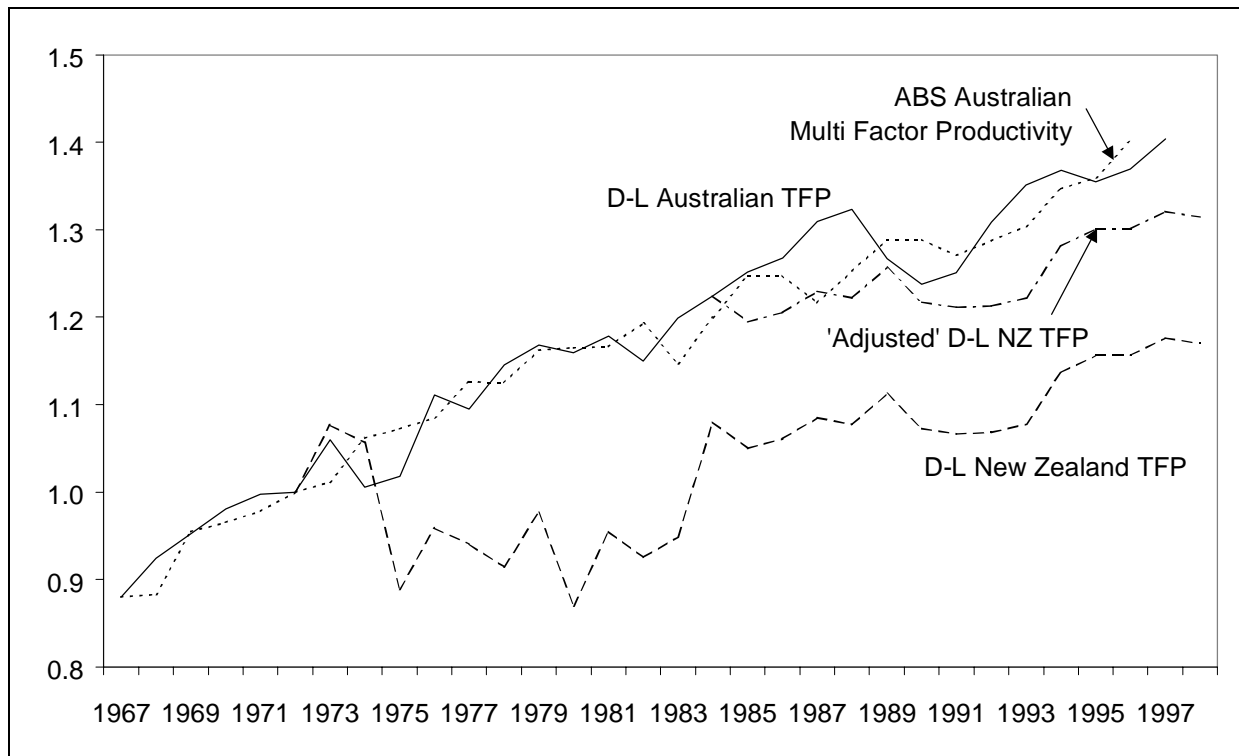
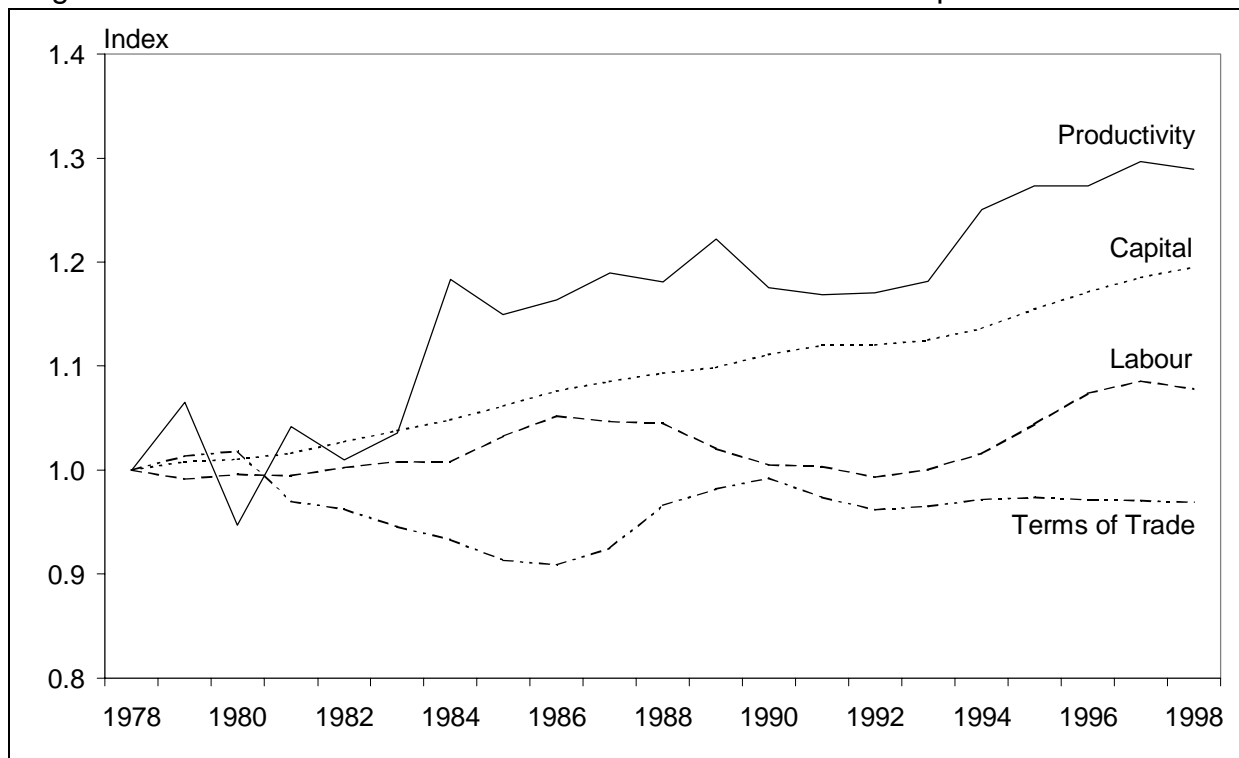


Figure 5: Individual Contributors to New Zealand's Real Net Output



productivity performance, particularly during the 1970s. Whereas Australia's productivity has generally increased steadily over the last three decades, New Zealand's poor productivity performance during the decade from 1972 on has left a substantial gap between New Zealand

and Australian performance when viewing the period as a whole. This is highlighted by 'adjusting' the New Zealand series upwards to start from the same value as the Diewert–Lawrence Australian index in 1984. This reduces the gap between Australian and New Zealand performance in 1997 from around 16 per cent of the Australian TFP index's value down to 6 per cent.

Contributors to economic growth

In figure 5 we present the individual contributions (all else unchanged) of productivity change, changes in capital and labour inputs and changes in the terms of trade to the change in real net output from 1978 to 1998. Productivity change would have increased real GDP by around 29 per cent over this period, all else unchanged. From 1984 onwards the contribution of productivity change to changes in real GDP has been far greater than any of the other three factors. In particular, productivity improvements have far outweighed the effect of terms of trade changes and have been more important than increases in either labour or capital inputs.

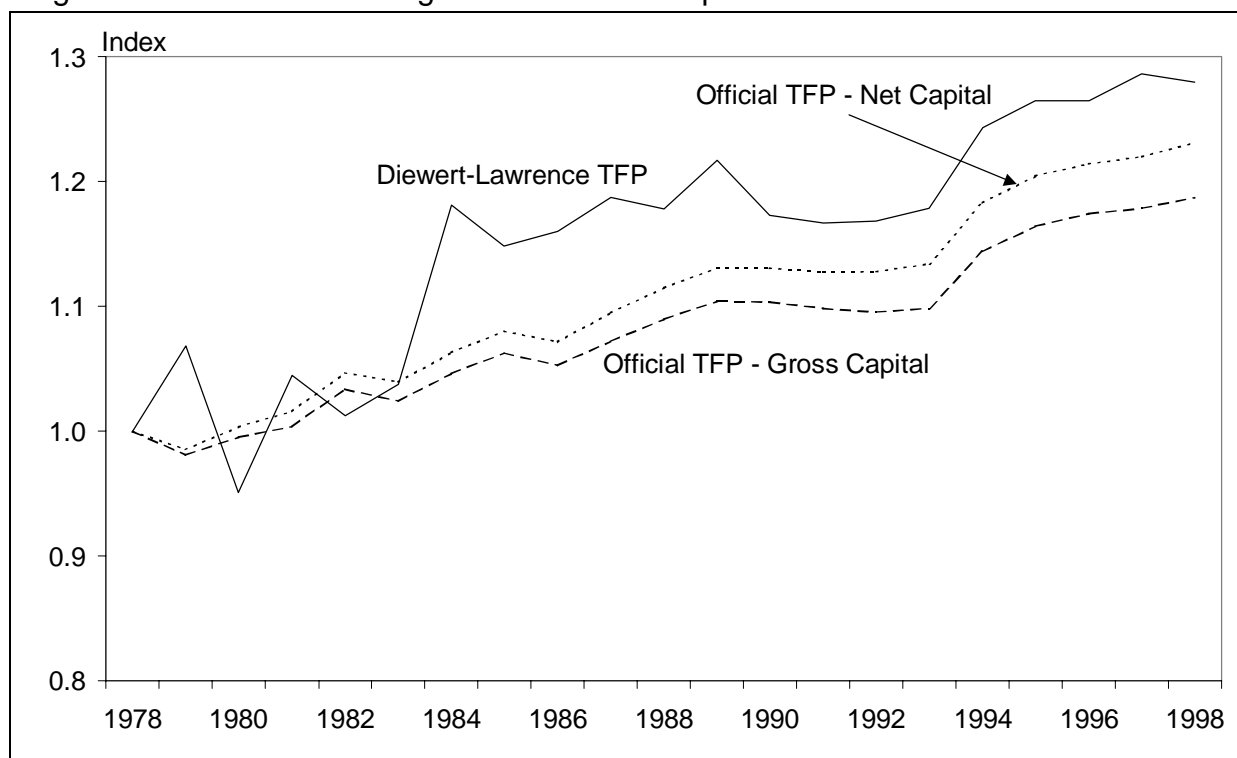
TFP estimates using the official database

An important objective of this project has been to construct TFP estimates using a standard, 'official' database based on generally available SNZ National Accounts and survey information. Sufficient information was available for us to proceed at the level of 20 separate market sector industries for production GDP, labour and capital. Capital inputs for the 20 industries are formed using a range of assumptions about the length of asset lives and depreciation. Our preferred set of estimates use asset lives derived by Philpott (1992), a composite labour series derived from HLFS, Quarterly Employment Survey and Economic Survey of Manufacturing sources and production based GDP data. The official database TFP results appear in figure 6 using both net and gross capital stock input measures.

Both the net and gross capital stock based official TFP indexes follow the same general pattern as the Diewert–Lawrence TFP index although they tend to lie below the Diewert–Lawrence index from 1984 onwards. The Diewert–Lawrence TFP index shows more variability than the two official indexes, particularly in the years prior to 1984.

The official net capital stock based TFP series always lies above that based on the gross capital stock estimates with the divergence between the two progressively increasing. This is because the gross capital stock shows more rapid increase than the net capital stock with old capital investment remaining around at full efficiency for its entire life allowing new investment to directly increase the size of the stock after replacing the oldest surviving year's investment (which has dropped off the capital stock). In the net capital stock case, on the other hand, part of new investment also goes towards replacing the loss in efficiency of older surviving investment.

Figure 6: TFP Indexes Using Gross and Net Capital Stock Estimates



Capital input sensitivity analyses

To test the sensitivity of the estimates to changes in assumed lengths of life and rates of depreciation, we have examined three alternative sets of assumptions compared to the Philpott lengths of life. The first alternative simply takes the unweighted average of the Philpott lives for each of the two asset types across the 20 industries. This produces a life of 18 years for Plant and equipment and 47 years for Building and construction. We then test a long life variant with assumed lives of 25 years for Plant and equipment and 55 years for Building and construction. A short life variant has assumed lives of 12 years for Plant and equipment and 40 years for Building and construction. The resulting TFP indexes for the four gross capital stock based series are presented in figure 7.

The four gross capital stock-based official TFP indexes generally lie below the Diewert-Lawrence index with the long life version showing the lowest rate of increase and the short life version the highest increase. This is because the longer the life of investment, the longer it remains available to contribute to production at full efficiency and less of current investment has to be used to replace the oldest surviving investment as it 'drops off' the capital stock in a growing economy. This leads to the most rapid increase in the capital stock and, hence, the slowest increase in TFP. A similar but more compressed range applies to the net capital stock results.

Figure 7: Official TFP Indexes Using Alternative Gross Capital Stock Estimates

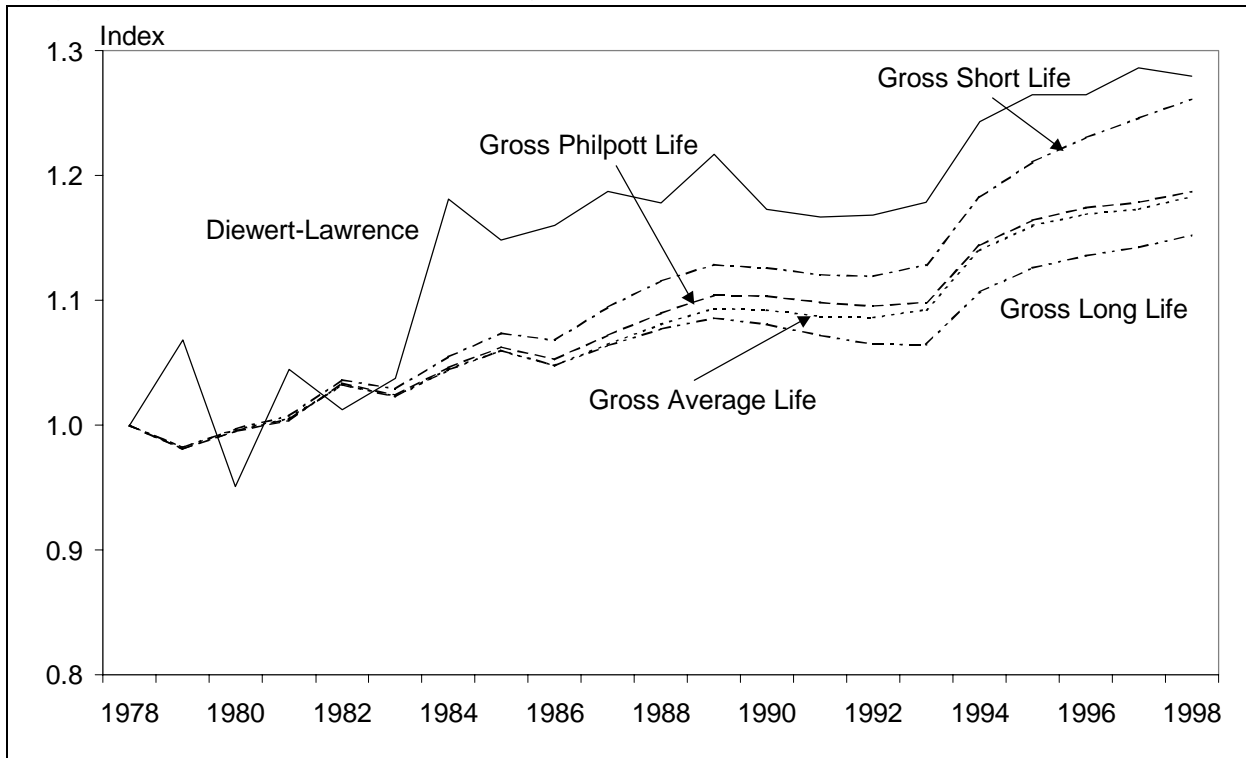
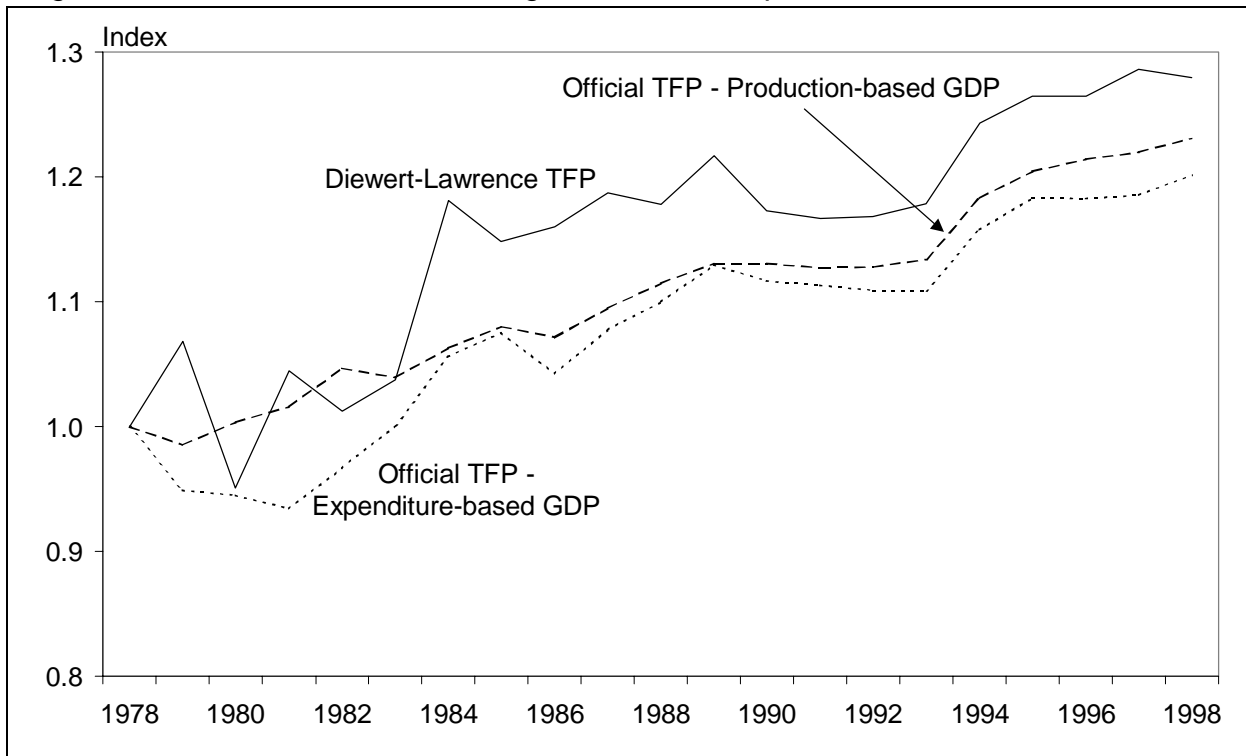


Figure 8: Official TFP Indexes Using Alternative Output Measures



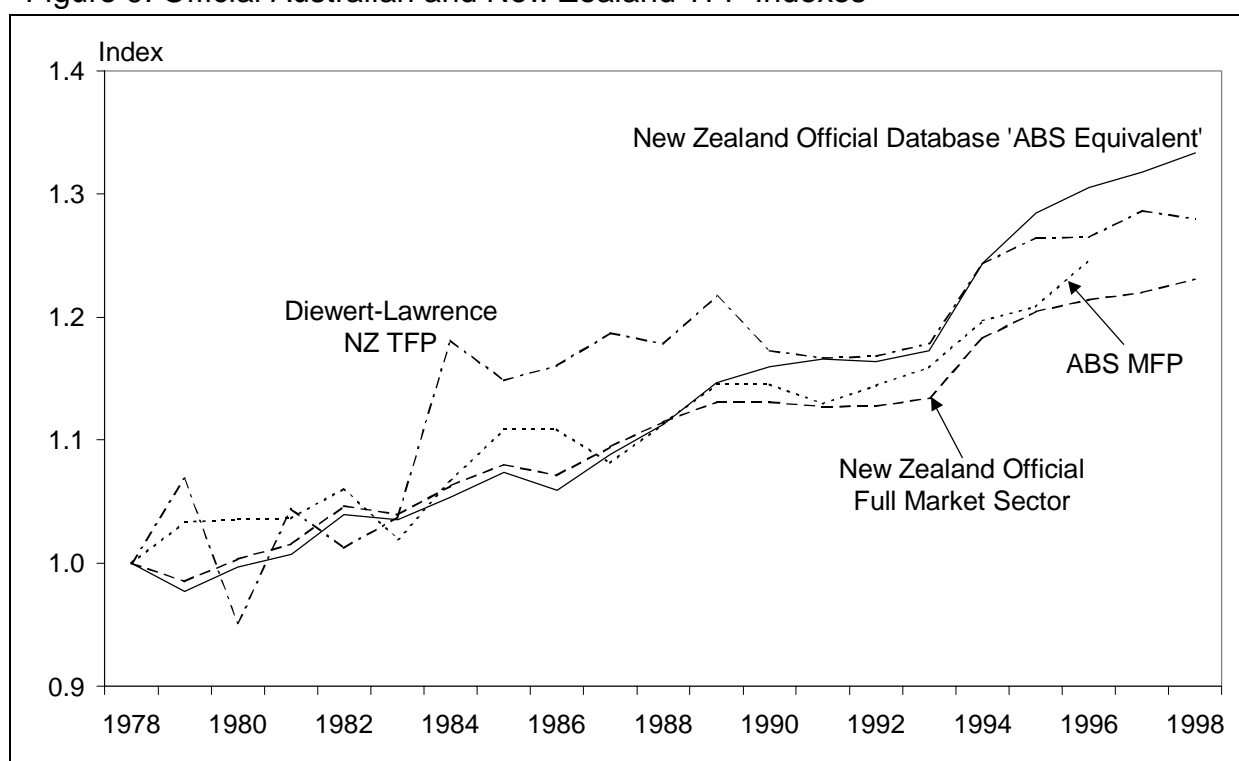
Output sensitivity analysis

In figure 8 we compare the official TFP index formed using the 20 market sector industry production GDPs with one using aggregate market sector expenditure based GDP. The expenditure based official TFP index tends to fluctuate more than the production based measure, particularly in the first half of the period. From around 1982 onwards it mirrors movements in the Diewert–Lawrence index more closely than the official production based index although having a consistently lower value. This is not unexpected as the Diewert–Lawrence output measured is formed from disaggregated expenditure data. During the 1990s the official expenditure based TFP index has moved more in unison with the official production based index.

'ABS equivalent' TFP index

An important difference between the ABS MFP productivity index for Australia and both the Diewert–Lawrence and official New Zealand series described so far is that the ABS index excludes the hard to measure Finance and Community Services sectors. To maximise the scope for a like with like comparison we have calculated an official TFP index for New Zealand which also excludes the Finance and the Community services industries and which takes the same weighted averages of the gross and net capital stocks as taken by the ABS.

Figure 9: Official Australian and New Zealand TFP Indexes



From figure 9 we note that rebasing the ABS and Diewert–Lawrence New Zealand indexes to 1978 actually reverses the relative position of the two indexes in 1996 compared to figure 4. Productivity is at a low point in 1978 in the overall Diewert–Lawrence series and rebasing to that year has the effect of lifting the New Zealand series and improving relative performance for the subsequent period. The official TFP index for the full New Zealand market sector also compares favourably with the ABS Australian series.

The significant difference comes when we compare the official ‘ABS equivalent’ New Zealand TFP index with the other indexes. Removing the Finance and Community services industries has the effect of substantially raising New Zealand’s TFP performance from 1988 onwards relative to the full market sector official index. The gap between the two indexes has continued to expand with the official ‘ABS equivalent’ New Zealand TFP index lying 8 per cent above the official full market sector New Zealand TFP index in 1998. This increases the New Zealand TFP trend annual growth rate from 1.09 per cent for the full market sector to 1.56 per cent for the smaller ‘ABS equivalent’ sector. Furthermore, while New Zealand’s productivity performance closely mirrored Australia’s up until 1993, between 1993 and 1996 the New Zealand ‘ABS equivalent’ index opened up a gap relative to the ABS MFP index for Australia.

Trend TFP growth rates

Regression fitted trend growth rates for the various TFP series are presented in table 1 for the whole period and three subperiods. The preferred Diewert–Lawrence series shows a trend annual decline up to 1984 (although it exhibits solid trend growth between 1978 and 1984 due mainly to strong TFP growth in 1984), then a decade of virtually no growth on average followed by healthy growth after 1993. The Diewert–Lawrence TFP index using the HLFS labour source generally shows slower growth.

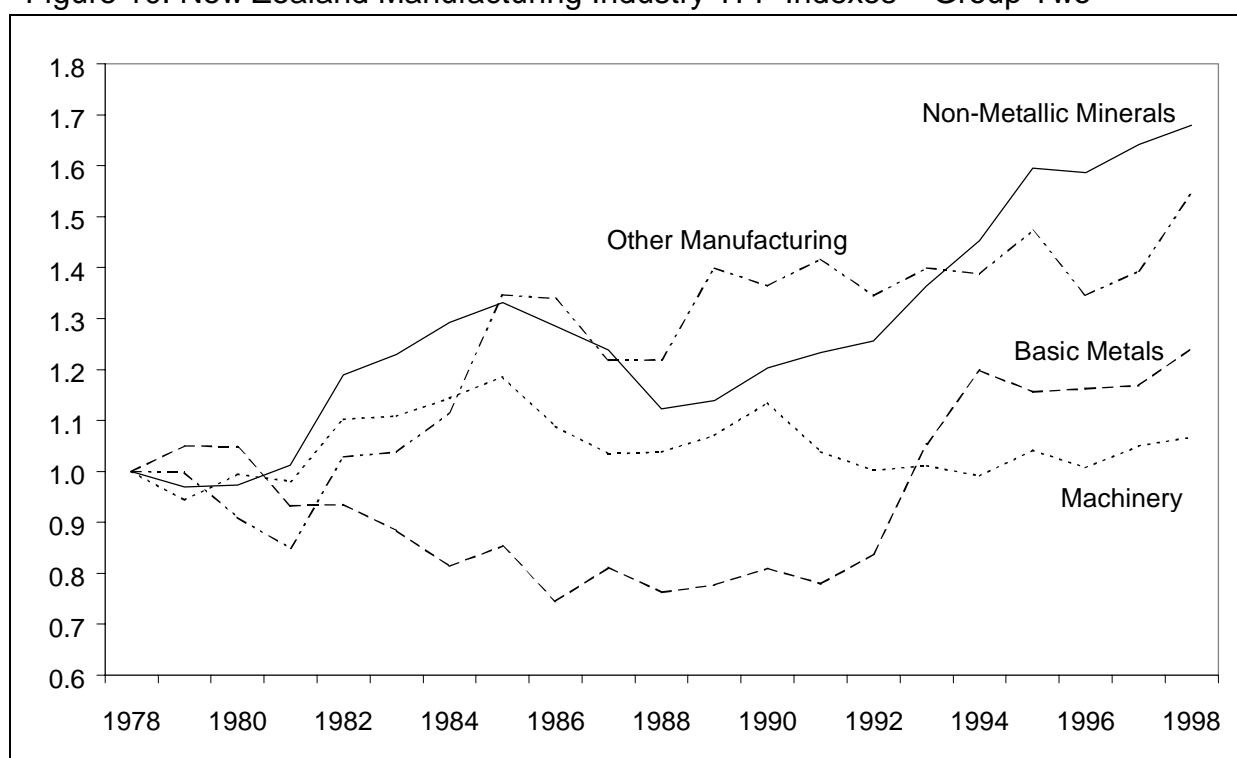
The official database TFP indexes generally show more even growth with less of a flat spot in the decade after 1984. Again there is a definite kick up in growth rates after 1993 with the ‘ABS equivalent’ index showing a much higher growth rate than the full market sector indexes. The two Australian TFP indexes show solid growth over the whole period.

Testing for whether there are statistically significant structural breaks in the TFP indexes at 1984 and 1993 shows in the case of the Diewert–Lawrence TFP index that the downturn in growth rates in 1984 was statistically significant but the upturn in growth in 1993 was not. Including an input variable for the unemployed to form a measure of ‘social TFP’ leads to the 1993 increase in TFP growth becoming significant. In the case of the official database TFP indexes the break at 1984 is not statistically significant but the increase in growth after 1993 is significant. This is particularly the case for the ‘ABS equivalent’ index where the post 1993 upturn is more pronounced.

Table 1: Trend TFP Growth Rates (per cent per annum)

	1972–84	1978–84	1984–93	1993–98	1972–98	1978–98
Diewert–Lawrence Database						
Diewert–Lawrence Preferred	-0.35	1.80	0.07	1.47	0.81	1.26
Diewert–Lawrence with HLFS Hours	-1.19	1.18	-0.15	1.17	0.36	0.95
Official Database						
Preferred Base Case		1.19	0.76	1.46		1.09
Highest Estimate		1.28	1.00	1.48		1.25
Lowest Estimate		0.34	0.14	1.63		0.58
'ABS Equivalent' for NZ		1.12	1.35	2.38		1.56
International						
ABS MFP	1.44	0.68	0.77	2.27	1.20	1.05
Diewert–Lawrence Australia	1.62	0.87	0.56	0.78	1.25	1.02

Figure 10: New Zealand Manufacturing Industry TFP Indexes – Group Two



Sectoral productivity

In chapter 5 of the report we present the individual TFP indexes for each of the 20 market sector industries included in the official database. The industry level TFP indexes tend to be more volatile than the aggregate market sector indexes and caution needs to be exercised in their interpretation due to likely classification and measurement problems. This applies particularly to the results for service industries. An illustration of the industry level TFP

indexes is presented in figure 10 where five of the manufacturing industry TFP indexes appear.

Other studies

In chapter 6 we review several earlier studies of the productivity performance of the New Zealand economy and compare their results with those of the current report. In particular, the final section of chapter 6 reviews the standard growth accounting approach to estimating productivity growth. This method is based on the use of the relatively inflexible Cobb–Douglas production function and hence results obtained with this methodology must be viewed with caution. Indeed, we find that when a more flexible functional form is used productivity growth rates change substantially and tend to closely approximate our index number based results.

Priorities for further work

The two most important areas identified requiring further work are labour data and the services sector. Alternative labour series have an unexpectedly large impact on the productivity results and urgent work is needed to improve the quality and consistency of labour data, particularly at the sectoral level.

Of even higher priority, however, is the treatment of the services sector in official statistics. While services have grown rapidly to now dominate most western economies, statistical agencies around the world have lagged in their ability to accurately measure service sector outputs and allocate new forms of inputs such as leased capital. In recognition of the particular measurement problems created by the rapid growth of the services sector in recent decades, in chapters 7 and 8 we discuss at length the likely impact of measurement problems on measured productivity and what can be done to overcome these problems.

Conclusion

Although our results highlight the importance of alternative specifications and data sources, a consistent picture emerges of New Zealand's recent productivity performance. Performance during the 1970s was generally poor. This was followed by relatively strong growth in productivity between 1980 and 1985 and a subsequent 'plateauing' of productivity through until 1993. After 1993 there was a productivity surge. This is likely to have been aided by the effects of the labour market reforms of the early 1990s, among other things.

1. INTRODUCTION*

The primary objectives of this study have been to try and establish the facts, as well as possible, on New Zealand's productivity performance over the last 20 years and to assess the importance of potential sources of measurement error. Empirical work uses two principal databases: the detailed Diewert–Lawrence database which contains consistent series for over 62 separate outputs and inputs of the New Zealand economy and an 'official' database formed from data supplied by the Department of Labour, the Reserve Bank of New Zealand and The Treasury.

The New Zealand Department of Labour, the Reserve Bank and the Treasury have commissioned Diewert Enterprises to examine New Zealand's recent productivity performance. This report is part of a wider program of research aimed at answering four main questions:

- Why has New Zealand's recent measured productivity been lower than anticipated by many?
- What is the sensitivity of productivity estimates to different data series, time periods, production specifications, estimation techniques and levels of aggregation?
- What is the growth potential of the New Zealand economy currently and in the medium term?
- What effects have the policy changes since 1984 had on the growth potential of the New Zealand economy?

Given the wide ranging nature of New Zealand's reform process since the mid 1980s, the performance of the New Zealand economy in response to these reforms is a matter of interest not just to domestic policymakers but to policy analysts around the world. One would expect the reforms to have had a significant beneficial impact on measured productivity. However, the previous literature on New Zealand's measured productivity experience uses a variety of data, estimation methods, time periods and choices of break points between pre and post reform periods. This makes it difficult to tell what is driving differences in results.

The consensus of previous research has been that productivity growth in New Zealand over the second half of this century has been comparatively lacklustre. For example, Bonato (1998)

* We would like to thank the six people who supplied written comments on an earlier draft of this report: Michael Andrews, Simon Chapple, Lewis Evans, Kevin Fox, David Galt and Benedikte Jensen. Any remaining errors or omissions are our responsibility.

used the Penn World Tables to show that over the period 1950 to 1990, GDP per worker in New Zealand has increased by 0.9 percent per annum. This is in contrast to the average 2.9 percent per annum growth recorded in other OECD countries. Given this poor performance, productivity might well have been expected to show a lift in its average growth rate following the reform process. Previous empirical tests of this hypothesis, however, have produced mixed results. For example, Viv Hall (1996) found that total factor productivity growth fell from an average 1.2 percent growth per annum over the 'pre-reform' period of 1978–85, to around 0.6 percent growth per annum over the 'reform and beyond' period of 1985–93. These results contrast with those of Philpott (1995) who calculated an annual TFP growth rate of 0.1 percent over the period 1975–85 followed by a higher average rate of 1.4 percent over the period 1985–94. Sarel (1996) also found an increase in New Zealand's TFP growth, from an average of 0.5 percent over the 1978–96 period to 2.1 percent over the latest 5 year period (1991–96).

A primary objective of this study has been to try and establish the facts, as well as possible, on New Zealand's productivity performance over the last 20 years. To do this we have used two principal data sources:

- the detailed Diewert–Lawrence database of the New Zealand economy which contains consistent series on a total of 62 outputs and inputs covering the March years 1972 to 1998; and
- an official database assembled by the Department of Labour, the Reserve Bank and the Treasury to facilitate detailed sensitivity analyses of alternative data sources and specifications and covering the March years 1978 to 1998.

Although our results highlight the importance of alternative specifications and data sources, a consistent picture emerges of New Zealand's recent productivity performance. Performance during the 1970s was generally poor with the era of 'Think Big' projects leading to a steady decline in productivity levels. This was followed by relatively strong growth in productivity between 1980 and 1985 and a subsequent 'plateauing' of productivity through until 1993. After 1993 there was a productivity surge. This is likely to have been aided by the effects of the labour market reforms of the early 1990s, among other factors.

The two most important areas identified requiring further work are labour data and the services sector. Alternative labour series have an unexpectedly large impact on the productivity results and urgent work is needed to improve the quality and consistency of labour data, particularly at the sectoral level. However, of even higher priority is the treatment of the services sector in official statistics. While services have grown rapidly to now dominate most western economies, statistical agencies around the world have lagged in their ability to accurately measure service sector outputs and allocate new forms of inputs such as

leased capital. In the New Zealand case, the importance of this issue is highlighted in chapter 4 where we form a productivity series for New Zealand similar to that used by the Australian Bureau of Statistics which excludes the hard to measure Financial and Community services sectors. When these sectors which have important measurement deficiencies in New Zealand are excluded, New Zealand's trend productivity growth rate for the 21 years up to 1998 jumps from just over 1 per cent per year to 1.6 per cent per year. Furthermore, while New Zealand's productivity performance closely mirrored Australia's up until 1993, between 1993 and 1996 New Zealand opened up a gap relative to Australia.

In recognition of the particular measurement problems created by the rapid growth of the services sector in recent decades, another major focus of this report is on identifying the likely impact measurement problems on measured productivity and what can be done to overcome these problems.

1.1 Structure of the Report

In the following chapter of the report we examine alternative approaches to measuring productivity and show how the index number method which we use is linked to the more traditional growth accounting approach more commonly used in earlier New Zealand studies. A technical appendix provides extensive detail on the economic theory behind productivity measurement.

In chapters 3 and 4 we provide details of the Diewert–Lawrence and the 'official' databases, respectively, and the productivity results obtained. We also report the results of a number of sensitivity analyses to the use of differing data sources and specifications. International comparisons are also reported to put New Zealand's productivity performance in context. Both chapters are supported by detailed appendices documenting the respective databases in detail while a separate appendix details our approach to constructing measures of capital inputs. In chapter 5 we present productivity results for 20 separate industries using the 'official' database.

We review and discuss 13 previous New Zealand productivity studies undertaken during the 1990s in chapter 6. We go on to discuss in detail many of the major measurement problems facing most western statistical agencies in chapter 7 along with additional measurement problems identified during the course of this study. Finally, in chapter 8 we identify some of the priority areas for further work in terms of both data collection and analytical studies.

2. APPROACHES TO MEASURING PRODUCTIVITY

This report focuses on the comprehensive productivity measure known as total factor productivity (TFP). This measure attempts to include all outputs and all inputs used in the production process. It gives a more accurate picture of performance than partial productivity measures such as labour productivity. We briefly review the growth accounting approach to measuring TFP and then describe the technique used throughout this report – the index number approach. A TFP index is generally defined as the ratio of an index of output growth divided by an index of input growth. Growth rates for individual outputs and inputs are weighted together using revenue and cost shares, respectively. Changes in the TFP index tell us how the amount of total output that can be produced from a unit of total input has changed over time.

Productivity measurement has long been of interest to economists. Along with increases in factor endowments and changes in the terms of trade, productivity improvement (the change in the amount of output produced per unit of input) is a major determinant of economic growth and national welfare.

There are several different approaches to measuring productivity. At the most basic level, productivity change is often approximated by changes in labour productivity (output per worker or per hour worked) because the requisite information is usually readily available. However, relying on labour productivity measures can produce misleading results as other inputs such as capital may be being substituted for labour. If this is happening, observed labour productivity will be increasing rapidly but when all inputs are taken into account, overall productivity will be increasing far less rapidly and, in the extreme case, may even be going backwards. To overcome this deficiency, it is necessary to look at the quantity of all outputs produced relative to the quantity of all inputs used.

This comprehensive productivity measure is known as total factor productivity (TFP) and should ideally include not just labour and capital inputs but also land, natural resource, inventory and all other inputs. Failure to include all inputs can also lead to biased results as the economy may in effect appear to be getting a 'free lunch' by excluding the increased use of certain inputs. Most productivity studies tend to concentrate on labour and capital inputs and some analysts recognise the incompleteness of their input coverage by referring to the resulting measures as 'multifactor' rather than 'total factor' productivity measures.

The concept of total factor productivity was introduced into the economics literature by Tinbergen (1942) and Stigler (1947). A much cited 1957 paper by Solow provides a useful frame of reference for the main empirical approaches to measuring TFP. The estimates of productivity provided in Solow's paper are computed using what has come to be known as the *growth accounting* approach. With this approach, TFP is computed as a residual: the residual that results from separately evaluating the contributions of specified input factors to output growth and then subtracting these measured contributions from the total growth of output. The resulting residual difference is referred to sometimes as 'the Solow residual'.

The growth accounting definition of TFP focused the attention of economists on trying to explain the reasons why output generally grows faster than measured inputs. This methodology can be used to produce a balance sheet showing the contribution of each input factor to economic growth. The production function is the conceptual link between growth accounting and some of the other approaches to productivity measurement. One of these is the measurement of productivity using estimated coefficients from production, cost or other related producer behavioral equations. This is the *econometric* approach. TFP can also be measured as a ratio of output and input quantity indexes in what is known as the *index number* approach to productivity measurement.

The growth accounting approach has been widely used in the previous New Zealand productivity literature which we review in detail in chapter 6. In this report we use the index number approach to productivity measurement. In the following section we briefly review the growth accounting approach and illustrate how it is linked to the index number approach. We then go on to examine the index number approach in more detail. Appendix A provides a detailed technical treatment of the various approaches and issues involved in productivity measurement.

2.1 The Solow Growth Accounting Approach

Solow (1957) represents the production function as

$$(1) \quad Q = F(K, L; t).$$

In this specification, Q is an output quantity aggregate (usually taken to be real gross domestic product in the national accounting framework), K and L are aggregate measures for the capital and labor inputs to the production process, and t denotes time. Solow states explicitly that the variable t 'for time' appears in F 'to allow for technical change.' Having introduced t in this way, he goes on to explain:

"I am using the phrase 'technical change' as a short-hand expression for any kind of shift in the production function. Thus slowdowns, speed-ups,

improvements in the education of the labor force, and all sorts of things will appear as 'technical change.'" (Solow 1957, p.312)

This definition of technical change in no way singles out the adoption of new production technologies or management methods. Nevertheless, Solow's methodology and findings were framed so that they marshaled the expertise of microeconomic theorists and experts in national income accounting for the stated purpose of measuring and analysing US economic efficiency and productivity: two vital concerns of business and political leaders. In short, Solow succeeded in harnessing the power of economic theory and measurement in the service of an urgent national cause that many view as closely linked to technological progress, economic growth, and competitive business success.

Solow focuses on the case of neutral technical change. If technical change is neutral, the shifts in production leave all marginal rates of substitution unchanged, and the production function F in (1) can be written as:

$$(2) \quad Q = A(t)f(K, L).$$

The multiplicative factor $A(t)$ in (2) represents the cumulative effects of shifts over time after controlling for the growth of K and L . Solow notes that if we differentiate equation (2) totally with respect to time and then divide by Q we obtain

$$(3) \quad \frac{\dot{Q}}{Q} = \frac{\dot{A}}{A} + A \frac{\partial f}{\partial K} \frac{\dot{K}}{Q} + A \frac{\partial f}{\partial L} \frac{\dot{L}}{Q}.$$

The dots in (3) denote time derivatives. He defines

$$(4) \quad w_K = \frac{\partial Q}{\partial K} \frac{K}{Q} \quad \text{and} \quad w_L = \frac{\partial Q}{\partial L} \frac{L}{Q}$$

and then rewrites equation (3) using these definitions and the fact that $\partial Q/\partial K = A\partial f/\partial K$ and $\partial Q/\partial L = A\partial f/\partial L$. The relationship obtained is

$$(5) \quad \frac{\dot{Q}}{Q} = \frac{\dot{A}}{A} + w_K \frac{\dot{K}}{K} + w_L \frac{\dot{L}}{L}.$$

Rearranging (5) leads to the following expression for productivity change:

$$(6) \quad \frac{\dot{A}}{A} = \frac{\dot{Q}}{Q} - w_K \frac{\dot{K}}{K} - w_L \frac{\dot{L}}{L}.$$

In other words, productivity change is equal to the rate of output growth less the rates of growth in capital and labour inputs weighted by their respective GDP shares.

Solow notes that if all factor inputs are classified as K or L , then w_K and w_L will always sum to one. He assumes that factors are paid their marginal products, that the hypotheses of Euler's theorem are satisfied, and that the function F is homogeneous of degree one. The capital and labour input quantities are reexpressed per unit of the aggregate labor input as:

$$(7) \quad Q/L = q \quad \text{and} \quad K/L = k.$$

Then using $w_L = 1 - w_K$, Solow restates the production function given in (5) as:

$$(8) \quad \frac{\dot{q}}{q} = \frac{\dot{A}}{A} + w_K \frac{\dot{k}}{k}.$$

Solow (1957, p.313) notes that if this model is an adequate simplification, then 'all we need to disentangle the technical change index $A(t)$ are series for output per man hour, capital per man hour and the share of capital'. This is the basis of the growth accounting estimation results Solow presented for the effects of technical change on US economic growth. His estimates for $A(t)$ were obtained without econometric estimation of the parameters of any equation such as (8). Rather, Solow used the production function framework as the basis for year by year calculations involving output and input quantity aggregates.

The link between the Solow growth accounting approach to productivity measurement and the index number approach can readily be seen by rearranging equation (6) as follows:

$$(9) \quad \frac{\dot{A}}{A} = (\dot{Q} - i) \left(\frac{Q}{I} \right) \quad \text{where} \quad \frac{i}{I} = w_K \frac{\dot{K}}{K} - w_L \frac{\dot{L}}{L}.$$

From (9) we can see that $A(t)$ can alternatively be expressed in the form:

$$(10) \quad A(t) = \frac{Q(t)}{I(t)}$$

where $Q(t)$ is an index of output quantities and $I(t)$ is an index of input quantities.

2.2 The Index Number Approach

A productivity index is generally defined as the ratio of an index of output growth divided by an index of input growth, where the outputs refer to the total quantities of all outputs produced by the production sector and the inputs are the total quantities of all inputs utilised by the same production sector over two accounting periods.

Suppose that the production sector produces M outputs and uses N inputs in each accounting period. Denote the quantity of output m produced in period t by y_m^t for $m = 1, \dots, M$ and denote the quantity of input n used in period t by x_n^t for $n = 1, \dots, N$.

In order to calculate an aggregate output growth index, it is necessary to aggregate the individual output growth rates going from period $t - 1$ to t , y_m^t / y_m^{t-1} for $m = 1, \dots, M$. Typically, the individual output prices p_m^t and p_m^{t-1} for $m = 1, \dots, M$ or the output revenue shares defined as

$$(11) \quad s_m^t \equiv p_m^t y_m^t / \sum_{i=1}^m p_i^t y_i^t; \quad m = 1, \dots, M$$

are used to weight the individual output growth rates, where p_m^t is the average selling price for output m in period t .

Similarly, in order to calculate an aggregate input growth index, it is necessary to aggregate the individual input growth rates x_n^t / x_n^{t-1} for $n = 1, \dots, N$. Typically, input prices w_n^t or input cost shares are used to weight the individual input growth rates where w_n^t is the total cost of input n divided by the total quantity x_n^t of input n used during period t .

Most economies have a diverse range of outputs (agricultural products, manufactures, services and exports) and an equally diverse range of inputs (eg labour, capital, land, inventories and natural resources). 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 petajoules of energy consumed).

The specific way in which output prices should be used to weight the growth rates of the individual outputs is not obvious. In practice, an index number formula is used to calculate an aggregate output growth rate. An output quantity index Q is a specific function of the price and quantity vectors pertaining to the two periods under consideration (say, periods 0 and 1) where the period t price and quantity vectors are $p^t \equiv (p_1^t, \dots, p_M^t)$ and $y^t \equiv (y_1^t, \dots, y_M^t)$ for $t = 0, 1$. The most commonly used quantity indexes are the Laspeyres, Paasche, Fisher (1922) and Törnqvist (1936) output indexes defined, respectively, as follows:

$$(12) \quad Q_L(p^0, p^1, y^0, y^1) \equiv p^0 \cdot y^1 / p^0 \cdot y^0 = \sum_{m=1}^M s_m^0 (y_m^1 / y_m^0);$$

$$(13) \quad Q_P(p^0, p^1, y^0, y^1) \equiv p^1 \cdot y^1 / p^1 \cdot y^0 = \left[\sum_{m=1}^M s_m^1 (y_m^1 / y_m^0)^{-1} \right]^{-1};$$

$$(14) \quad Q_F(p^0, p^1, y^0, y^1) \equiv \left[Q_L(p^0, p^1, y^0, y^1) Q_P(p^0, p^1, y^0, y^1) \right]^{0.5};$$

$$(15) \quad Q_T(p^0, p^1, y^0, y^1) \equiv \prod_{m=1}^M (y_m^1 / y_m^0)^{0.5(s_m^0 + s_m^1)};$$

where the period t output shares s_m^t are defined by (11) for $t = 0, 1$ and $p^0 \cdot y^1 \equiv \sum_{m=1}^M p_m^0 y_m^1$ denotes the inner product of the vectors p^0 and y^1 .

Similarly, the most commonly used input quantity indexes are the Laspeyres, Paasche, Fisher and Törnqvist input indexes I_L, I_P, I_F and I_T defined as follows:

$$(16) \quad I_L(w^0, w^1, x^0, x^1) \equiv w^0 \cdot x^1 / w^1 \cdot x^0 = \sum_{n=1}^N s_n^0 (x_n^1 / x_n^0);$$

$$(17) \quad I_P(w^0, w^1, x^0, x^1) \equiv w^1 \cdot x^1 / w^0 \cdot x^0 = \left[\sum_{n=1}^N s_n^1 (x_n^1 / x_n^0)^{-1} \right]^{-1};$$

$$(18) \quad I_F(w^0, w^1, x^0, x^1) \equiv \left[I_L(w^0, w^1, x^0, x^1) I_P(w^0, w^1, x^0, x^1) \right]^{0.5};$$

$$(19) \quad I_T(w^0, w^1, x^0, x^1) \equiv \prod_{n=1}^N (x_n^1 / x_n^0)^{0.5(s_n^0 + s_n^1)};$$

where the period t cost share for input n is defined as

$$(20) \quad s_n^t \equiv w_n^t x_n^t / \sum_{i=1}^N w_i^t x_i^t; \quad n = 1, \dots, N.$$

A productivity index can now be more precisely defined as an output quantity index $Q(p^0, p^1, y^0, y^1)$ divided by an input quantity index $I(w^0, w^1, x^0, x^1)$.

There are various approaches to the problem of finding the 'best' functional forms for Q and I . The two most commonly used approaches are the economic and the axiomatic approaches.

The economic approach selects index number formulations on the basis of an assumed underlying production function and assuming price taking, profit maximising behaviour on the part of producers. For example, the Törnqvist index used extensively in past TFP studies can be derived assuming the underlying production function has the translog form and assuming producers are price taking revenue maximisers and price taking cost minimisers.

The axiomatic approach to the selection of an appropriate index formulation specifies a number of desirable properties an index formulation should possess. Potential indexes are then evaluated against the specified properties and the index that passes the most tests would be preferred for the analysis. In appendix A we review alternate index number formulations to determine which index is best suited to TFP calculations. The tests used to evaluate the alternate indexes include:

- the constant quantities test: if quantities are the same in two periods, then the output index should be the same in both periods irrespective of the price of the goods in both periods;
- the constant basket test: if prices are constant over two periods, then the level of output in period 1 compared to period 0 is equal to the value of output in period 1 divided by the value of output in period 0;
- the proportional increase in outputs test: if all outputs in period t are multiplied by a common factor, λ , then the output index in period t compared to period 0 should increase by λ also; and
- the time reversal test: if the prices and quantities in period 0 and t are interchanged, then the resulting output index should be the reciprocal of the original index.

When evaluated against the tests listed above, only the Fisher index passes all four tests. The Laspeyres and Paasche index fail the time reversal test while the Törnqvist index fails the constant basket test. On the basis of these tests we recommend using the Fisher index as the index of choice for TFP work although, in practice, the Törnqvist index can also be used as it closely approximates the Fisher index.

As noted above, the Fisher ideal index is the square root of the product of the Laspeyres and Paasche indexes. More formally, the Fisher ideal output index is given by:

$$(2) \quad Q_F^t = [(\sum_{i=1}^m p_i^B y_i^t / \sum_{j=1}^m p_j^B y_j^B)(\sum_{i=1}^m p_i^t y_i^t / \sum_{j=1}^m p_j^t y_j^B)]^{0.5}$$

where:

- Q_t^F is the Fisher ideal output index for period t ;
- p_i^B is the price of the i th output in the base period;
- y_i^t is the quantity of the i th output in period t ;
- p_i^t is the price of the i th output in period t ;
- y_j^B is the quantity of the j th output in the base period.

Similarly, the Fisher ideal input index is given by:

$$(3) \quad I_F^t = [(\sum_{i=1}^n w_i^B x_i^t / \sum_{j=1}^n w_j^B x_j^B)(\sum_{i=1}^n w_i^t x_i^t / \sum_{j=1}^n w_j^t x_j^B)]^{0.5}$$

where:

- I_t^F is the Fisher ideal input index for period t ;
- w_i^B is the price of the i th input in the base period;
- x_i^t is the quantity of the i th input in period t ;
- w_i^t is the price of the i th input in period t ;
- x_j^B is the quantity of the j th input in the base period.

The Fisher ideal TFP index is then given by:

$$(4) \quad TFP_F^t = Q_F^t / I_F^t .$$

Associated with the Fisher output and input indexes are Fisher price indexes. The Fisher output price index is given by:

$$(5) \quad P_{QF}^t = \sum_{i=1}^m p_i^t y_i^t / Q_F^t .$$

The Fisher input price index is given by:

$$(6) \quad P_{IF}^t = \sum_{i=1}^n w_i^t x_i^t / I_F^t .$$

In this report the Fisher index was chosen as the preferred index formulation. The Fisher index can be used in either the unchained or chained form. In its unchained form, one year is taken to be the base year and output and input indexes for all other years are calculated relative to that base year. This means that the weights used in deriving the indexes for any

year will come half from that year and half from the base year. As we move further away from the base year, that half of the weight attributable to the base year will become less representative of the current situation. In other words, the unchained Fisher index suffers, to some degree, from the traditional 'index number problem'. This problem is at its most severe in the Laspeyres and Paasche indexes where the weights are constant throughout the period.

To overcome this problem totally, in the chained Fisher index instead of using one base observation for the whole period, we calculate the Fisher index for each period using the previous period's observation as the base. We then link these different calculations together to form an index number series which uses the most representative weights possible for each observation. Denoting the Fisher output index between observations i and j by $Q_F^{i,j}$, the chained Fisher index between observations 1 and t is given by:

$$(7) \quad Q_{CF}^{1,t} = 1 \times Q_F^{1,2} \times Q_F^{2,3} \times \dots \times Q_F^{t-1,t}.$$

To implement the above methodology, data is required on the price and quantity of all of the New Zealand economy's outputs and inputs. In the following chapters we turn to examine the two main data sources used in this study – the Diewert–Lawrence database and the 'official' database – and the resulting productivity estimates.

3. NEW ZEALAND TFP ESTIMATES USING THE DIEWERT–LAWRENCE DATABASE

The Diewert–Lawrence database contains consistent series on a total of 62 outputs and inputs valued at producers' prices covering the March years 1972 to 1998. TFP performance can be divided into 4 periods. From 1972 through to 1982 TFP generally declined in New Zealand. This was followed by strong TFP growth between 1982 and 1984 and then another flat period through to 1992. From 1993 onwards TFP growth has again improved. The trend annual rate of TFP increase over the 27 years has been only 0.81 per cent. The TFP estimates are relatively sensitive to the specification and source of labour input data used but insensitive to the inclusion or exclusion of land and inventory inputs. New Zealand's TFP performance has generally lagged behind that of Australia over the period. Statistical tests indicate there has not been a significant improvement in TFP performance after 1993 although including the unemployed as an input to the private sector to form a measure of 'social TFP' does lead to a significant increase in growth. Finally, TFP increase has made a far more important contribution to economic growth from 1978 onwards than changes in the terms of trade or increases in capital and labour inputs.

3.1 The Diewert–Lawrence TFP Database

Calculating the productivity of the market sector of the New Zealand economy depends crucially on having accurate data on the quantities of all outputs produced and all inputs utilised by the market sector each year. Excluding an output whose quantity has increased rapidly over time will tend to bias measured productivity downwards. Conversely, excluding an input whose quantity has increased rapidly will tend to bias measured productivity upwards while excluding one whose quantity has been constant will bias measured productivity downwards.

Another important part of forming a consistent productivity accounting framework is to ensure that these output and input quantities are valued at the prices producers actually face. National income accounting data are not constructed with productivity measurement in mind. Thus, final demand components (or final expenditure data) contain all of the commodity tax wedges that final demanders pay. The corresponding final demand prices contain these tax wedges. However, from the viewpoint of production theory (which is the theoretical basis for

making productivity comparisons), the appropriate prices are the prices that producers face, which should not include these final demand tax wedges. However, some commodity taxes (such as the property tax and tariffs on imports) fall on inputs to the production sector and so these taxes should be included in producer prices for productivity purposes. Moreover, some commodity taxes such as fuel taxes create tax wedges within the private production sector and these taxes need to be accounted for when making productivity comparisons. Subsidies also create problems in trying to determine what the “correct” producer prices are for subsidised outputs.

To address these concerns regarding the comprehensiveness of output and input specification and valuation at producers' prices, we have updated, expanded and further improved the detailed database first developed in Diewert and Lawrence (1994, 1998a). The current Diewert–Lawrence TFP database contains consistent data in producers' prices for 62 separate outputs and inputs for the 27 year period 1972 to 1998. There are 49 outputs including 22 goods and services supplied to private final consumption, government consumption of intermediates and investment goods, residential dwellings investment, private production investment, exports and imports (which are treated as negative outputs in line with national accounting conventions). There are 13 inputs including labour, nonresidential construction, machinery and equipment, inventories, land and natural resources. Electrical equipment inputs are separately identified to help us better address the impact on productivity of rapidly increasing rates of computer usage combined with rapidly falling computer prices.

The quantity of capital inputs are measured using a net capital stock model and valued using a detailed user cost formula which takes account of depreciation, the rate of return and capital gains. It should be noted that our present study uses *ex poste* user costs which make use of actual end of year capital gains on assets and use the actual economy wide rates of return that the economy achieved each year. Our earlier study (Diewert and Lawrence 1998a) used an *ex ante* or anticipated user cost approach where capital gains and interest rates were estimated. Different approaches to measuring capital inputs are discussed in detail in appendices A, B and D¹.

We also pay special attention to measuring labour inputs. To allow for the increasing importance of part–time work, we use data extracted by Statistics New Zealand on as consistent a basis as possible from the last six Censuses on the numbers employed and hours worked for three broad occupational groupings. This data has been used to form consistent series of hours worked by occupation from 1972–1998. We have also allocated the return to

¹ The role of public sector infrastructure in influencing private sector productivity is not addressed in this report and remains an important topic for future research.

the self-employed between labour and capital components which permits a more accurate apportioning of labour and capital costs and taxes.

The present national accounting framework neglects land as an input into the production function. A justification for this omission might be something like the following argument: land does not change from period to period so it cannot explain variations in production so we might as well just omit it from the list of inputs into the economy. However, even though the quantity of land may remain constant, the price of land is generally strongly increasing over time. Thus, when constructing a price weighted quantity index of input growth for the economy (which is the denominator for a productivity calculation), the fixed quantity of land for many economies will receive a higher price weighting over time, leading to a lower growth of aggregate input and hence leading to a higher measure of productivity growth, compared to a traditional measure which neglects land. The Diewert–Lawrence TFP database includes land inputs.

Another omission in the present national accounts framework is the neglect of natural resource inputs. In New Zealand, there are at least three important resource inputs into the private production sector during each period: depletion of forests; depletion of oil and gas; and, depletion of mineral resources. In the Diewert–Lawrence TFP database we attempt to measure the depletion of forests and oil and gas for the period 1972–1998.

The construction of the Diewert–Lawrence TFP database is described in detail in appendix B where the contents of the database and much of the intermediate data used to form it are also listed.

3.2 Diewert–Lawrence TFP Estimates

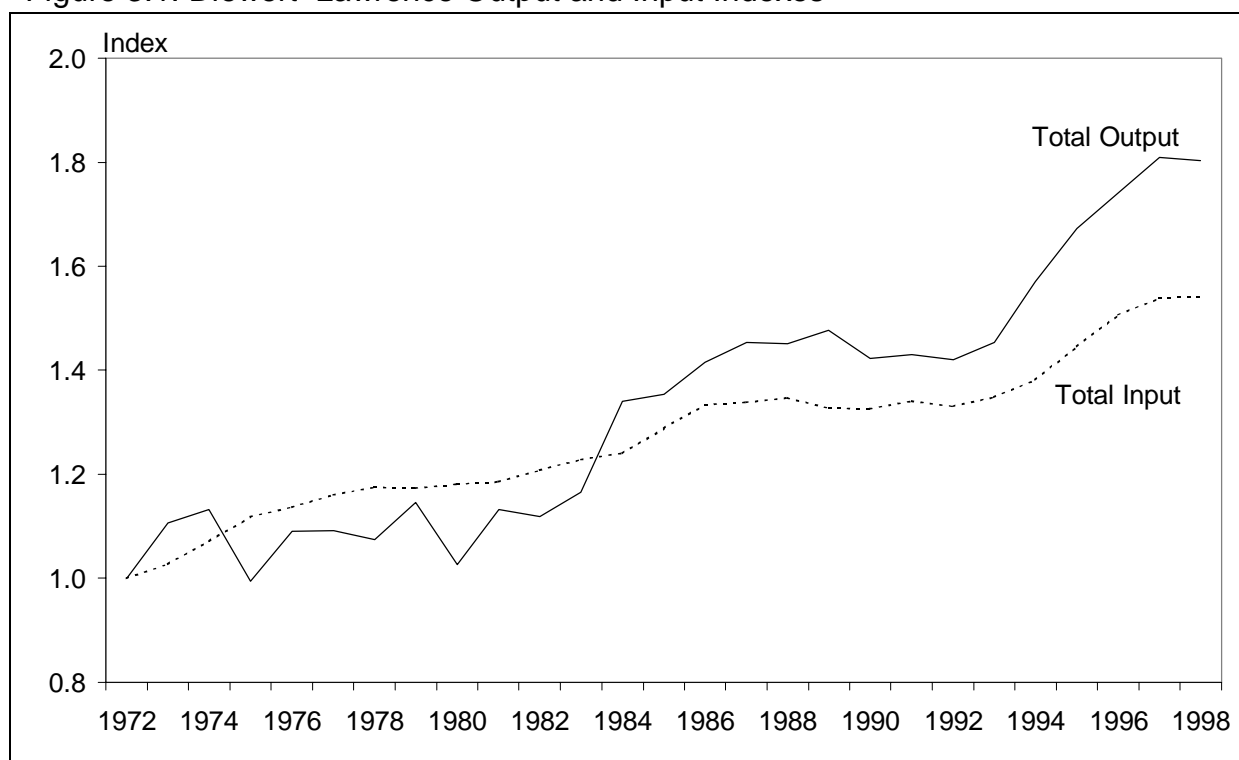
Having assembled the detailed database of outputs and inputs expressed in producers' prices, we next form a total output index by aggregating the 49 output components and a total input index by aggregating the 13 input components using chained Fisher indexes. The TFP index is formed by taking the ratio of the total output index to the total input index. For any one year these indexes show total output, total input and TFP levels for that year relative to what they were in the base year – in our case 1972. Comparing the change in the indexes between any two years shows the relative change in the variable between those two years.

The total output and total input indexes for the market sector of the New Zealand economy are presented in table 3.1 and figure 3.1.

After increasing strongly initially, total market sector output fell back in 1975 and then fluctuated around this lower level for the following 5 years. Output growth again started to improve in the early 1980s before increasing strongly in the mid 1980s. Output growth was

then more subdued in the second half of the 1980s and again fell during the recession in the early 1990s. From 1992, however, output growth again improved markedly up until 1997 before falling slightly in 1998. For the 27 year period as whole total output increased at a trend rate² of 2.22 per cent per annum.

Figure 3.1: Diewert–Lawrence Output and Input Indexes



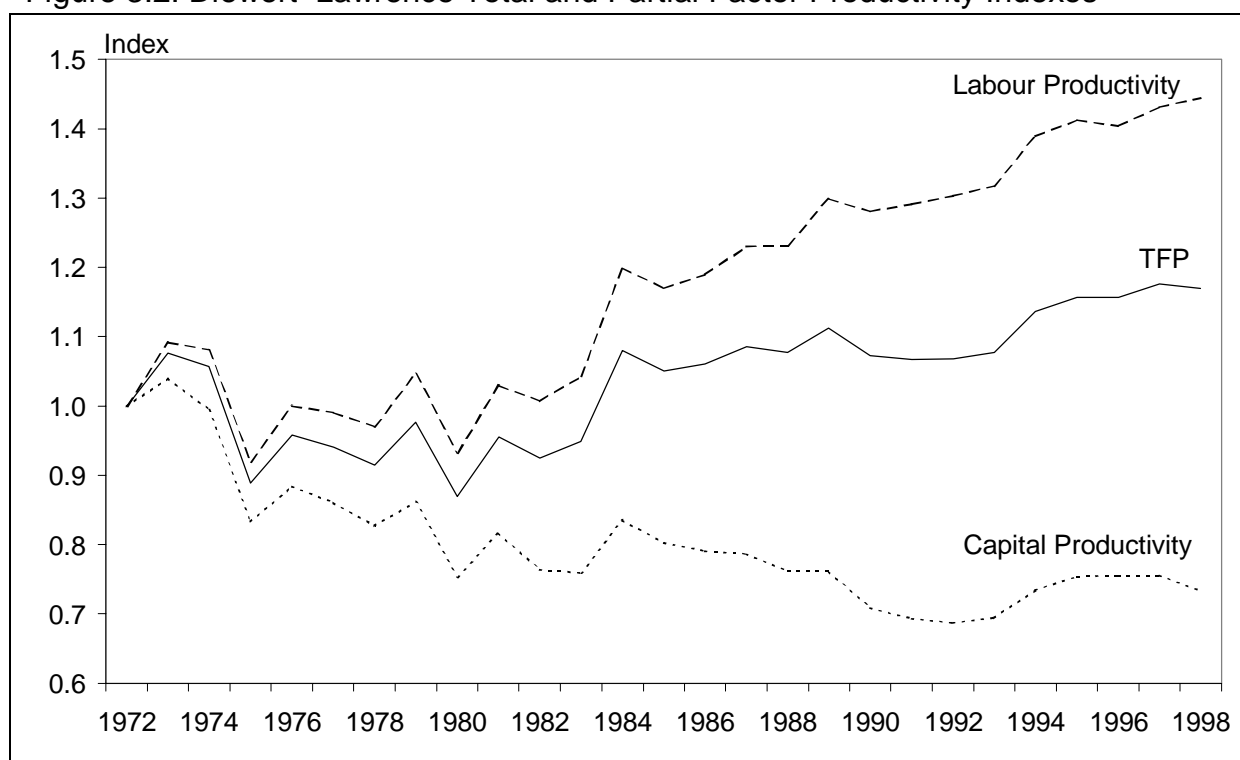
Input levels generally followed a similar pattern to total output with inputs plateauing at a higher relative level in the second half of the 1970s before then increasing at a slower rate than total output for the remainder of the period. For the 27 year period as a whole total inputs increased at a trend rate of 1.40 per cent per annum.

The TFP index is presented in figure 3.2 and table 3.1 along with labour and capital partial productivity indexes (the total output index divided by an index of labour inputs and by an index of capital inputs, respectively). For the first decade, TFP performance was poor coinciding with the period of high assistance to industry and large expenditure of public resources on ‘Think Big’ projects. TFP suffered a 16 per cent fall in 1975 due to a combination of reduced output and increased input usage. A large increase in imports combined with a large fall in exports and modest increases in consumption and investment goods outputs were not offset by the relatively large proportional increase in government consumption of intermediates. At the same time capital stocks increased reflecting the

² The trend growth rate for variable Y is calculated using the log–linear regression $\ln Y = a + bt$ where t is a time trend. The coefficient ‘ b ’ gives the trend rate of growth.

increased output of investment goods in the preceding year. TFP levels then fluctuated for several years and the economy was not to regain its 1972 productivity level until 1984. Our inclusion of changes in inventory levels as an output also contributes to volatility in total output and TFP levels in the first half of the period. The impact of the oil price shocks of 1973 and 1979 can also be expected to have had an adverse impact on New Zealand's performance (as could the decline in oil prices following 1986 after there had been heavy investment in major projects based on the assumption of continuing high oil prices).

Figure 3.2: Diewert–Lawrence Total and Partial Factor Productivity Indexes



TFP again suffered a sharp fall in 1980 with a large reduction in the output of government consumption of intermediates combined with a surge in imports and virtually no change in the output of consumption and investment goods. Again changes in signs of both inventory outputs served to magnify this change in total outputs. TFP levels then recovered strongly in 1984 with good across the board growth in the output of consumption and investment goods and exports and only modest growth in input usage. The effects of the fiscal stimulus, heavy wage freeze, government guarantees and overseas borrowing underpinning the construction phase of the major projects are likely contributors to this growth. A large change in the inventories outputs from negative to positive again served to magnify this change in total outputs in this year³. However, between 1984 and 1993 the TFP level again changed little. Output growth was variable and matched fairly evenly by input growth. Another surge in

³ The impact of excluding inventories from the specification of outputs and inputs is examined in section 3.3.

productivity in 1994 of 6 per cent has been supported by TFP growth of around 2 per cent in 1995 and 1997. TFP fell by 0.5 per cent in 1998 due to a reduction in total output (driven mainly by falls in the output of consumption and investment goods).

Table 3.1: Diewert–Lawrence Output, Input, TFP and Partial Productivity Indexes

<i>Year</i>	<i>Total Output</i>	<i>Total Input</i>	<i>TFP</i>	<i>Annual TFP</i>	<i>Labour Partial</i>	<i>Capital Partial</i>
	<i>Index</i>	<i>Index</i>	<i>Index</i>	<i>Change</i> <i>%pa</i>	<i>Productivity</i> <i>Index</i>	<i>Productivity</i> <i>Index</i>
1972	1.000	1.000	1.000		1.000	1.000
1973	1.106	1.027	1.077	7.68	1.092	1.040
1974	1.132	1.072	1.056	-1.90	1.081	0.995
1975	0.995	1.119	0.889	-15.84	0.920	0.833
1976	1.090	1.137	0.959	7.86	1.000	0.884
1977	1.092	1.161	0.941	-1.90	0.991	0.861
1978	1.075	1.175	0.914	-2.78	0.970	0.828
1979	1.146	1.173	0.977	6.83	1.046	0.862
1980	1.027	1.181	0.869	-10.99	0.932	0.754
1981	1.133	1.186	0.955	9.82	1.030	0.816
1982	1.118	1.208	0.926	-3.07	1.007	0.764
1983	1.166	1.229	0.949	2.49	1.043	0.759
1984	1.340	1.240	1.080	13.85	1.199	0.835
1985	1.354	1.289	1.050	-2.77	1.169	0.803
1986	1.416	1.334	1.061	1.04	1.190	0.791
1987	1.453	1.339	1.085	2.28	1.230	0.787
1988	1.451	1.347	1.077	-0.74	1.231	0.761
1989	1.477	1.327	1.113	3.29	1.299	0.761
1990	1.422	1.326	1.072	-3.62	1.281	0.709
1991	1.430	1.341	1.067	-0.53	1.291	0.693
1992	1.421	1.331	1.068	0.14	1.303	0.687
1993	1.453	1.348	1.078	0.88	1.318	0.695
1994	1.571	1.382	1.137	5.48	1.389	0.734
1995	1.672	1.446	1.156	1.73	1.413	0.754
1996	1.742	1.506	1.156	0.00	1.404	0.756
1997	1.810	1.539	1.176	1.72	1.431	0.756
1998	1.804	1.542	1.170	-0.54	1.444	0.733

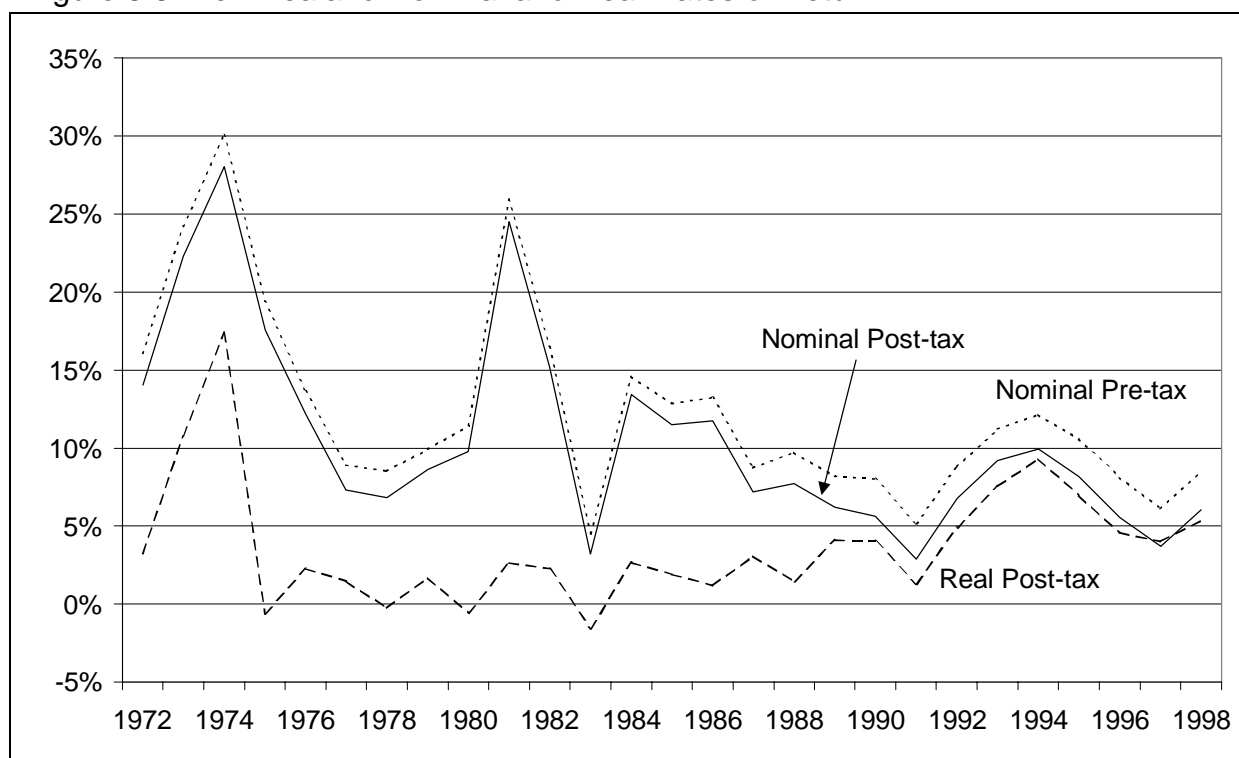
After more than two and a half decades New Zealand's TFP level is still less than 20 per cent higher than it was in 1972. The trend annual rate of TFP increase has been only 0.81 per cent⁴.

⁴ Measurement problems (which will be addressed in chapter 7) may have contributed to the relatively poor observed performance. For instance, the removal of barriers to imports since the 1980s has greatly expanded consumer choice.

Over this period labour productivity has consistently grown faster than TFP while capital productivity has generally fallen reflecting the increasing capital intensity of production. Labour productivity grew at a trend annual growth rate of 1.66 per cent while capital productivity declined at a trend annual rate of 1.13 per cent.

The profitability of the market sector of the New Zealand economy is reflected in the nominal and real rates of return presented in Figure 3.3 and Table 34 of appendix B. The before-tax nominal rate of return averaged 12.4 per cent for the 27 year period. The highest before-tax nominal rate of return achieved was 30 per cent in 1974. The lowest nominal before-tax rate of return was 4.5 per in 1983. The after-tax nominal rate of return averaged 10.6 per cent. These rates of return fluctuate more than those found in Diewert and Lawrence (1998a) as no data smoothing is carried out in the current study.

Figure 3.3: New Zealand Nominal and Real Rates of Return



Source: Diewert–Lawrence TFP database

The weighted average real after-tax rate of return observed for New Zealand, after allowing for asset specific rates of inflation, over the 27 years to 1998 was 3.7 per cent. This is consistent with the long-term real after-tax rate of return for most western countries which Robbins and Robbins (1992) found to lie in the range of 3 to 5 per cent. The real rate of return has converged with the corresponding nominal rate as inflation has been reduced to low levels towards the end of the period.

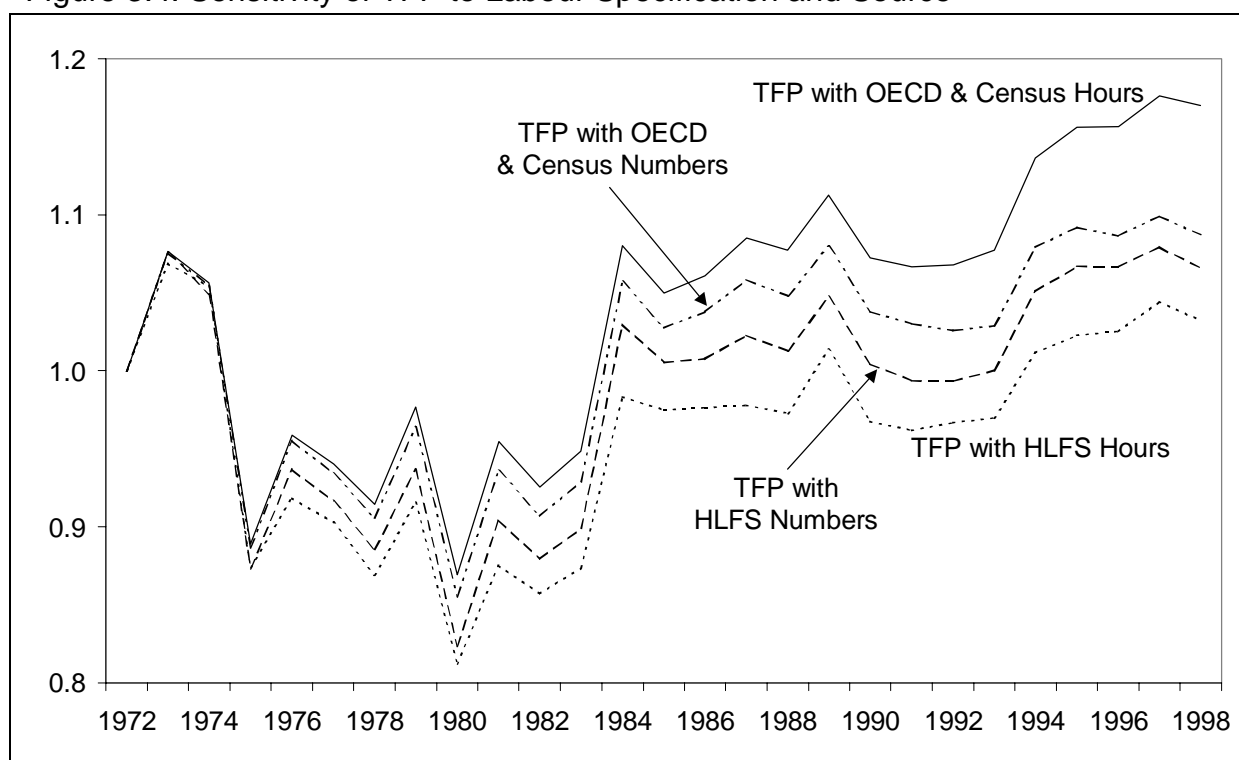
3.3 Sensitivity Analyses

Since the specification of outputs and inputs used in this study is perhaps as comprehensive as is currently possible, it is possible to examine the impact of changing the coverage and definition of inputs to assess the robustness of the results. This will facilitate comparison with other studies and also the 'official' database where less information is available. In particular, we examine the impact of specifying the labour input in terms of numbers employed rather than estimated hours worked in the market sector and the impact of excluding land, inventories and computers from the range of inputs included.

Labour

Many productivity studies use numbers employed as the measure of labour inputs. However, this measure does not take account of changes in the amount of time the average person spends at work. The latter can change from year to year in response to short term economic conditions as well as trending up or down over time reflecting underlying structural change in the economy and society. An obvious example of longer term structural change leading to a decline in average hours worked per person is the growth in part time employment associated with the increasing importance of the services sector. To gain an accurate measure of labour input and ensure that we are comparing like with like through time, it is preferable to measure labour input by total hours worked rather than numbers employed.

Figure 3.4: Sensitivity of TFP to Labour Specification and Source



To gauge the importance of using the conceptually more accurate measure of labour input, we have recalculated our TFP index using our OECD based total numbers employed in the market sector while retaining the same total value for labour inputs. The construction of the labour input in terms of both total employment and employment adjusted for changes in hours worked across our three broad occupational groups is explained in detail in appendix B. The impact of the alternative labour specifications on TFP is illustrated in figure 3.4.

The specification of labour inputs has a major impact on TFP over the 27 year period. This is because average hours worked per person trends steadily downwards for each of the three broad occupational groups (Managers, Clerical and Production workers). Not allowing for this by simply measuring labour inputs by the number of people employed leads to an overestimate of the quantity of labour inputs with a subsequent reduction in TFP. By the end of the period the TFP level is 7 per cent lower using the Diewert–Lawrence numbers employed measure compared to the hours measure. Using numbers employed reduces the trend annual TFP growth rate from 0.81 per cent to 0.56 per cent.

There are a number of alternative sources for New Zealand labour data. While they all have their own shortcomings, particularly when extended back as far as the 1970s, it is worthwhile looking at the impact of another of the alternative sources. As outlined at the start of this chapter and in appendix B, the Diewert–Lawrence New Zealand database draws on labour numbers time series presented in the OECD's *Economic Outlook* and Census based hours worked per person by occupation data supplied by Statistics New Zealand. However, some analysts (including those in the Department of Labour) prefer information derived from the Household Labour Force Survey (HLFS). This survey based information is claimed to be collected on a more consistent basis through time than the Census labour data. We have recalculated TFP using both aggregate market sector HLFS labour hours and numbers while retaining the Diewert–Lawrence total value of labour inputs. The HLFS labour series used are described in appendix C. The results of the sensitivity analysis are presented in figure 3.4 and table 3.2.

Using the HLFS labour hours series results in a substantial worsening in measured TFP performance. In fact, using this labour series results in TFP being only 3 per cent higher in 1998 than it was in 1972. The trend annual TFP growth rate is halved to 0.4 per cent. Furthermore, using the HLFS labour source, we now find the labour numbers based TFP index lying above the HLFS hours based TFP index although still substantially below the Diewert–Lawrence hours based TFP index and somewhat below the Diewert–Lawrence labour numbers based TFP index. This is because the HLFS source implies that average hours worked per person in the labour force have increased over the first half of the time period and then remained relatively constant on average instead of having progressively decreased as

implied by the Diewert–Lawrence Census based series. With the increasing importance of the services sector which is characterised by increasing casualisation and lower levels of unionisation, it seems implausible to us that average hours worked have increased over time. However, proponents of the HLFS series argue that deregulation of the labour market will have resulted in many of those in employment working longer which could more than offset the impacts of service sector casualisation. Whatever the truth is, this example serves to highlight the importance of having accurate data on the key inputs used in the economy. The issue of alternative labour data sources is explored further in chapter 4.

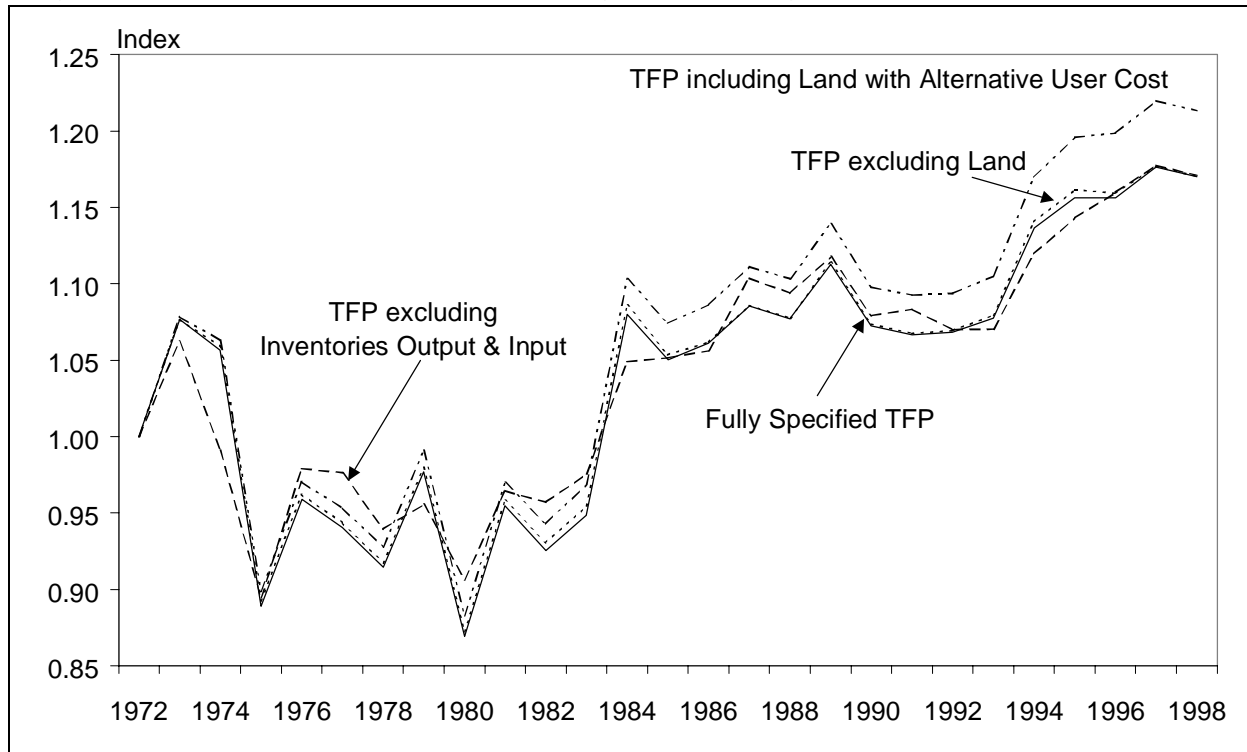
Land

Given the characteristics of the New Zealand data, the impact of excluding land from the coverage of inputs, on the other hand, has a negligible impact on TFP (see figure 3.5). This is because land has a relatively small (ex post) user cost (see appendix B) and consequently has a small weight in forming the overall total inputs index⁵. The main reason for land's relatively small user cost is the fact that it does not include a depreciation component – we assume that maintenance activities picked up elsewhere lead to the quality of land being held constant through time. Furthermore, increases in the observed price of land have led to significant capital gains which have largely offset (and in some years exceeded) the interest cost associated with holding land. This has led to land having a negative (ex post) user cost in some years. Where this occurs land effectively becomes an output instead of an input to the production process.

Depending on what methodology is used to measure user costs, including land can potentially have a significant impact on measured TFP. For instance, using a method that allocates a common real interest rate to all asset types as well as a common rate of asset inflation, Diewert and Fox (1998) found that including land in productivity calculations led to a 0.5 per cent per annum increase in the TFP growth rate for Japan for the period from 1955 to 1987. Including land whose quantity remains constant over time provides an offset against other inputs whose quantities are normally increasing through time. This leads to a lower value of the total inputs index and, hence, a higher level of TFP. This effect is reinforced using the simplified Diewert and Fox user cost approach as rapidly increasing land prices in countries like Japan (and, to a lesser extent, New Zealand) give progressively more weight to the constant quantity land input. Using the more sophisticated (ex post) user cost method of the current study, this effect is largely negated as the asset specific capital gains term offsets and in some cases exceeds the interest rate term leading to a small user cost value. The changing sign of the land input further reduces any effect it would otherwise have.

⁵ Ex post user costs (which use changes in asset prices actually observed) are more appropriate for measuring actual economic performance. Ex ante user cost concepts (which use expected instead of actual capital gains) are more appropriate for econometric modeling purposes.

Figure 3.5: Sensitivity of TFP to Including or Excluding Land and Inventories



To examine the potential impact of land using alternative user cost methods we have calculated TFP allocating land its stock price rather than its user cost price (but retaining the current user cost value in 1972). This is a crude approximation to the effect of including land using the common real return method. From figure 3.5 we see that including land in this way does indeed then increase measured TFP. By 1998 TFP is 3.7 per cent higher than using the current study's approach. This is enough to lift the trend annual TFP growth rate from 0.81 per cent to 0.93 per cent.

Inventories

Standard National Accounts conventions usually treat the change in inventories as an output but do not include the stock of inventories as an input. For comparison purposes it is, therefore, useful to examine the impact on TFP of excluding the stock of inventories from the list of inputs. From table 3.2 we can see that excluding inventories as an input while leaving other aspects of the specification unchanged leads to a negligible change in the level of measured TFP. Although the value of the stock of inventories is relatively high, we assume that the stock does not depreciate and hence its user cost (and the weight it receives in forming the total inputs index) is relatively low. Its sign also changes in those years where the proportional price increase for inventory stocks exceeded the interest rate. As in the case of land the user cost method we have adopted negates the importance of including inventory inputs.

Using alternative methods such as that of Diewert and Fox would lead to the inclusion of inventory stocks having a larger impact on measured TFP. This is particularly the case with nonagricultural inventories which decline in magnitude over the period and thus their inclusion with a higher and more stable weight decreases the rate of input growth hence increasing TFP. The reduction in the size of nonagricultural inventories is common across OECD economies with the increasing importance of computerisation and the use of 'just in time' inventory techniques.

Table 3.2: Input and TFP Indexes Under Alternative Labour and Land Specifications

Year	Total Input Index					TFP Index				
	D-L Labour Numbers	HLFS Labour Hours	HLFS Labour Numbers	Excl. Land	Excl. Invent- ories	D-L Labour Numbers	HLFS Labour Hours	HLFS Labour Numbers	Excl. Land	Excl. Invent- ories
1972	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1973	1.028	1.035	1.028	1.027	1.029	1.076	1.069	1.076	1.077	1.075
1974	1.073	1.074	1.079	1.069	1.078	1.054	1.054	1.049	1.059	1.050
1975	1.122	1.138	1.139	1.114	1.121	0.887	0.874	0.873	0.893	0.888
1976	1.141	1.187	1.163	1.133	1.138	0.955	0.919	0.937	0.962	0.958
1977	1.168	1.209	1.191	1.157	1.160	0.934	0.903	0.917	0.944	0.941
1978	1.187	1.237	1.213	1.172	1.172	0.906	0.869	0.886	0.917	0.917
1979	1.189	1.252	1.224	1.170	1.168	0.964	0.916	0.937	0.980	0.981
1980	1.201	1.265	1.247	1.178	1.180	0.855	0.812	0.823	0.872	0.870
1981	1.210	1.294	1.252	1.182	1.183	0.936	0.875	0.905	0.958	0.958
1982	1.233	1.304	1.271	1.202	1.206	0.907	0.857	0.880	0.931	0.927
1983	1.255	1.334	1.296	1.221	1.226	0.929	0.874	0.899	0.954	0.950
1984	1.267	1.362	1.301	1.233	1.238	1.057	0.983	1.030	1.086	1.082
1985	1.317	1.389	1.346	1.285	1.286	1.028	0.975	1.005	1.053	1.052
1986	1.364	1.450	1.405	1.333	1.332	1.038	0.976	1.008	1.062	1.063
1987	1.373	1.486	1.420	1.338	1.336	1.059	0.978	1.023	1.086	1.088
1988	1.385	1.492	1.433	1.347	1.345	1.048	0.973	1.013	1.078	1.079
1989	1.368	1.457	1.410	1.326	1.326	1.080	1.014	1.048	1.114	1.114
1990	1.370	1.470	1.416	1.325	1.325	1.038	0.967	1.004	1.074	1.073
1991	1.388	1.487	1.439	1.340	1.340	1.030	0.962	0.994	1.068	1.067
1992	1.386	1.470	1.431	1.329	1.331	1.026	0.967	0.993	1.069	1.068
1993	1.412	1.498	1.452	1.346	1.349	1.029	0.970	1.001	1.079	1.077
1994	1.455	1.553	1.495	1.377	1.383	1.079	1.012	1.051	1.140	1.136
1995	1.531	1.635	1.567	1.440	1.447	1.092	1.023	1.067	1.162	1.156
1996	1.603	1.699	1.633	1.502	1.507	1.086	1.025	1.066	1.159	1.156
1997	1.647	1.733	1.676	1.538	1.540	1.099	1.044	1.080	1.177	1.175
1998	1.659	1.748	1.693	1.541	1.544	1.087	1.032	1.066	1.170	1.169

The values of the total inputs and TFP indexes under the alternative labour, land and inventories specifications are presented in table 3.2. Total output remains unchanged in all cases.

As an additional sensitivity analysis we have also excluded the change in inventories from our output as well as excluding inventories from our input specification. From figure 3.5 excluding inventories totally serves to reduce the variability of the TFP index, particularly in the first half of the period, and reduces the size of the increase in TFP in 1984 but overall has little impact on TFP levels.

Computers

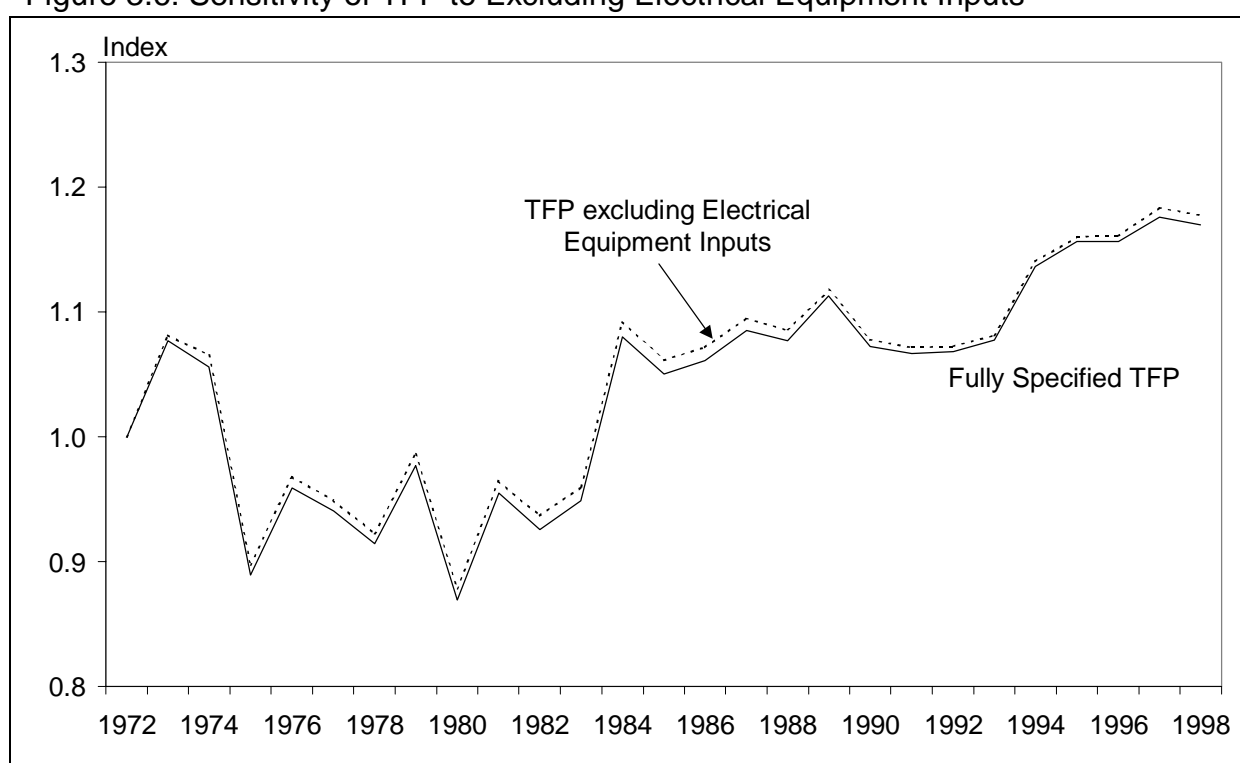
Computers are playing an ever increasing role in modern production methods. Accompanying rapid technological change has been an equally rapid fall in the effective price of computing power. How this should be allowed for in the National Accounts has been the subject of much debate – in some cases the use of fixed weight price indexes may have given too much importance to computer investment in recent years (see Sieper 1996). Statistics New Zealand currently uses the United States Bureau of Economic Analysis (BEA) hedonic computer price index which takes account of quality changes to deflate computer imports (after adjusting for the impact of exchange rate changes). The value of this price index had fallen by 80 per cent over the decade to 1998 leading to a large increase in the implied quantity of computer imports and investment. The impact of this on real GDP is not likely to be large as imports of and investment in computers largely offset each other but it can have significant implications for the size of the measured capital stock.

Given the importance of computers, we have identified electrical equipment as a separate component of the capital stock in the Diewert–Lawrence TFP database. It is formed from data on the value and price of imports of electrical equipment and machinery. The stock price of this component has fallen by 20 per cent over the past decade. Between 1972 and 1998 the price of the electrical equipment capital stock component increased by 170 per cent compared to around 550 per cent for both transport equipment and plant and other machinery. Although the reduction in recent years for our electrical equipment price index has been considerably less than the fall in SNZ's BEA based computer price index because electrical equipment include noncomputer equipment as well, the size of our stock of electrical equipment has still increased by more than 10 fold over the 27 year period. In 1972 the implicit quantity of the electrical equipment stock was only around 20 per cent that of transport equipment but by 1998 the electrical equipment stock was 40 per cent larger than that of transport equipment.

To get a feel for the impact of this rapid growth in the implied stock of computer equipment on measured TFP, we have recalculated TFP excluding the electrical equipment stock. From figure 3.6 we see that excluding electrical equipment leads to a small increase in measured

TFP, particularly during the 1980s. The gap between the two TFP indexes narrows during the 1990s as the effects of the increasing stock of computers are offset to some extent by the falling price of computers and other electrical machinery. By 1998 TFP is only 0.6 per cent higher if we exclude the electrical equipment input. While simply excluding computer inputs is equivalent to assuming they move in the same proportion as total included inputs, it is preferable to include them as accurately as possible. This sensitivity analysis does, however, show that, using our framework, issues associated with measuring computer inputs are unlikely to account for a large component of overall productivity change.

Figure 3.6: Sensitivity of TFP to Excluding Electrical Equipment Inputs



3.4 Comparison with Australia

Given the similarities in structure, institutional background and history of the New Zealand and Australian economies, it is informative to compare the two countries' recent productivity performance.

Diewert and Lawrence (1997, 1998b) constructed a database for Australia covering the years 1967 to 1994 along similar lines to that used in the current study for New Zealand. In this study we have updated this database to 1997 and made revisions to it to put it on as comparable a footing as possible with the New Zealand database. The major remaining differences between our Australian and New Zealand databases are:

- the Australian database does not include a separate subsidies output nor separate resources and fuel tax inputs;
- the Australian database contains less detail on consumption components; and
- the Australian database does not have separate treatment of computers or electrical equipment.

While containing less detail than our New Zealand database, the Diewert–Lawrence Australian database provides a good like with like comparison.

The other major Australian productivity series is the Australian Bureau of Statistics' (ABS) 'multifactor' productivity (MFP) index. The ABS MFP index uses some of the techniques used in the Diewert–Lawrence TFP databases. For instance, agricultural land and inventories are included, a simple user cost of capital formula is used to calculate an internal rate of return and user cost weighted capital inputs and labour inputs are aggregated using a Törnqvist index (see Aspden 1990). However, important differences between the ABS MFP and Diewert–Lawrence series remain. These include:

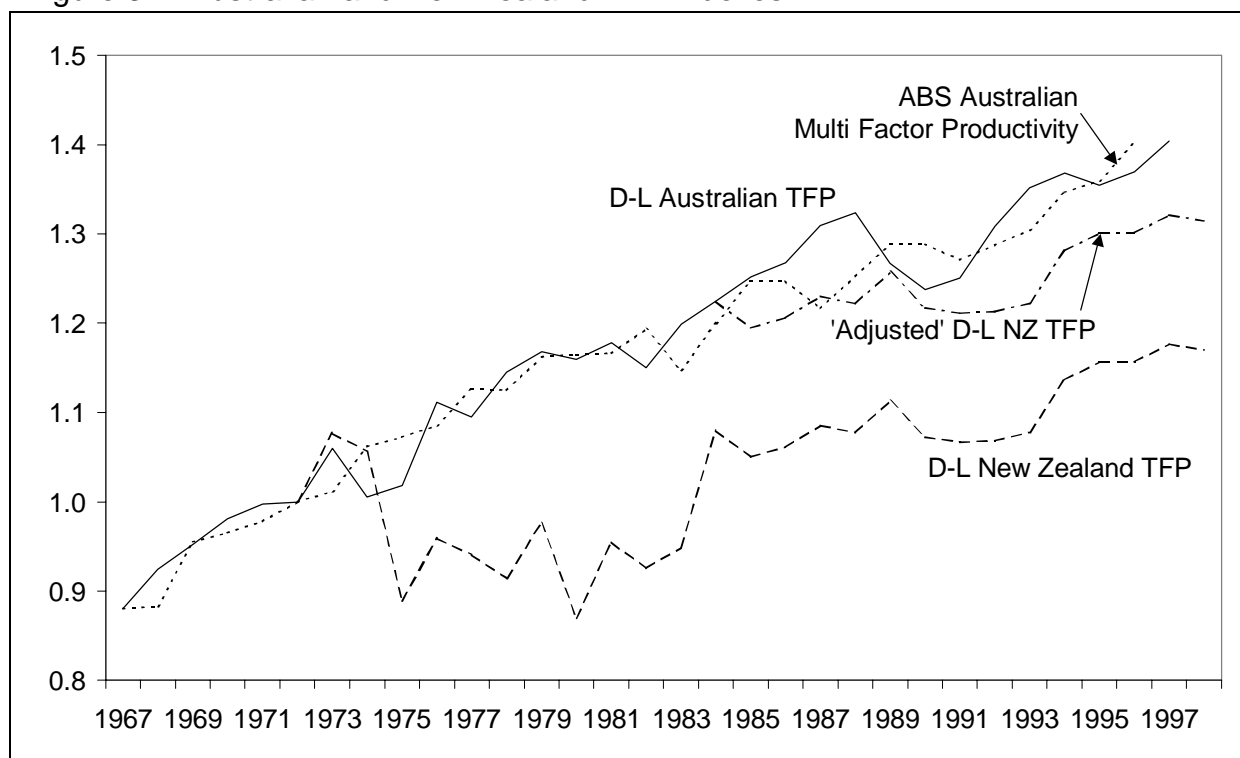
- the ABS MFP database is not in producer prices;
- the ABS does not include non–agricultural land but does include real estate transfer expenses;
- the ABS take a weighted average of net and gross official capital stock estimates whereas Diewert–Lawrence use their own net capital stock estimates derived from ABS information;
- the ABS exclude the difficult to measure Finance and Community services sectors whereas Diewert–Lawrence cover all of the market sector.

The two Australian TFP indexes and the Diewert–Lawrence New Zealand TFP index are shown in figure 3.7 and table 3.3. The ABS MFP and Diewert–Lawrence Australian TFP indexes are very similar from 1967 right through until 1996, the latest year for which the ABS MFP index is currently available. The Diewert–Lawrence Australian TFP index fluctuates more in some periods than the ABS MFP index with the recession of the early 1990s being more pronounced in our index. As we shall see in the following chapter, the difference in sectoral coverage of the two series is likely to explain some of these differences. Overall, however, the two indexes are in very close agreement.

Basing the three indexes in 1972, the starting year for the New Zealand series, highlights a fundamental difference between Australian and New Zealand productivity performance, particularly during the 1970s. Whereas Australia's productivity has generally increased steadily over the last three decades, New Zealand's poor productivity performance during the decade from 1972 on has left a substantial gap between New Zealand and Australian

performance when viewing the period as a whole. This is highlighted by 'adjusting' the New Zealand series upwards to start from the same value as the Diewert–Lawrence Australian index in 1984. From figure 3.7 we see that this reduces the gap between Australian and New Zealand performance in 1997 from around 16 per cent of the Australian TFP index's value down to 6 per cent.

Figure 3.7: Australian and New Zealand TFP Indexes



The differences in performance are further highlighted by comparing trend growth rates. For the period from 1972 onwards, the ABS MFP index grew at a trend annual rate of 1.20 per cent and the Diewert–Lawrence Australian index grew at a trend annual rate of 1.25 per cent. The Diewert–Lawrence New Zealand index, on the other hand, only grew at a trend annual rate of 0.81 per cent. If we take the period from 1984 onwards the difference in trend annual growth between the two Diewert–Lawrence series is reduced with the Australian index growing at 0.85 per cent compared to the New Zealand index's 0.61 per cent. The ABS MFP series continues to grow strongly after 1984 with a trend annual growth rate of 1.06 per cent.

The sources of the difference between Australian and New Zealand productivity growth can be seen from table 3.3. Between 1972 and 1997, Australia's total output increased by 125 per cent whereas New Zealand's output only increased by 81 per cent. Until 1990, however, Australia's proportionate increase in total input use since 1972 was less than New Zealand's and by 1996 Australia and New Zealand had both had the same proportionate increase in total input use of roughly 50 per cent despite Australia's considerably larger increase in output.

Table 3.3: TFP, Output and Input Indexes for Australia and New Zealand

Year	ABS	Diewert–Lawrence Australia			Diewert–Lawrence New Zealand		
	Multifactor Productivity	Output Index	Input Index	TFP Index	Output Index	Input Index	TFP Index
1967	0.880	0.761	0.864	0.881			
1968	0.883	0.824	0.891	0.924			
1969	0.955	0.867	0.911	0.952			
1970	0.965	0.925	0.943	0.981			
1971	0.978	0.972	0.975	0.998			
1972	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1973	1.012	1.086	1.025	1.060	1.106	1.027	1.077
1974	1.062	1.056	1.050	1.006	1.132	1.072	1.056
1975	1.072	1.058	1.039	1.018	0.995	1.119	0.889
1976	1.085	1.140	1.026	1.111	1.090	1.137	0.959
1977	1.126	1.128	1.030	1.095	1.092	1.161	0.941
1978	1.125	1.181	1.031	1.145	1.075	1.175	0.914
1979	1.162	1.224	1.048	1.168	1.146	1.173	0.977
1980	1.165	1.259	1.086	1.159	1.027	1.181	0.869
1981	1.166	1.301	1.104	1.178	1.133	1.186	0.955
1982	1.193	1.283	1.116	1.150	1.118	1.208	0.926
1983	1.147	1.322	1.102	1.199	1.166	1.229	0.949
1984	1.200	1.367	1.116	1.225	1.340	1.240	1.080
1985	1.247	1.451	1.159	1.252	1.354	1.289	1.050
1986	1.247	1.512	1.193	1.268	1.416	1.334	1.061
1987	1.216	1.601	1.223	1.309	1.453	1.339	1.085
1988	1.253	1.669	1.262	1.323	1.451	1.347	1.077
1989	1.289	1.681	1.326	1.267	1.477	1.327	1.113
1990	1.289	1.704	1.376	1.238	1.422	1.326	1.072
1991	1.271	1.718	1.374	1.251	1.430	1.341	1.067
1992	1.287	1.770	1.352	1.309	1.421	1.331	1.068
1993	1.304	1.833	1.357	1.351	1.453	1.348	1.078
1994	1.347	1.909	1.396	1.368	1.571	1.382	1.137
1995	1.360	1.974	1.457	1.355	1.672	1.446	1.156
1996	1.402	2.051	1.497	1.370	1.742	1.506	1.156
1997		2.125	1.513	1.404	1.810	1.539	1.176
1998					1.804	1.542	1.170

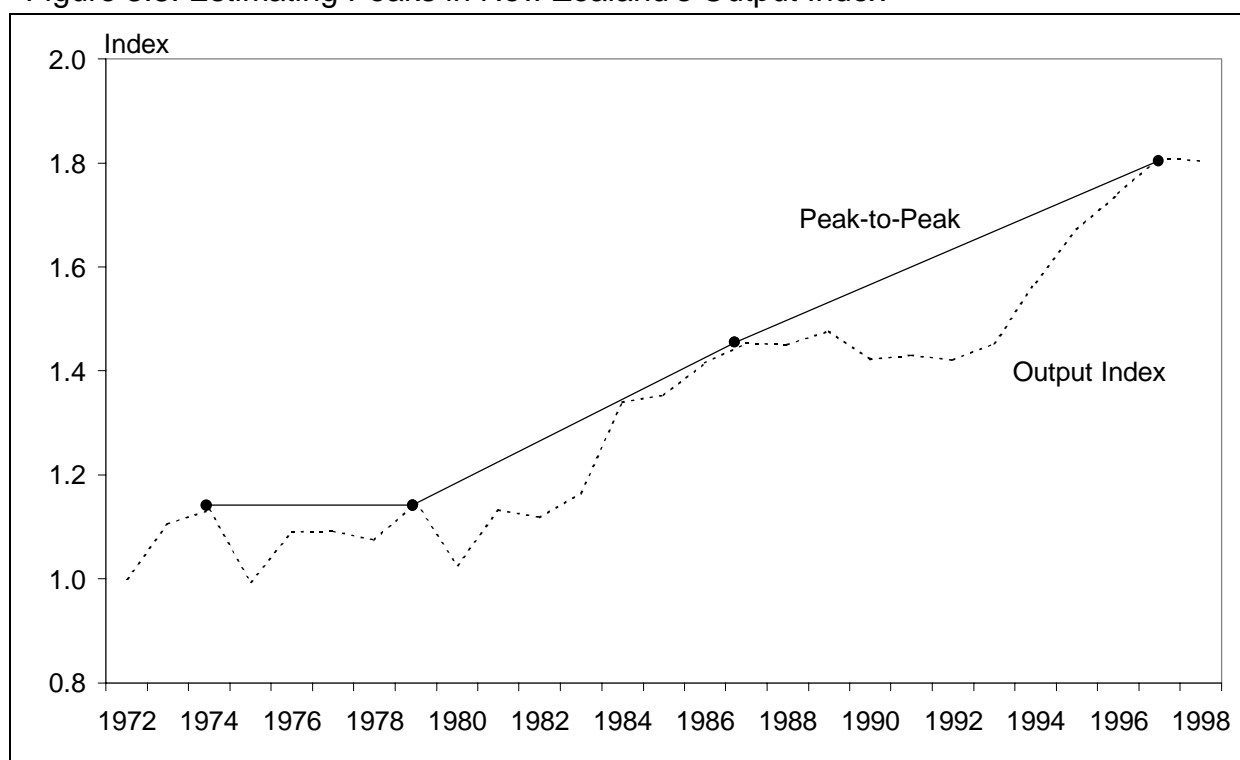
3.5 Peak to peak Growth Rates

Productivity growth rates are sometimes reported on a ‘peak to peak’ basis. By choosing points which are at the peak of the business cycle it is thought that reporting productivity growth rates between these points gives an indication of underlying changes in efficiency

abstracting from changes in utilisation associated with business cycle effects (see Hall 1996). This goes some way towards treating capital in a similar fashion to labour where the hours input measure captures labour utilisation rather than availability. By choosing peaks rather than troughs or midpoints as the appropriate comparison points we are more likely to have similar levels of capital utilisation. The peaks are usually chosen on the basis of output quantity (or real GDP).

In figure 3.8 we have estimated that output peaks occurred in 1974, 1979, 1987 and 1997 on the basis of changes in the output quantity index. Between the 1974 and 1979 peaks TFP actually declined at an annual rate of 1.6 per cent. This then turned around to an annual growth rate of 1.3 per cent between the 1979 and 1987 peaks. Growth then fell somewhat to an annual rate of 0.8 per cent between the 1987 and 1997 peaks, coinciding with the trend annual rate of TFP growth for the 27 years from 1972 to 1998 of 0.81 per cent.

Figure 3.8: Estimating Peaks in New Zealand's Output Index



3.6 Testing for Structural Breaks

Given the extent of major policy reforms New Zealand has introduced since 1984, one focus of this study has been to test whether there are identifiable structural breaks in the rate of productivity growth around the time of the reforms. The reforms have been ongoing but it is possible to group them around two time periods. In 1984 and 1985 many changes were introduced affecting the operations of capital markets and the financial sector and the process of industry deregulation and liberalisation of international trade was begun. Major tax reform

and the corporatisation of government enterprises were begun in 1986. The second key time period relates to the introduction of major labour market reforms in the form of the 1991 Employment Contracts Act. Major reforms affecting resource use and social services also began around 1991. Bollard, Lattimore and Silverstone (1996) provide a detailed listing of relevant reforms.

On the basis of 'eyeballing' figure 3.2 there appear to be four distinct segments between 1972 and 1998 with differing TFP growth rates. These are a downward sloping segment between 1972 and 1982, a sharp increase between 1982 and 1984, a relatively flat period between 1984 and 1993 and a generally increased rate of growth after 1993 (excluding 1996 and 1998). Consequently, we initially test for structural breaks in 1982, 1984 and 1993 using linear splines (see Diewert and Wales 1993). We also test separately for a structural break in 1991.

Table 3.4: Testing for Structural Breaks

<i>Period</i>	<i>Variable</i>	<i>Coefficient</i>	<i>t-statistic</i>	<i>Growth Rate</i> <i>%pa</i>
<i>Regression 1 – Full Sample</i>				
	Constant	0.0315	1.260	
1972–1982	Time trend	-0.0126	-3.467	-1.26
1982–1984	Spline 1	0.0955	5.269	8.29
1984–1993	Spline 2	-0.0797	-4.350	0.32
1993–1998	Spline 3	0.0140	1.367	1.72
<i>Regression 2 – Sample from 1980 Onwards</i>				
	Constant	-0.5542	-7.045	
1980–1984	Time trend	0.0464	6.880	4.64
1984–1993	Spline 1	-0.0415	-4.926	0.49
1993–1998	Spline 2	0.0115	1.654	1.64
<i>Regression 3 – Sample from 1980 Onwards</i>				
	Constant	-0.5609	-6.864	
1980–1984	Time trend	0.0470	6.660	4.70
1984–1991	Spline 1	-0.0433	-4.602	0.37
1991–1998	Spline 2	0.0093	1.509	1.30
<i>Regression 4 – Social TFP: Sample from 1980 Onwards</i>				
	Constant	-0.5508	-6.330	
1980–1984	Time trend	0.0443	5.948	4.43
1984–1993	Spline 1	-0.0433	-4.646	0.10
1993–1998	Spline 2	0.0190	2.478	2.00

The linear spline technique for testing for changes in growth rates involves regressing the natural logarithm of the dependent variable on a time trend (starting at zero in the first year) and introducing an additional time trend (or 'spline') which starts from a value of one the

year after the change is thought to have taken place. The spline variable has a value of zero for years up to and including the year where the structural break is being tested for. If the spline has a statistically significant coefficient then the structural break is significant. The growth rate for the second period is equal to the sum of the coefficients on the first time trend and the spline. Additional break points can be tested for by introducing additional splines.

From table 3.4 we see that running the regression over the full period from 1972 to 1998 indicates that the breaks in 1982 and 1984 are both significant but the break in 1993 is not significant. The annual growth rates go from -1.3 per cent for the decade from 1972, to a high of 8.3 per cent for the two years after 1982, to a small positive growth rate of 0.3 per cent for the 9 years after 1984, to a growth rate of 1.7 per cent after 1993.

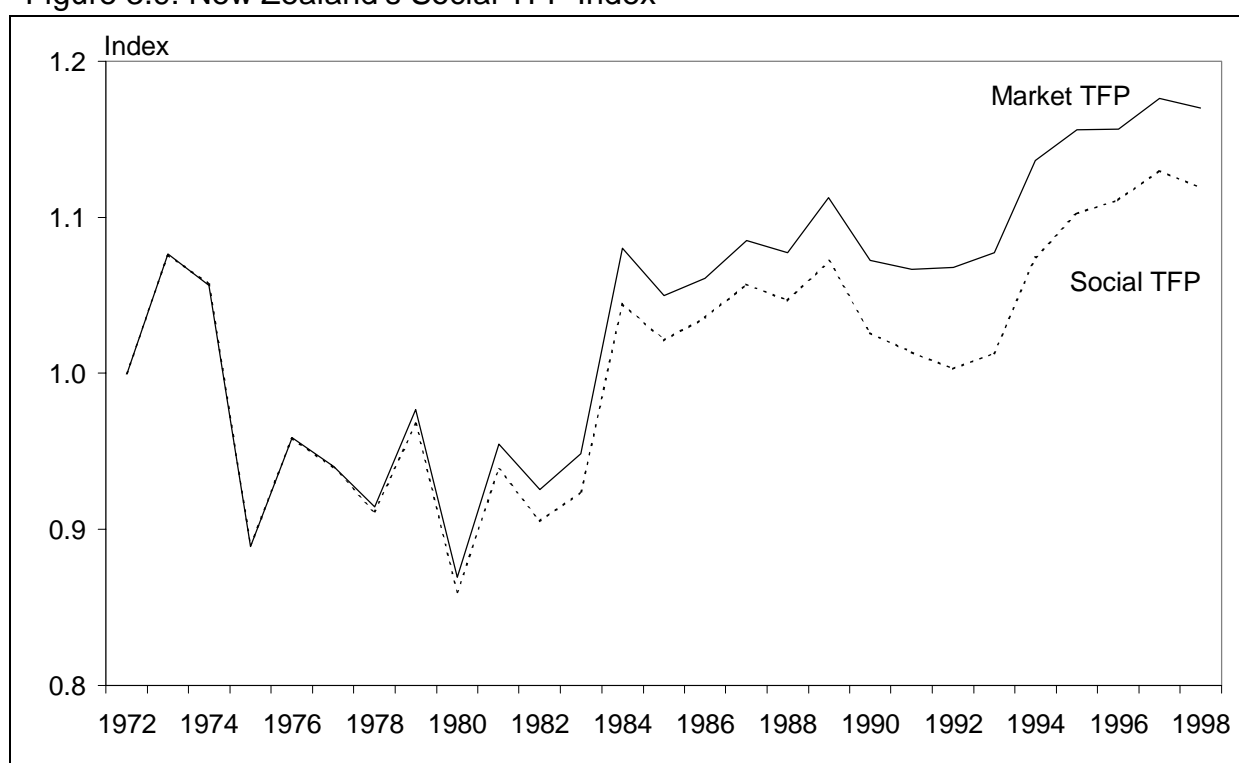
The high degree of variability in the TFP index for the first decade means that it will be difficult to fit a time trend for this period with low variances. This will correspondingly influence the accuracy of the subsequent spline tests. A more accurate measurement with lower variances can be obtained for the period after 1980. Consequently, we have fitted a second regression for the period from 1980 onwards and tested for structural breaks in 1984 and 1993. This procedure can be viewed as a heteroskedasticity adjustment. The results of this regression are also presented in table 3.4 and indicate that while the t -statistic for the 1993 break spline coefficient increases somewhat, it is still statistically insignificant. The growth rate falls from 4.6 per cent before 1984 to 0.5 per cent between 1984 and 1993 before again increasing to 1.6 per cent post 1993.

Given the interest in the immediate impact of the labour market reforms introduced in 1991 we have also repeated the post 1980 regression to test for structural breaks in 1984 and 1991. The results are presented as Regression 3 in table 3.4. The significance of the second break point is less when it is located at 1991 instead of 1993 and this break is again statistically insignificant. The growth rate in this instance falls from 4.7 per cent before 1984 to 0.4 per cent between 1984 and 1991 before again increasing to 1.3 per cent post 1991.

Given the importance of labour market reforms in New Zealand we have also calculated a more broadly defined 'social TFP' index. This definition of TFP includes as an additional input the number of unemployed (valued at a shadow wage rate of two thirds that applying to the unskilled Production workers occupation). With this inclusion, the full social cost of having unemployed labour lying idle is taken into account. Increases in unemployment are reflected in an increase in total inputs leading to a reduction in social TFP. Conversely, a reduction in unemployment is reflected in a relative reduction in total inputs and an improvement in social TFP.

The rate of unemployment in New Zealand has gone from a low of less than half of one per cent in the early to mid 1970s to a high of over 10 per cent in the early 1990s and has subsequently fallen to less than 7 per cent. The effect of including the unemployed on TFP is shown in figure 3.9. The gap between TFP and social TFP is widest in the early 1990s and then progressively narrows as unemployment falls in the mid 1990s. It highlights the initial restructuring cost of the reform process with higher levels of unemployment at a time when unemployment was rising in most western countries. However, following the freeing up of the labour market in 1991, the improved performance associated with reduced unemployment levels is highlighted by a larger upturn in the social TFP index between 1992 and 1997 of 12.7 per cent compared to 10 per cent for the standard TFP index.

Figure 3.9: New Zealand's Social TFP Index



The superior performance of the economy after 1993 is highlighted by the tests for structural breaks in social TFP presented in table 3.4. We see a lower growth of social TFP between 1984 and 1993 compared to market TFP followed by a higher growth rate of social TFP after 1993. The structural break in 1993 is now statistically significant for social TFP. Social TFP has grown at an annual trend rate of 2.0 per cent after 1993.

3.7 Contributors to Economic Growth

The relative importance of different sources of economic growth has been of considerable interest to policymakers. In particular, the importance of changes in the terms of trade (the ratio of export prices to import prices) to national welfare has received much attention (see,

for example, Smith and Grimes 1990). If a country's terms of trade are declining then it is able to purchase a smaller quantity of imports in exchange for a given quantity of exports over time. This means national welfare will be falling unless the country is able to generate productivity improvements sufficient to offset the deteriorating terms of trade. Productivity improvement allows the country to produce more exports from a given quantity of inputs over time and hence maintain or even improve its ability to purchase imports from the rest of the world in spite of the adverse international price movements it faces. This effect has the potential to be quite important for a small trading economy like New Zealand.

Diewert and Morrison (1986) developed a method for adjusting productivity change for changes in the nation's terms of trade. This has recently been extended by Fox and Kohli (1998) to decompose changes in a country's nominal GDP into changes due to growth in labour and capital endowments, changes in the terms of trade, productivity change and changes in nontraded goods prices. The approach is based on the translog 'GDP function' developed by Kohli (1978) and extended by Lawrence (1989, 1990) and uses index number manipulation to isolate changes in nominal GDP due to each of the factors, assuming all else remained unchanged.

In table 3.5 we present the year on year changes in GDP due to each of the five factors and construct indexes which show how GDP would have moved over the 21 years 1978 to 1998 if only the individual factor had changed and all else had remained unchanged from 1978 onwards. We present the results for the shorter period from 1978 onwards for consistency with the results of the official database discussed in detail in the following chapter.

Around 70 per cent of the change in nominal GDP between 1978 and 1998 was accounted for by changes in nontraded goods prices, or domestic inflation. In the remainder of this section we concentrate on the other four factors which contribute to changes in real GDP. In figure 3.10 we plot the individual effect indexes listed in table 3.5 for labour and capital endowments, the terms of trade and productivity change.

The terms of trade actually has the smallest impact on real GDP over the 20 years of the four factors examined. Although a deterioration in the terms of trade between 1978 and 1986 would have reduced real GDP by around 10 per cent, all else unchanged, this was quickly recovered between 1986 and 1990 and plateaued at a level around three per cent below 1978 real GDP from 1992 onwards.

The impact of labour input changes on real GDP, all else unchanged, has fluctuated but by 1998 would have only increased real GDP by around 7 per cent. Capital endowment changes would have increased real GDP by around 20 per cent over the 21 years, all else unchanged, with a more steady effect than labour changes.

Table 3.5: Individual Contributors to Changes in New Zealand's Nominal GDP

Year	Year on Year Change						Individual Effect Indexes					
	Nom- inal GDP	Labour	Capital	Terms of Trade	Product ivity	Non- traded Prices	Nom- inal GDP	Labour	Capital	Terms of Trade	Product ivity	Non- traded Prices
1978							1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1979	1.2056	0.9912	1.0080	1.0137	1.0651	1.1176	1.2056	0.9912	1.0080	1.0137	1.0651	1.1176
1980	1.0235	1.0048	1.0025	1.0048	0.8892	1.1372	1.2338	0.9959	1.0105	1.0186	0.9471	1.2709
1981	1.2306	0.9988	1.0057	0.9522	1.1005	1.1692	1.5184	0.9947	1.0162	0.9699	1.0423	1.4859
1982	1.1608	1.0077	1.0110	0.9925	0.9689	1.1848	1.7626	1.0024	1.0274	0.9627	1.0098	1.7606
1983	1.1834	1.0056	1.0103	0.9820	1.0258	1.1563	2.0857	1.0080	1.0380	0.9453	1.0359	2.0357
1984	1.1749	0.9997	1.0098	0.9871	1.1424	1.0322	2.4506	1.0077	1.0481	0.9331	1.1834	2.1013
1985	1.0766	1.0247	1.0130	0.9789	0.9718	1.0903	2.6384	1.0326	1.0618	0.9135	1.1499	2.2910
1986	1.1753	1.0188	1.0135	0.9951	1.0120	1.1303	3.1008	1.0519	1.0762	0.9090	1.1637	2.5895
1987	1.1297	0.9949	1.0083	1.0177	1.0222	1.0825	3.5029	1.0465	1.0851	0.9250	1.1896	2.8032
1988	1.0923	0.9987	1.0075	1.0444	0.9927	1.0471	3.8264	1.0452	1.0932	0.9660	1.1810	2.9353
1989	1.0534	0.9765	1.0049	1.0161	1.0347	1.0210	4.0307	1.0207	1.0985	0.9816	1.2220	2.9968
1990	1.0191	0.9849	1.0115	1.0112	0.9618	1.0518	4.1076	1.0052	1.1112	0.9926	1.1753	3.1521
1991	1.0364	0.9983	1.0080	0.9811	0.9945	1.0556	4.2573	1.0035	1.1201	0.9738	1.1689	3.3274
1992	1.0046	0.9900	1.0003	0.9877	1.0014	1.0258	4.2768	0.9934	1.1204	0.9618	1.1705	3.4131
1993	1.0342	1.0071	1.0041	1.0037	1.0093	1.0095	4.4231	1.0005	1.1250	0.9654	1.1814	3.4456
1994	1.0896	1.0159	1.0098	1.0068	1.0585	0.9967	4.8194	1.0164	1.1360	0.9719	1.2505	3.4343
1995	1.1026	1.0277	1.0165	1.0019	1.0185	1.0343	5.3141	1.0445	1.1548	0.9738	1.2737	3.5523
1996	1.0725	1.0279	1.0142	0.9977	1.0001	1.0311	5.6994	1.0737	1.1712	0.9715	1.2737	3.6628
1997	1.0531	1.0113	1.0121	0.9990	1.0182	1.0114	6.0018	1.0858	1.1853	0.9706	1.2970	3.7046
1998	1.0037	0.9927	1.0086	0.9984	0.9944	1.0098	6.0242	1.0779	1.1955	0.9691	1.2897	3.7408

Productivity change, on the other hand, would have increased real GDP by around 29 per cent over this period, all else unchanged. From 1984 onwards the contribution of productivity change to changes in real GDP has been far greater than any of the other three factors. In particular, productivity improvements have far outweighed the effect of terms of trade changes and have also been more important than increases in either labour or capital endowments.

By progressively multiplying the individual effect indexes together we can obtain the cumulative effect of multiple factors on real GDP growth. In figure 3.11 we see the effect of labour changes in isolation, labour and capital changes combined, labour, capital and terms of trade changes combined and, finally, these three effects plus productivity change combined (which equals the actual change in real GDP). This graph again highlights the overriding importance productivity change has had in increasing New Zealand's real GDP, particularly from 1993 onwards.

Figure 3.10: Individual Contributors to New Zealand's Real Net Output

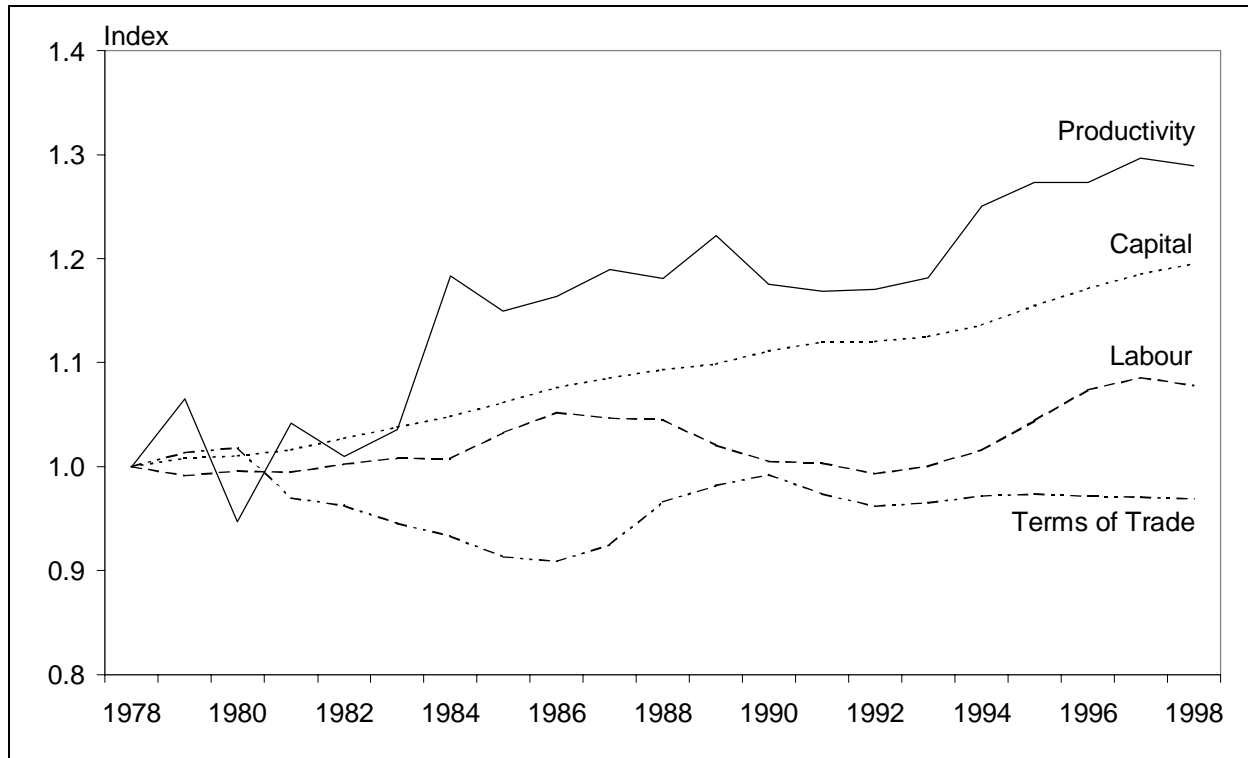
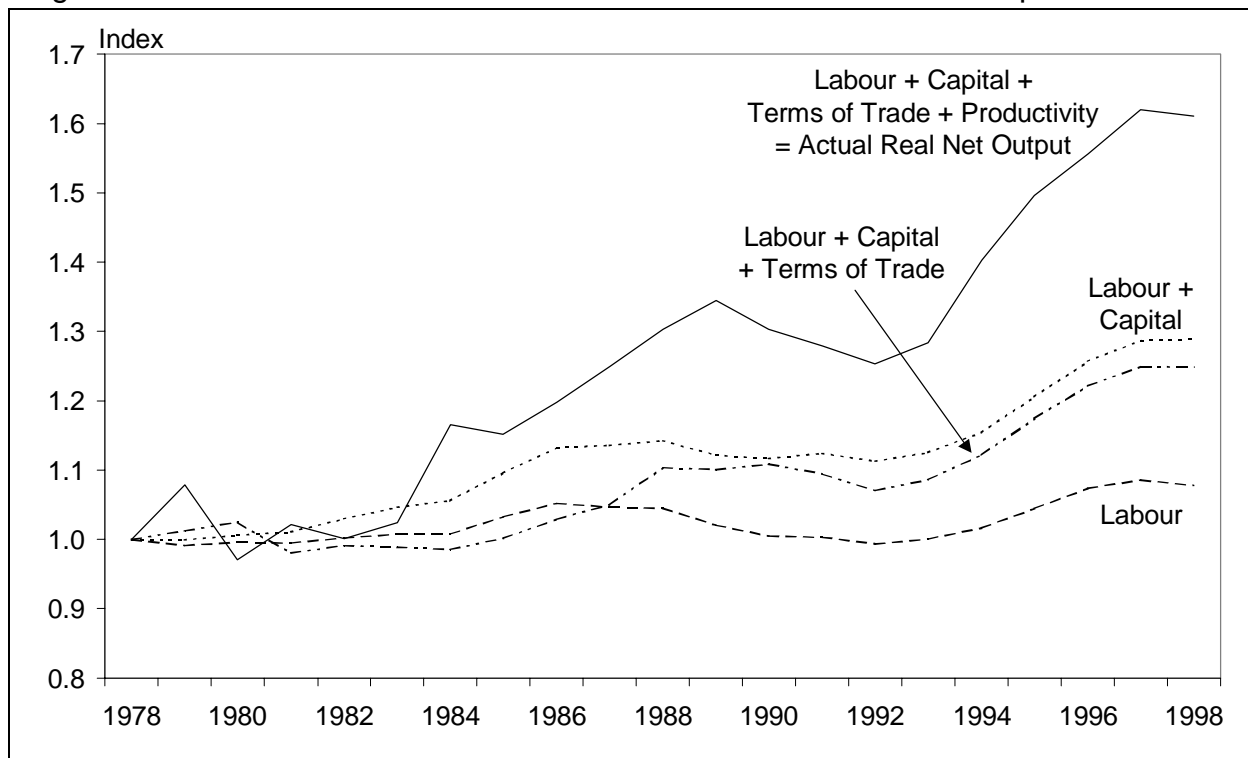


Figure 3.11: Cumulative Contributions to New Zealand's Real Net Output



4. NEW ZEALAND TFP ESTIMATES USING THE 'OFFICIAL' DATABASE

The 'official' database uses generally available SNZ data on production GDP, labour and capital for 20 separate market sector industries. Capital inputs for the 20 industries are formed using a range of assumptions about the length of asset lives and depreciation. Both the net and gross capital stock based official TFP indexes follow the same general pattern as the Diewert–Lawrence TFP index although they tend to lie below the Diewert–Lawrence index from 1984 onwards. The official net capital stock based TFP series always lies above that based on the gross capital stock estimates with the divergence between the two progressively increasing. Examining the impact of different capital length of life assumptions shows the long life version having the lowest rate of TFP increase and the short life version the highest increase.

A TFP index formed using expenditure rather than production GDP as the output measure tends to fluctuate more than the production based measure, particularly in the first half of the period. Removing the Finance and Community services industries to form a productivity index equivalent to that of the Australian Bureau of Statistics' multifactor productivity index has the effect of substantially raising New Zealand's TFP performance from 1988 onwards relative to the full market sector official index. While New Zealand's 'ABS equivalent' TFP performance closely mirrored Australia's up until 1993, between 1993 and 1996 the equivalent New Zealand index opened up a gap relative to that for Australia. Using the official database there is a statistically significant increase in TFP growth after 1993. This is particularly the case for the 'ABS equivalent' index where the post 1993 upturn is more pronounced.

4.1 The 'Official' Database

An important objective of this project has been to construct TFP estimates using a standard, 'official' database based on generally available SNZ National Accounts and survey information. Using such a database provides a comparison point for results obtained from the more detailed Diewert–Lawrence database and facilitates sensitivity analyses across a wide range of capital, output and labour specifications and sources. It also allows us to construct

sectoral productivity estimates, something which is not currently possible with the aggregate level Diewert–Lawrence database.

The ‘official’ database supplied by the Department of Labour, the Reserve Bank and the Treasury for this purpose consists of detailed information on GDP, labour and capital. GDP information covers real and nominal series for production, expenditure and income based GDP covering varying time periods and varying levels of disaggregation. Of particular interest are a detailed set of Annual Production Accounts which present a breakup of income based GDP for 27 two digit sectors. Labour information covers one and two digit level series from three sources: the Household Labour Force Survey (HLFS), the Quarterly Employment Survey (QES) and the Economic Survey of Manufacturing (ESM). Also included is a composite series for two digit industries drawing on all three sources plus additional work by the New Zealand Institute for Economic Research (NZIER) and Bryan Philpott. Capital information covers nominal and real investment in Buildings and construction and Plant and equipment at the two digit level from 1950 onwards. The contents of the official database are described in detail in Keegan (1998), a summary of which appears as appendix C to this report.

To advance the analysis in a structured and consistent way we have had to make a number of decisions on industry coverage, the time period covered and a preferred ‘base case’ set of TFP estimates. To maximise comparability with other TFP estimates including those of the OECD and those derived from the Diewert–Lawrence database and to minimise the influence of measurement problems, our official database TFP estimates cover the market sector of the New Zealand economy. Ownership of dwellings is excluded due to measurement problems and difficulties in interpreting its contribution to productivity. Sufficient information was available for us to proceed at the level of 20 separate market sector industries for production GDP, labour and capital. The 20 industries included are listed in table 4.1.

Table 4.1: The 20 Market Sector Industries Covered

Agriculture	Basic Metal Product Manufacturing
Fishing and Hunting	Machinery and Equipment Manufacturing
Forestry and Logging	Other Manufacturing
Mining and Quarrying	Electricity, Gas and Water
Food and Tobacco	Construction
Textiles, Clothing and Footwear Manufacturing	Trade, Restaurants and Hotels
Wood and Wood Products Manufacturing	Transport and Storage
Pulp and Paper Products, Printing and Publishing	Communications
Petroleum, Chemical, Plastics and Rubber Products	Finance, Insurance, Real Estate and Business Services
Non-Metallic Mineral Products Manufacturing	Community, Social and Personal Services

Official database series are available for varying time periods and a mixture of quarterly and yearly bases. The information we needed was available for most relevant variables in March

year format for the period 1978 to 1998 and all results are presented on this basis. This has the added advantage of maximising comparability with the Diewert–Lawrence database results which cover the March years from 1972 to 1998. For some of the detailed nominal series information was only available up to 1995. These series have been updated to 1998 by pro-rating the relevant aggregates as outlined in appendix C which also contains a listing of the various series used.

TFP estimates are constructed using chained Fisher indexes of GDP, labour and capital built up from separate series for the 20 industries listed in table 4.1 wherever possible. This has the advantage of utilising as much information as possible while providing a consistent basis for calculating separate TFP series for each of the 20 industries. The 20 separate industry TFP results are reported in the following chapter while this chapter concentrates on aggregate level results and sensitivity analyses for alternative output and input specifications. To facilitate the sensitivity analyses we have had to settle on a preferred base case set of TFP estimates. The base case used includes:

- production GDP aggregated across the 20 industries using chained Fisher indexes;
- the official database's composite two digit labour series for the 20 industries drawn from the HLFS, QES, ESM and other sources; and
- net capital stocks for Building and construction and Plant and equipment for each of the 20 industries weighted by user costs and based on industry-specific depreciation and length of life assumptions derived from the work of Bryan Philpott (1992).

In the following four sections of this chapter we present TFP sensitivity analyses for:

- capital – gross and net capital stocks using different length of life, depreciation and weighting assumptions;
- output – production and market sector expenditure GDP;
- labour – manufacturing and service sector TFP using the HLFS, QES and various composite sources; and
- functional forms – Cobb–Douglas, CES, Laspeyres, Paasche, Törnqvist and Fisher indexes.

Following this, we construct TFP estimates which are as close as possible to the ABS multifactor productivity series for Australia, calculate peak to peak TFP growth rates, test for structural breaks and compare our results with OECD estimates for New Zealand and other countries and the results of earlier New Zealand studies.

4.2 Capital Input Specifications

Capital inputs typically pose the largest problems in constructing a TFP database due to their durability. A capital good purchased this period will provide ongoing inputs to the production process over many years. Labour and materials purchases, on the other hand, are typically used up in the period they are purchased in. The problem is how to allocate both the quantity and cost of capital over its lifetime. Most TFP studies assume that the quantity of capital input in any one period – its service flow – is proportional to the stock of capital in existence that period. But there are many ways of calculating the stock of capital depending on assumptions about the length of life of different capital assets and the rate at which the service they provide deteriorates through time.

At this stage New Zealand only has official estimates of capital investment. SNZ is currently constructing official capital stock estimates but these are unlikely to be available before mid-1999. In forming TFP estimates for New Zealand it is, therefore, necessary to construct capital stock estimates. Even in countries where official capital stock estimates are available, many researchers prefer to form their own estimates as their beliefs about the economic characteristics of capital may differ from statistical agency practice. Since capital stock estimates typically have a major impact on measured TFP, in this section we examine the impact on TFP of a range of assumptions made in forming the capital stock estimates.

The first major choice to be made in forming capital stock estimates is whether to use the gross or net capital stock approach. The gross capital stock approach assumes that a capital good delivers a constant service flow over its entire life. Maintenance prevents the 'efficiency' of the asset from deteriorating until it suddenly collapses at the end of its life. This is often referred to as the 'one hoss shay' or 'light bulb' depreciation assumption. Capital stock estimates are easy to form under the gross approach as it simply involves summing past investment in constant prices for as far back as the assumed length of life of the asset. The real gross capital stock in period t , K_t^G , is then given by:

$$(1) \quad K_t^G = \sum_{i=1}^L I_{t-i}$$

where I_t is real investment in period t and L is the assumed length of life of the asset.

In the net capital stock approach the service flow from an asset is assumed to fall through time as the capital good deteriorates. Real net capital stock, K_t^N , is calculated using the following declining balance formula:

$$(2) \quad K_t^N = (1-\delta)K_{t-1}^N + I_t$$

where δ is the assumed depreciation rate. This approach assumes that a certain proportion of the capital stock is retired each period. The next period's net capital stock is then equal to the

previous period's capital stock multiplied by one minus the proportion of the stock retired plus new investment. To be operational the net capital stock formula (2) requires a starting estimate of the value of the net stock.

In many ways the gross and net capital stock approaches represent limiting assumptions about the rate at which the efficiency of capital inputs decline through time. Some argue that the gross capital approach of effectively assuming no deterioration is more appropriate for Buildings and structures while the net capital stock approach of assuming a steady deterioration is more appropriate for Plant and equipment. As noted in the previous chapter, the ABS actually takes weighted averages of the gross and net capital stock estimates with the weights varying by asset type to more closely approximate deterioration patterns estimated by the US Bureau of Economic Analysis. In general, we believe the net capital stock approach provides a closer approximation to the contribution of capital assets to the production process and better approximates economic depreciation.

To form gross capital stock estimates for long-lived assets we need a long time series of real investment. In the official database we have estimates of real investment for each of the 20 industries back to 1950. For some of the manufacturing industries real investment is provided for a longer period. We also have estimated gross capital stocks for 1950 for each industry and the two asset types considered by Bryan Philpott (1992). In the interests of having as consistent a set of estimates as possible, we have formed estimates of pre 1950 real investment by taking Philpott's 1950 stock estimates by industry and asset type and distributing them equally across 1950 and preceding years back as far as the assumed asset life. This procedure leads to our gross capital stock estimates for 1950 coinciding with Philpott's. We have furthermore assumed that the gross and net capital stock estimates were equal in 1950. This is equivalent to assuming that the economy was in a 'steady state' in 1950 where retirements under the gross and net capital stock models are equal¹. This provides consistent starting values for the net capital stock formula (2) of the Philpott estimates in 1950. We then assume that the depreciation rate used in the net model is the reciprocal of the equivalent asset life assumed in the gross model. The Philpott estimated stocks for 1950 (expressed in 1992 prices) and Philpott's estimated asset life² for each of the 20 industries and two asset types are listed in table 4.2.

Having constructed gross and net capital estimates, the next task is to assign each of the asset types a user cost to be used in forming the total input index. Some studies have simply allocated the value of gross operating surplus (GDP less compensation of employees) to

¹ With fresh capital investment after the war the 1950 gross capital stock may have been higher than the net stock but our TFP estimates will be relatively insensitive to this.

² SNZ (1998) provides an alternative source for estimated asset lives.

capital as a whole and simply summed the constant dollar values of the different asset stocks. However, it is preferable to explicitly assign a user cost to each asset type and then include the assets separately when aggregating inputs together using the chained Fisher index. Our approach to forming user costs for gross and net capital stocks is outlined in detail in appendix D. The user cost price for a component of the gross capital stock is given by:

$$(3) \quad U_t^G = r_t (1 + r_t)^{-1} [1 - (1 + r_t)^{-L}]^{-1} P_t$$

where r_t is the real interest rate in period t and P_t is the asset's price index for period t . The user cost for a component of the net capital stock is given by:

$$(4) \quad U_t^N = (1 + r_t)^{-1} (r_t + \delta) P_t$$

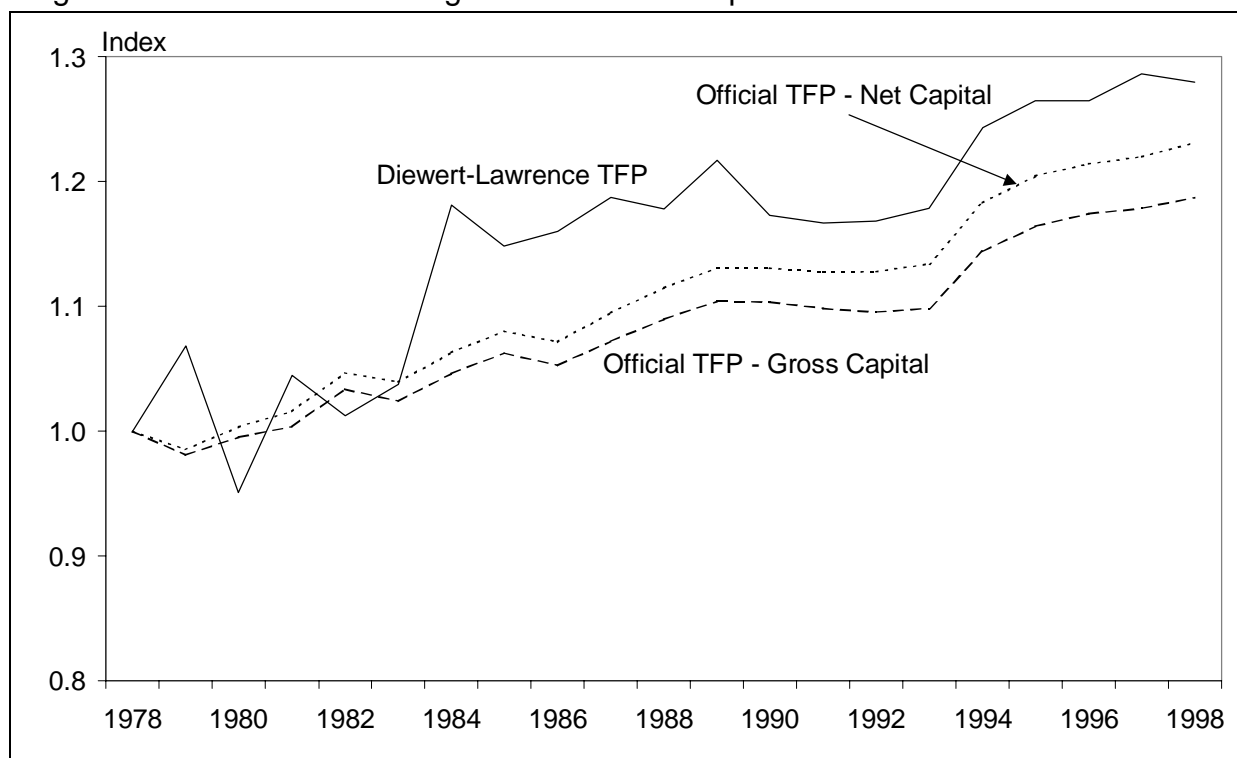
In deriving the user costs in (3) and (4), we solve for the real interest rate to equate the sum of the user costs to the value of gross operating surplus in each year³.

Table 4.2: Philpott length of life assumptions and 1950 starting values

<i>Industry</i>	<i>Plant and equipment</i>		<i>Building and construction</i>	
	<i>Life</i> <i>Years</i>	<i>1950 Stock</i> <i>\$1992m</i>	<i>Life</i> <i>Years</i>	<i>1950 Stock</i> <i>\$1992m</i>
Agriculture	16	1447.8	50	19963.5
Fishing and Hunting	20	85.4	40	9.8
Forestry and Logging	13	73.5	40	351.3
Mining and Quarrying	16	126.6	30	263.8
Food and Tobacco	20	576.0	47	1111.4
Textiles, Clothing and Footwear	20	230.1	47	498.9
Wood and Wood Products	20	322.4	47	380.1
Pulp, Paper, Printing and Publishing	20	194.1	47	303.7
Petroleum, Chemicals, Plastics	20	172.4	47	263.8
Non-Metallic Mineral Products	20	142.8	47	166.4
Basic Metal Product Manufacturing	20	14.5	47	30.4
Machinery and Equipment	20	258.4	47	759.4
Other Manufacturing	20	30.1	47	35.3
Electricity, Gas and Water	20	1475.0	70	5580.8
Construction	14	512.2	32	351.3
Trade, Restaurants and Hotels	16	4809.1	46	5229.7
Transport and Storage	15	1847.5	50	300.5
Communications	18	78.6	40	39.1
Finance and Business Services	15	154.7	47	2704.4
Community and Personal Services	16	742.9	53	1338.4

³ In the 'Official Capital' spreadsheets the formula for r_t is derived explicitly for the net capital stock case while we use the 'goal seek' function in Excel to solve for r_t in the gross capital case.

Figure 4.1: TFP Indexes Using Gross and Net Capital Stock Estimates



The official database TFP estimates constructed using the Philpott length of life assumptions are plotted in figure 4.1 along with the Diewert–Lawrence TFP series for reference. The official database TFP estimates are formed by taking the ratio of the output index formed by aggregating the 20 individual industry production GDPs and the 60 input components (20 industry labour inputs from the composite database, 20 industry Plant and equipment stocks and 20 industry Building and construction stocks).

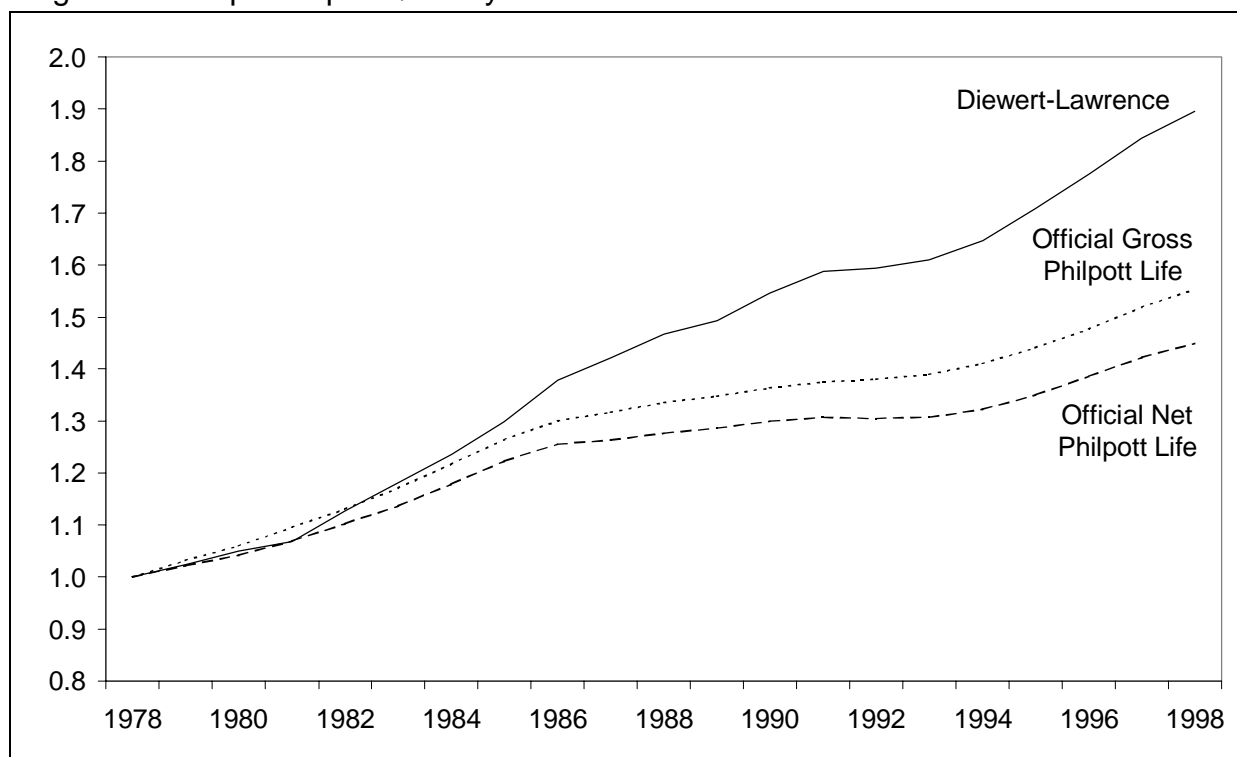
Both the net and gross capital stock based official TFP indexes follow the same general pattern as the Diewert–Lawrence TFP index although they tend to lie below the Diewert–Lawrence index from 1984 onwards. The Diewert–Lawrence TFP index shows more variability than the two official indexes, particularly in the years prior to 1984. This will partly reflect the fact that the Diewert–Lawrence database values outputs and inputs at producer prices and partly the different data sources used and the more comprehensive coverage of inputs and outputs by Diewert–Lawrence.

The Diewert–Lawrence user costs were also constructed using actual ex poste capital gains for the individual assets whereas the user costs constructed using the official database implicitly assume a common rate of capital gains for each asset. The Diewert–Lawrence user costs are thus more volatile than those used in the official database. There was insufficient information available to replicate the Diewert–Lawrence method using the official database. The fully specified Diewert–Lawrence TFP index presented here is otherwise relatively

comparable with the specification of the official TFP index as the inclusion of land and inventory inputs have relatively minor impacts on the Diewert–Lawrence series as shown in the preceding chapter. All three TFP indexes show a marked improvement in 1993 and the following years.

The official net capital stock based TFP series always lies above that based on the gross capital stock estimates with the divergence between the two progressively increasing. This is because the gross capital stock shows more rapid increase than the net capital stock with old capital investment remaining around at full efficiency for its entire life allowing new investment to directly increase the size of the stock after replacing the oldest surviving year's investment (which has dropped off the capital stock). In the net capital stock case, on the other hand, part of new investment also goes towards replacing the loss in efficiency of older surviving investment. This leads to a slower increase in the net capital stock, a slower increase in total inputs and a correspondingly higher increase in TFP. By 1998 the net capital stock–based TFP index is 3.7 per cent higher than that based on the gross capital stock measure.

Figure 4.2: Capital Input Quantity Indexes

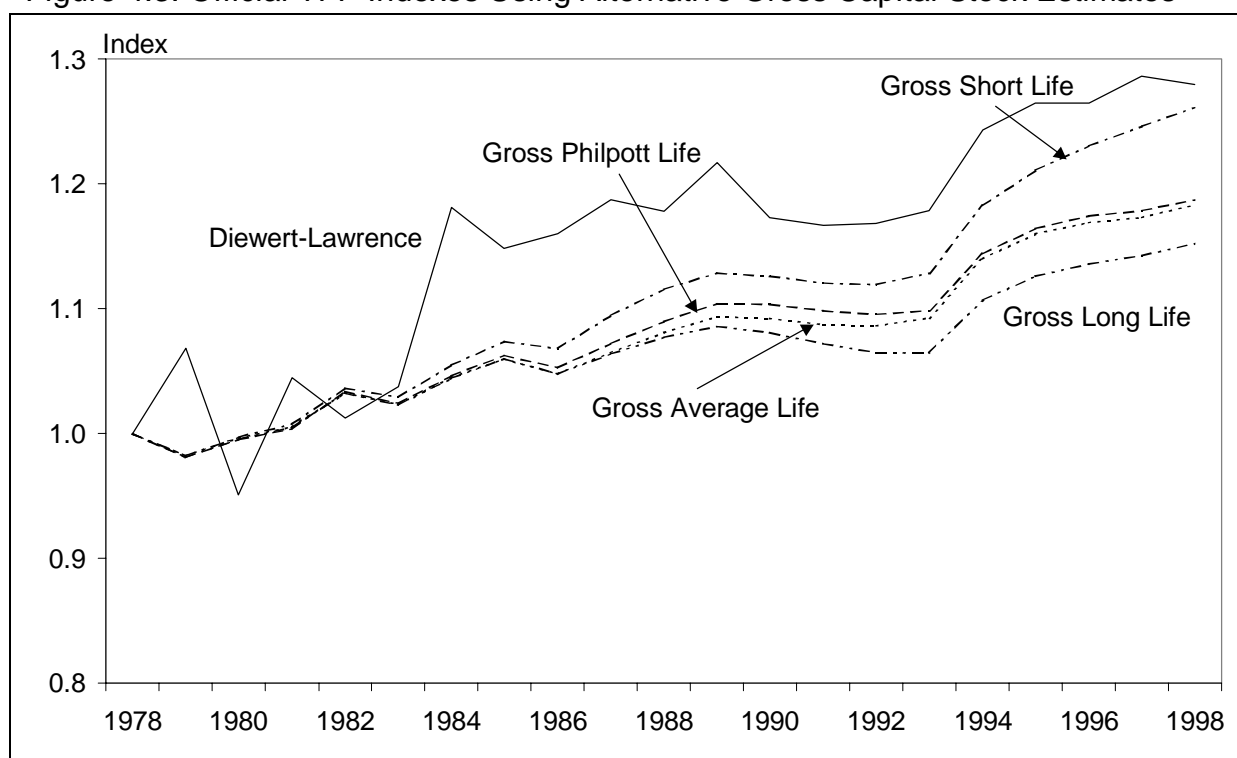


The impact of the different assumptions on the size of the capital stock is illustrated in figure 4.2 which shows the changes in the capital stock quantities for the two official database estimates and the Diewert–Lawrence aggregate for Nonresidential construction, Transport equipment, Electrical equipment and Plant and other machinery in index form. By 1998 our estimated official database gross capital stock had increased by 55 per cent in real terms

above its 1972 level whereas the estimated net capital stock had only increased by 45 per cent. The equivalent Diewert–Lawrence database capital stock increases much more rapidly than either of the official database estimates with an increase of 90 per cent in real terms over the 20 years. The explanation for this difference lies in the starting values used in the two databases.

The Diewert–Lawrence starting value for the Nonresidential construction stock was \$73.5 billion in 1987 obtained from New Zealand Planning Commission (1990). This compares to the equivalent official database net capital stock estimate for 1987 of \$86.7 billion. A more significant difference exists on the Plant and equipment side with the Diewert–Lawrence database using a starting value in 1972 of \$3.3 billion formed from accumulated import data. The equivalent official database net capital stock estimate for 1972 is \$6.5 billion. There are also differences regarding assumed lengths of life. While the two databases use roughly the same length of life for Buildings and construction, the Diewert–Lawrence database uses much shorter lives for Plant and equipment components than those reported by Philpott (1992).

Figure 4.3: Official TFP Indexes Using Alternative Gross Capital Stock Estimates



To test the sensitivity of the estimates to changes in assumed lengths of life and rates of depreciation, we have examined three alternative sets of assumptions compared to the Philpott assumptions listed in table 4.2. The first alternative simply takes the unweighted average of the Philpott lives for each of the two asset types across the 20 industries. This produces a life of 18 years for Plant and equipment and 47 years for Building and construction. We then test a long life variant with assumed lives of 25 years for Plant and equipment and 55 years for

Building and construction. A short life variant has assumed lives of 12 years for Plant and equipment and 40 years for Building and construction. The resulting TFP indexes for the four gross capital stock based series are presented in figure 4.3 and for the four net capital stock based series in figure 4.4. The 8 indexes are also presented in table 4.3.

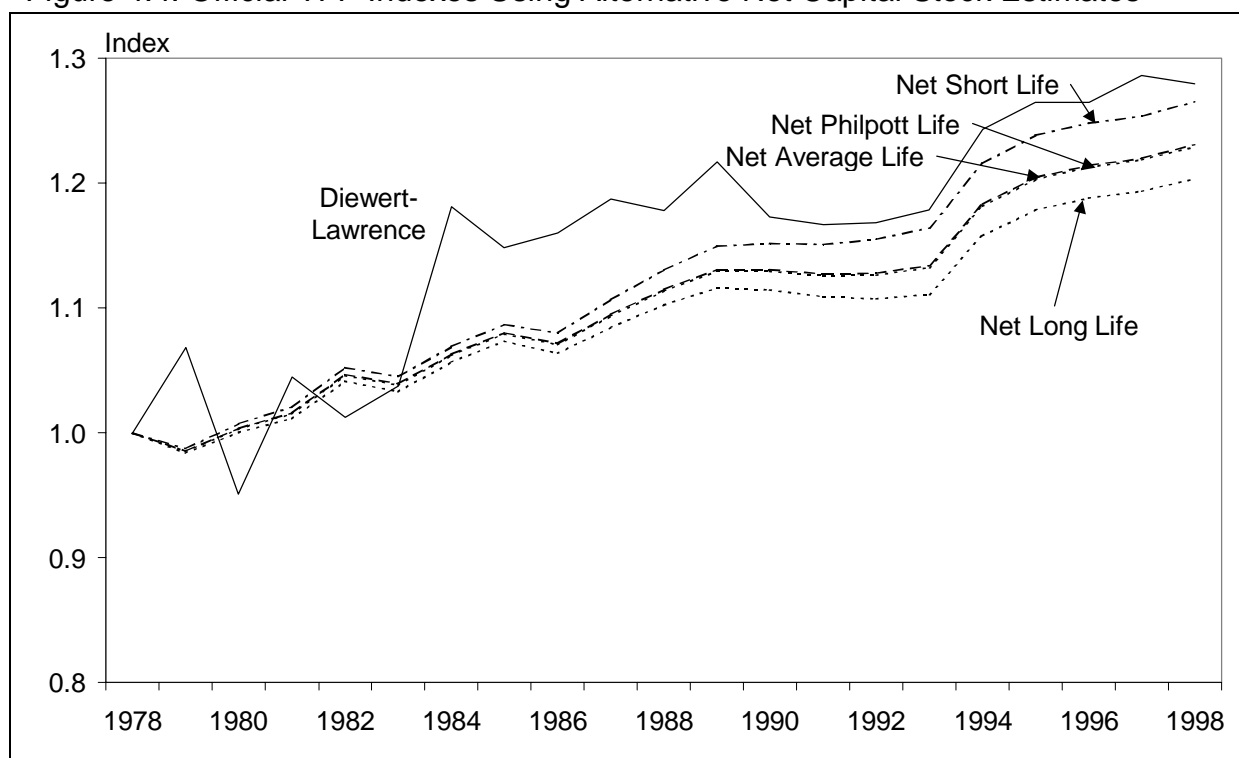
Table 4.3: Official TFP Indexes Under Alternative Capital Specifications

Year	Using Gross Capital Stock				Using Net Capital Stock			
	Long Life	Philpott Lives	Average Life	Short Life	Long Life	Philpott Lives	Average Life	Short Life
1978	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	0.981	0.981	0.982	0.982	0.984	0.985	0.985	0.987
1980	0.995	0.995	0.996	0.997	1.000	1.003	1.003	1.007
1981	1.005	1.004	1.005	1.007	1.011	1.016	1.015	1.021
1982	1.032	1.034	1.033	1.036	1.041	1.047	1.046	1.052
1983	1.023	1.024	1.023	1.029	1.033	1.039	1.038	1.045
1984	1.044	1.046	1.045	1.055	1.056	1.063	1.062	1.069
1985	1.060	1.063	1.060	1.074	1.073	1.080	1.079	1.087
1986	1.048	1.053	1.048	1.068	1.064	1.072	1.070	1.080
1987	1.063	1.072	1.065	1.094	1.084	1.095	1.093	1.107
1988	1.077	1.090	1.081	1.115	1.102	1.115	1.114	1.130
1989	1.086	1.104	1.093	1.128	1.116	1.131	1.129	1.149
1990	1.081	1.103	1.092	1.126	1.114	1.131	1.129	1.152
1991	1.072	1.098	1.087	1.120	1.109	1.127	1.126	1.151
1992	1.065	1.095	1.086	1.119	1.107	1.128	1.126	1.155
1993	1.065	1.098	1.093	1.128	1.111	1.134	1.132	1.164
1994	1.107	1.144	1.140	1.183	1.158	1.183	1.181	1.216
1995	1.126	1.164	1.160	1.211	1.179	1.204	1.203	1.238
1996	1.136	1.174	1.169	1.230	1.188	1.214	1.213	1.248
1997	1.142	1.178	1.173	1.246	1.194	1.220	1.218	1.253
1998	1.152	1.187	1.183	1.261	1.203	1.231	1.229	1.265

The four gross capital stock-based official TFP indexes generally lie below the Diewert-Lawrence index with the long life version showing the lowest rate of increase and the short life version the highest increase. This is because the longer the life of investment, the longer it remains available to contribute to production at full efficiency and less of current investment has to be used to replace the oldest surviving investment as it 'drops off' the capital stock in a growing economy. This leads to the most rapid increase in the capital stock and, hence, the slowest increase in TFP. Conversely, with the short life assumption more of current investment has to be used to replace the oldest surviving investment as it 'drops off', the capital stock increases more slowly and TFP more quickly compared to the long life case. By 1998 the short life TFP index is 9.5 per cent higher than the long life TFP index and

6.3 per cent higher than the Philpott life TFP index. The trend annual growth rate for the short life TFP index is 1.19 per cent compared to 0.71 per cent for the long life TFP index and 0.92 per cent for the Philpott life TFP index. There is little difference between the Philpott life and average life TFP indexes.

Figure 4.4: Official TFP Indexes Using Alternative Net Capital Stock Estimates

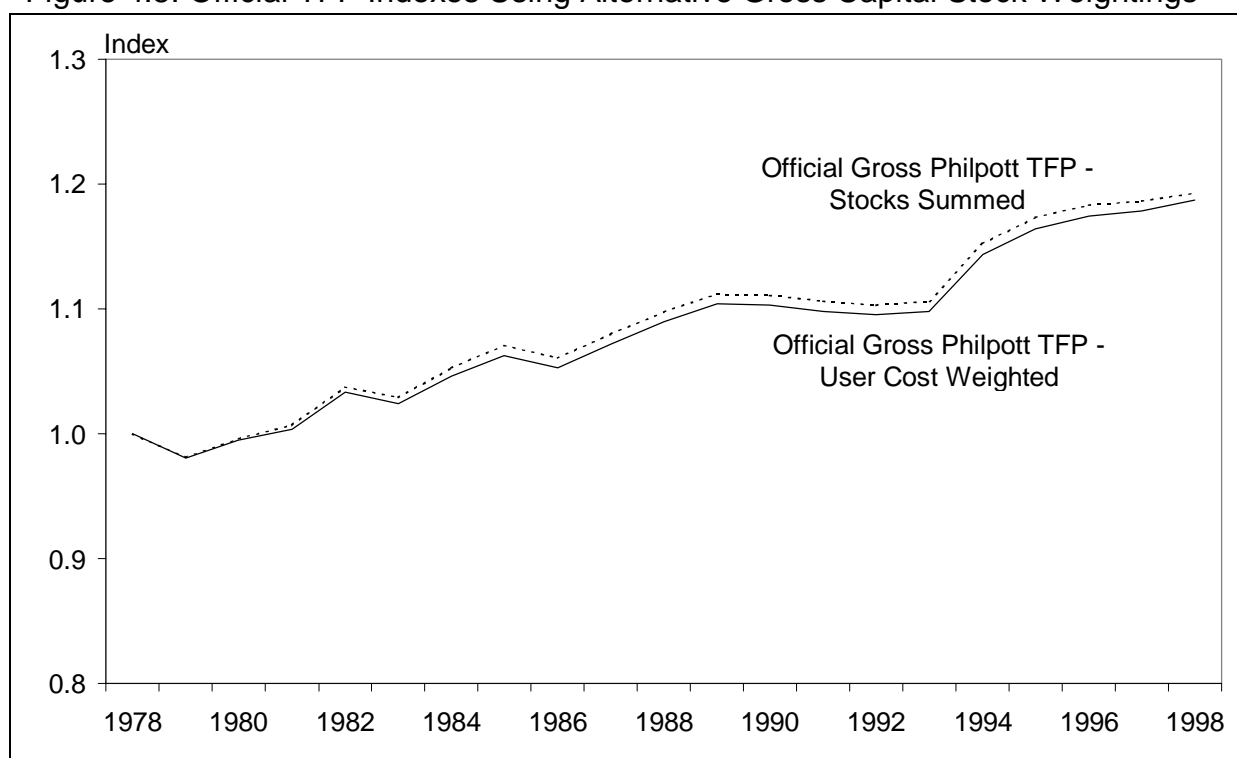


A similar pattern is repeated with the net capital-based TFP indexes in figure 4.4. This time there is a smaller spread of the TFP indexes with the short life version only being 5 per cent higher than the long life version and 2.8 per cent higher than the Philpott life version in 1998. Again this is a result of the different assumption about the deterioration pattern of investment. In this case there is negligible difference between the Philpott and average life TFP indexes. The trend annual growth rate for the short life TFP index is 1.25 per cent compared to 0.97 per cent for the long life TFP index and 1.09 per cent for the Philpott life TFP index. The short life TFP index lies close to the Diewert-Lawrence TFP index from around 1990 onwards reflecting the fact that the Diewert-Lawrence database uses shorter lives for Plant and equipment.

The final sensitivity analysis we carry out on the capital input specification relates to the method used to aggregate the Plant and equipment and Building and construction components. The results presented above use the user cost formulas in (3) and (4) to weight the real capital stocks in forming the total input index. As mentioned above, a simpler but theoretically less accurate way of combining the two capital components is to simply add the constant price series for Plant and equipment and Building and construction stocks together

and allocate the value of gross operating surplus to the resulting measure. Using this simpler method runs the risk of giving a disproportionate weight to Building and construction which typically has a higher stock value but lower depreciation rate (leading to a proportionately smaller user cost share) than Plant and equipment. As a result TFP estimates using the simpler method can be significantly biased unless either the prices or quantities of the two components are moving in a similar pattern. In the US, Jorgenson and Griliches (1972) showed that TFP estimates were significantly biased as a result of using the simpler method.

Figure 4.5: Official TFP Indexes Using Alternative Gross Capital Stock Weightings



In figure 4.5 we present official TFP indexes based on gross capital stock estimates using the Philpott lives and with capital aggregated using the two methods. In New Zealand's case it makes little difference which aggregation method is used given the past movement of stock quantities and prices. However, the user cost weighted method is the more accurate of the two and should be used if possible. It is the method used by the ABS in forming its multifactor productivity index (Aspden 1990).

4.3 Output Specifications

In the National Accounts output can be measured in three ways. Production based GDP sums the value added by all industries in the economy. Expenditure based GDP sums over sources of final demand while income based GDP sums the returns to factors of production. In principle the measures of output resulting from these three approaches should all be equal but in practice they tend to vary due to measurement errors. From a productivity accounting

viewpoint both the production and expenditure based GDP measures are suitable candidates to measure the economy's output and this section examines the sensitivity of the 'official' TFP measure to which output specification is used.

The official database contains production-based GDP estimates for each of the 20 market sector industries we include. However, expenditure based GDP is only provided at the aggregate economy level and includes imports as negative outputs. To ensure that we are comparing like with like we need to derive an expenditure based measure relating to market sector outputs. To do this we subtract from total expenditure based GDP the value of *nonmarket* compensation of employees (covering government, nonprofit and domestic services obtained from the database's Annual Production Accounts) and the value of imputed rent (which relates to owner occupied housing which is excluded from our definition of the market sector). The value and price of imputed rent are obtained from the detailed time series of household consumption expenditures supplied to us by SNZ to facilitate formation of the Diewert-Lawrence database. The price of nonmarket labour is formed as a composite of detailed National Accounts information supplied by Treasury for the period from 1983 onwards and the government wage rate series used in the Diewert-Lawrence database for years prior to 1983. The expenditure based GDP deflator is formed as a composite of that in the official database from 1983 onwards and the OECD's GDP deflator for earlier years.

Having information on the value and price of total expenditure based GDP and for each of the two components we wish to exclude, we form a price index for the residual market sector expenditure-based GDP using formula (1) in appendix B. While this process introduces some scope for error, we believe it is preferable to try and ensure that all variables included are on a conceptually like with like basis rather than mixing total economy and market sector measures.

The resulting official TFP indexes are presented in figure 4.6 along with the Diewert-Lawrence TFP index for reference. The output and TFP indexes are also presented in table 4.4. The Diewert-Lawrence market GDP figure is smaller than the official database GDP figures because it excludes indirect taxes and subsidies. The production based TFP index is again formed as the ratio of an output index formed by aggregating the 20 industry outputs and an input index formed by aggregating labour, plant and equipment and building and construction across each of the 20 industries using chained Fisher indexes. The expenditure based TFP index is formed as the ratio of real market sector expenditure GDP normalised to equal one in 1978 to the same total input index.

The expenditure based official TFP index tends to fluctuate more than the production based measure, particularly in the first half of the period. From around 1982 onwards it mirrors movements in the Diewert-Lawrence index more closely than the official production based

index although having a consistently lower value. This is not unexpected as the Diewert–Lawrence output measured is formed from disaggregated expenditure data. During the 1990s the official expenditure based TFP index has moved more in unison with the official production based index. In 1998 the expenditure based index was 2.4 per cent below the production based index.

Table 4.4: Official Indexes Under Alternative Output Specifications

Year	<i>Diewert–Lawrence</i>		<i>Official Production–based</i>		<i>Official Expenditure–based</i>		
	Mkt. GDP \$m	Mkt. GDP \$m	Output Index	TFP Index	Mkt. GDP \$m	Output Index	TFP Index
1978	10,925	12,482	1.000	1.000	12,049	1.000	1.000
1979	13,131	14,087	0.997	0.985	13,470	0.960	0.949
1980	13,491	16,532	1.025	1.003	15,766	0.965	0.945
1981	16,600	19,081	1.037	1.016	18,067	0.954	0.934
1982	19,284	23,194	1.090	1.047	21,837	1.007	0.967
1983	22,916	26,211	1.100	1.039	25,184	1.059	1.001
1984	26,921	29,345	1.140	1.063	28,264	1.133	1.056
1985	29,224	33,280	1.208	1.080	32,326	1.202	1.075
1986	34,734	37,900	1.227	1.072	36,604	1.193	1.043
1987	39,094	44,399	1.264	1.095	43,601	1.245	1.078
1988	43,109	48,259	1.276	1.115	48,783	1.259	1.100
1989	45,448	51,768	1.275	1.131	52,372	1.274	1.129
1990	46,431	54,292	1.278	1.131	55,663	1.262	1.117
1991	48,135	54,597	1.263	1.127	55,963	1.248	1.113
1992	48,321	54,397	1.246	1.128	55,786	1.225	1.109
1993	50,070	56,084	1.261	1.134	57,952	1.233	1.109
1994	55,142	61,634	1.351	1.183	63,789	1.322	1.158
1995	60,468	66,671	1.431	1.204	69,030	1.406	1.183
1996	64,632	71,112	1.491	1.214	72,371	1.452	1.182
1997	67,608	74,640	1.538	1.220	75,241	1.495	1.185
1998	68,037	76,899	1.579	1.231	77,339	1.541	1.201

The trend annual growth rates for the three TFP indexes are 1.26 per cent for Diewert–Lawrence, 1.09 per cent for official production based and 1.22 per cent for the official expenditure based index. The official expenditure based index has a higher trend growth rate than the production based index even though it starts from the same value, finishes at a lower value than and never goes above the production based index. This is because it has a relatively large downward bulge in the first five years and highlights the need for caution in putting too much weight on quoted growth rates.

Figure 4.6: Official TFP Indexes Using Alternative Output Measures

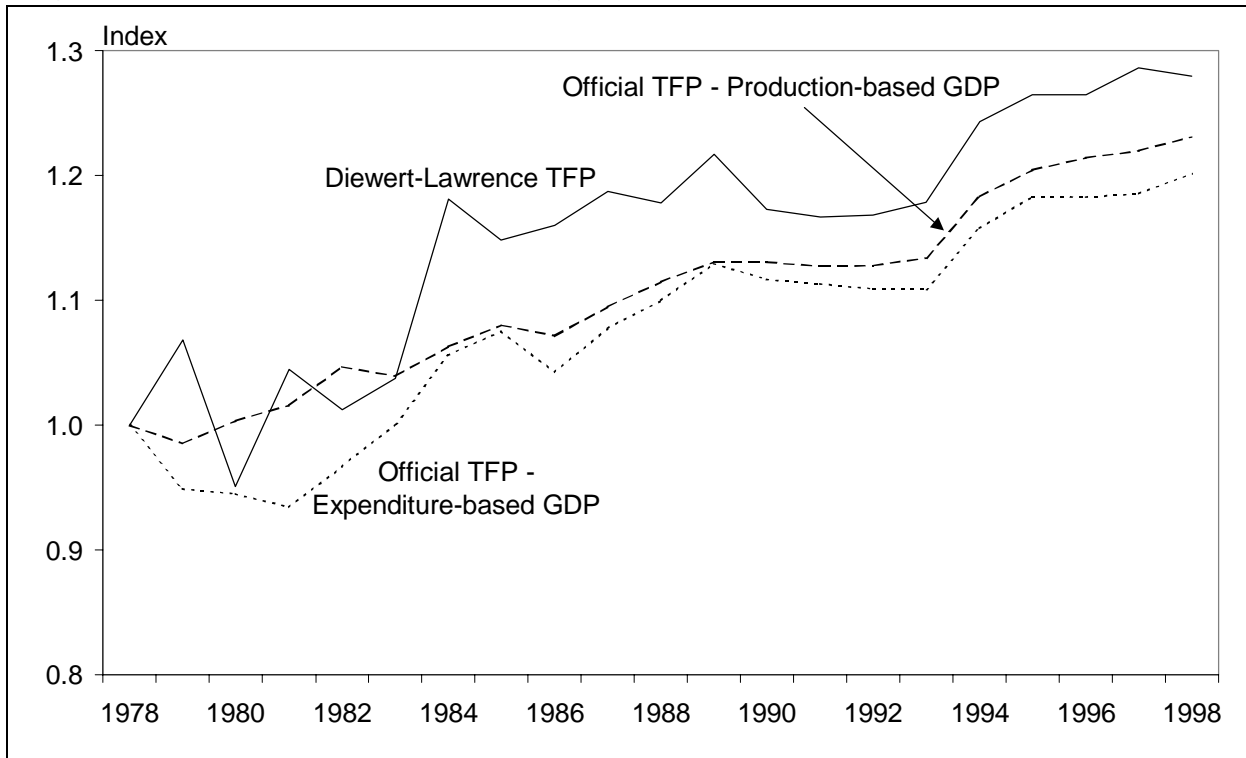


Figure 4.7: Alternative Output Indexes

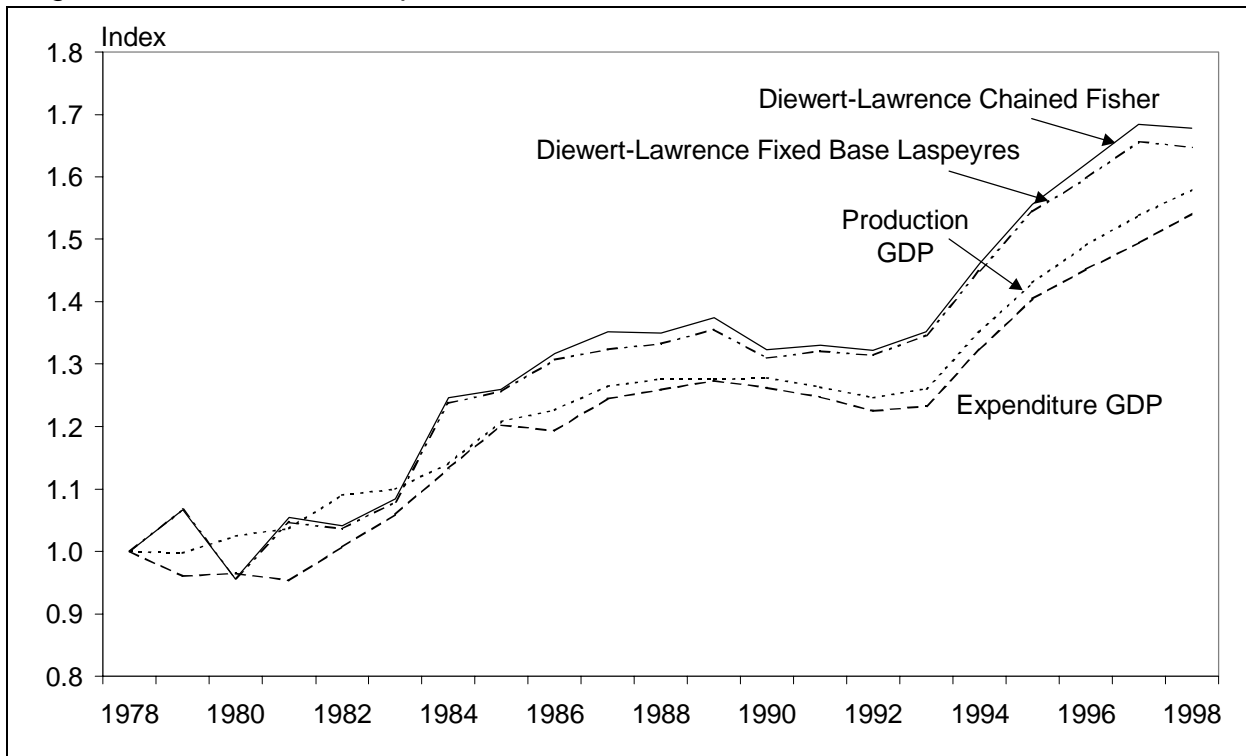
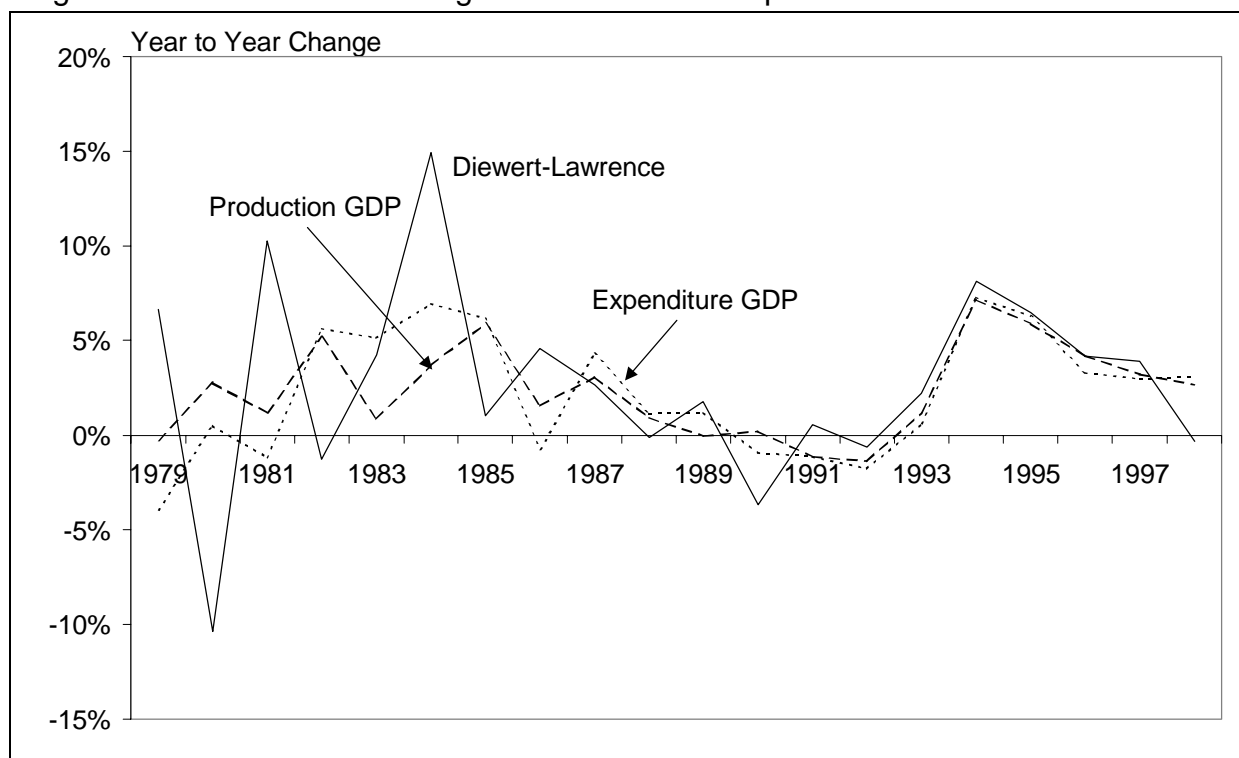


Figure 4.8: Year to Year Changes in Alternative Output Indexes



The production and expenditure based official database output quantity indexes are presented in levels in figure 4.7 and in year to year percentage changes in figure 4.8. The Diewert–Lawrence output index is more variable than the official expenditure based index which is turn more variable than the official production based output index. During the 1990s the three indexes have moved much more in unison than in earlier years. Apart from being derived from producer price series, the Diewert–Lawrence output index is formed from a wider range of sources drawing on a wide range of price deflators. It also consistently uses the more accurate chained Fisher index whereas the official series use a mix of indexing procedures including fixed base Laspeyres indexes from the national accounts. To examine the impact of using Laspeyres indexes in some of the official data sources we have reconstructed the Diewert–Lawrence output index using a fixed base Laspeyres technique. The resulting index lies below the chained Fisher output index and somewhat closer to the official indexes, particularly in the later 1980s and at the end of the period (see figure 4.7).

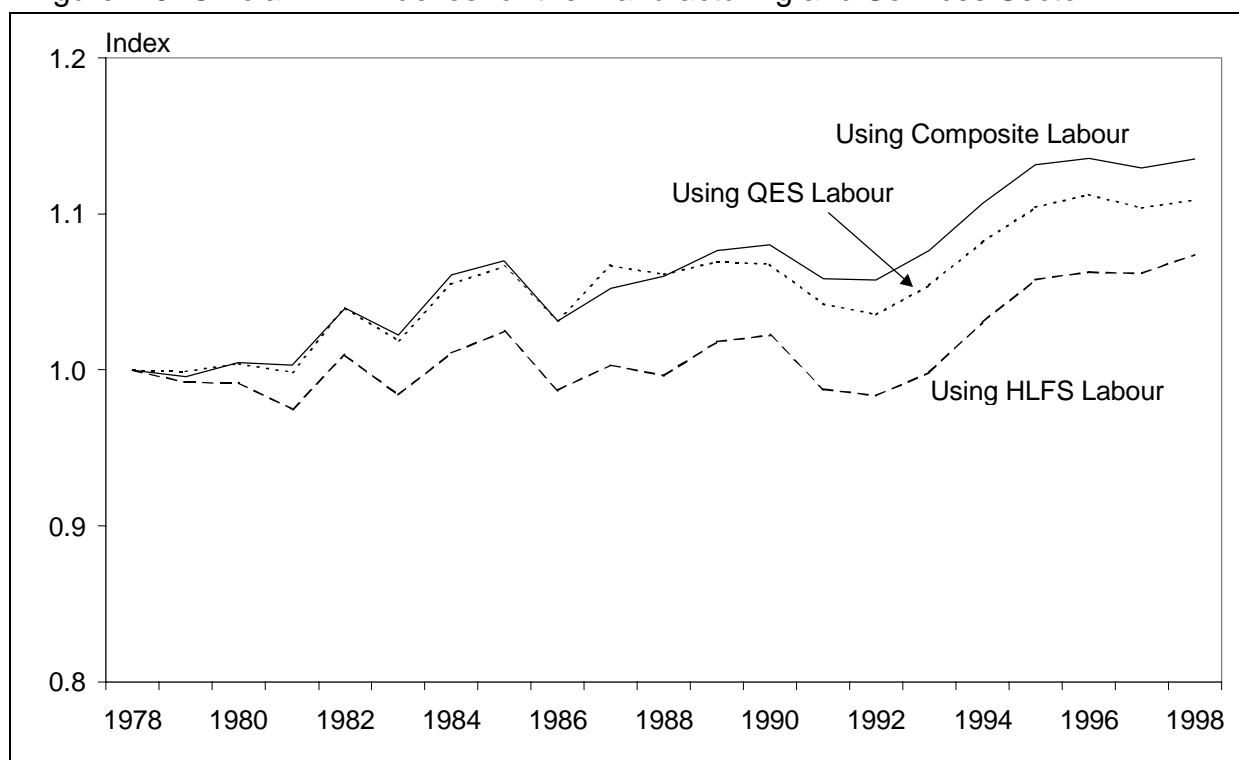
4.4 Alternative Labour Input Sources

In the preceding chapter we illustrated the significant impact on TFP of changing between numbers employed and hours worked measures of labour in the Diewert–Lawrence database. That database uses OECD data on numbers employed in the market sector combined with SNZ census data on occupations and changes in hours worked by occupation. However, there are several alternative SNZ survey based sources of hours worked classified by different industries. The official database contains information on hours worked obtained from the

HLFS, QES and ESM. In this section we examine the impact of using labour input data from these different sources.

There are a number of differences between the HLFS and QES in terms of industry coverage (eg the QES excludes agriculture, hunting and fishing), definitions (eg the QES measures filled jobs whereas the HLFS measures employed persons) and timing (eg the HLFS takes average results for a quarter whereas the QES takes one pay period in a quarter). These are explained in more detail in appendix C. Our base case official TFP estimates also draw on the ESM for two digit manufacturing information and the NZIER and other sources for fishing, forestry and mining to form an overall composite two digit labour database. To compare the HLFS and QES sources directly we have to look at the subset of the market sector excluding agriculture, forestry and mining due to differences in coverage between the two surveys.

Figure 4.9: Official TFP Indexes for the Manufacturing and Services Sector



To form TFP estimates using the two data sources we first aggregate the 16 manufacturing and services outputs using a chained Fisher index. For each of the HLFS and QES sources we then sum labour hours for the one digit manufacturing and services industries and allocate the total hours a value equal to the sum of compensation of employees for these industries (at this stage no separate allowance is made for the wages of the self employed). We then aggregate this total labour figure with the 16 two digit manufacturing and services net capital inputs using Philpott lives of Plant and equipment and Building and construction using user cost weights and a chained Fisher index. The resulting manufacturing and services TFP indexes

are presented in figure 4.9 and table 4.6 along with the corresponding TFP index from the composite two digit labour database.

Table 4.6: Alternative Official Indexes for the Manufacturing and Services Sector

<i>Year</i>	<i>Output Index</i>	<i>Total Input Indexes Using:</i>			<i>TFP Indexes Using:</i>		
		<i>Composite</i>	<i>QES</i>	<i>HLFS</i>	<i>Composite</i>	<i>QES</i>	<i>HLFS</i>
1978	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	1.006	1.011	1.007	1.015	0.996	0.999	0.992
1980	1.023	1.018	1.019	1.032	1.005	1.004	0.992
1981	1.019	1.016	1.021	1.045	1.003	0.999	0.975
1982	1.079	1.038	1.038	1.069	1.040	1.040	1.009
1983	1.079	1.055	1.059	1.096	1.022	1.019	0.984
1984	1.135	1.070	1.076	1.123	1.061	1.055	1.011
1985	1.201	1.123	1.126	1.172	1.070	1.066	1.025
1986	1.191	1.155	1.154	1.207	1.031	1.032	0.987
1987	1.231	1.170	1.154	1.227	1.052	1.067	1.003
1988	1.233	1.163	1.162	1.238	1.060	1.061	0.996
1989	1.233	1.145	1.152	1.211	1.077	1.069	1.018
1990	1.241	1.149	1.162	1.214	1.080	1.068	1.022
1991	1.206	1.139	1.157	1.221	1.059	1.042	0.988
1992	1.184	1.119	1.143	1.204	1.058	1.036	0.983
1993	1.217	1.131	1.155	1.219	1.077	1.054	0.998
1994	1.293	1.168	1.195	1.254	1.107	1.082	1.031
1995	1.382	1.222	1.252	1.307	1.132	1.104	1.058
1996	1.443	1.271	1.297	1.358	1.136	1.112	1.063
1997	1.483	1.313	1.344	1.397	1.130	1.104	1.062
1998	1.524	1.343	1.374	1.419	1.135	1.109	1.074

The QES based manufacturing and services TFP index consistently lies above the HLFS based index. By 1998 the QES based TFP index is around 3 per cent higher than the HLFS based index and both show low productivity improvement compared to that obtained for the market sector as a whole from the composite labour series. The composite based TFP index for the manufacturing and services sector generally lies above the QES based index, particularly from 1988 onwards and finished 2.3 per cent higher in 1998. The major difference between the composite and one digit QES based series is the composite series' use of the ESM for two digit manufacturing information. The ESM has a larger proportionate reduction in manufacturing hours worked than does the QES.

As another sensitivity analysis on labour inputs we have formed a new composite labour hours worked series drawing on the HLFS for agriculture, the HLFS and Bryan Philpott for fishing and hunting and the QES one digit series for all other industries. The four available labour hours measures for the whole market sector are plotted as indexes in figure 4.10. The HLFS shows the highest growth with an increase of 23 per cent between 1978 and 1998. The official composite series increases by 14 per cent over the same period and finishes very close to the Diewert–Lawrence labour index based on OECD and SNZ census information. The Diewert–Lawrence labour series increased by 13 per cent between 1978 and 1998. The new composite labour series lies very close to the Diewert–Lawrence labour series and increased by 16.5 per cent over the 21 year period.

The impact of using the new composite labour series for the market sector is shown in figure 4.11. Here the new composite labour series is used in conjunction with the production–based GDP measures for the 20 industries and the net capital stock estimates using Philpott lives to form a new official TFP index which is compared with the Diewert–Lawrence TFP index. The official TFP index using the new composite labour input now lies 5 per cent below the Diewert–Lawrence TFP index level in 1998 compared to the official TFP index using the database's composite labour input which is 3.8 per cent below.

Figure 4.10: Alternative Indexes of Labour Inputs for the Market Sector

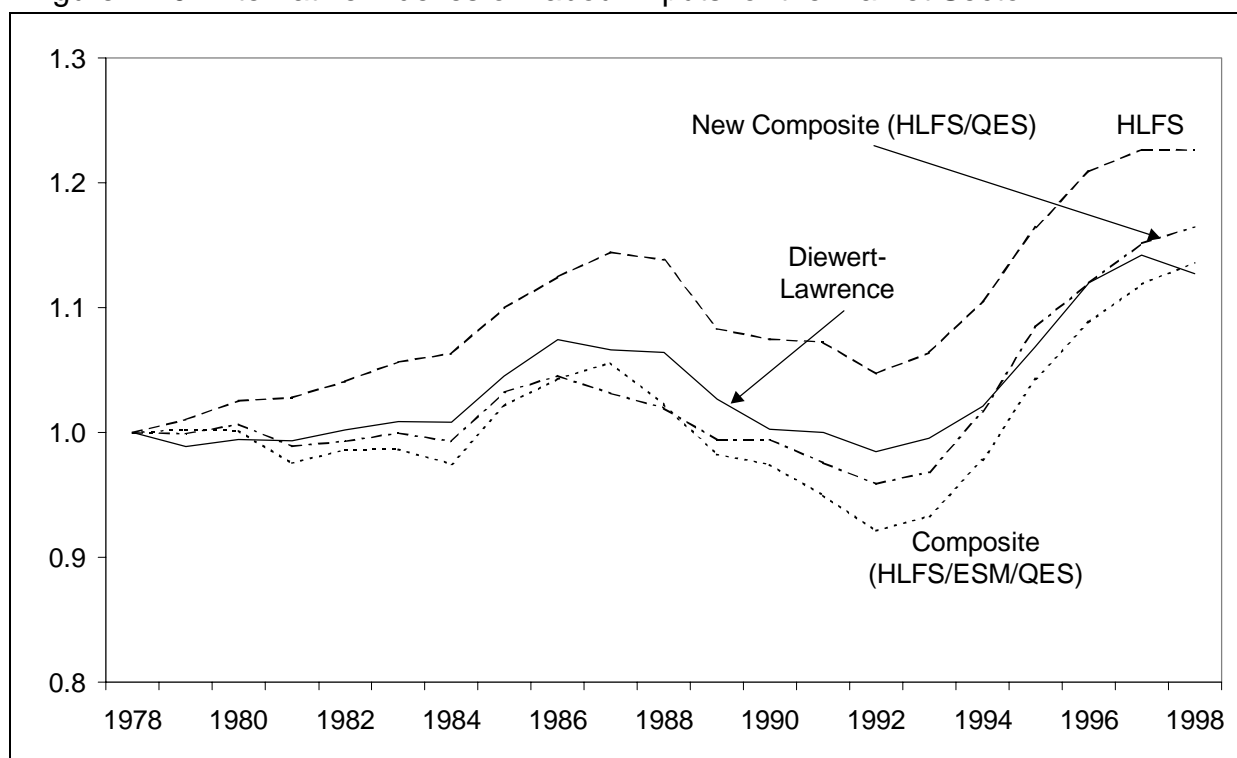
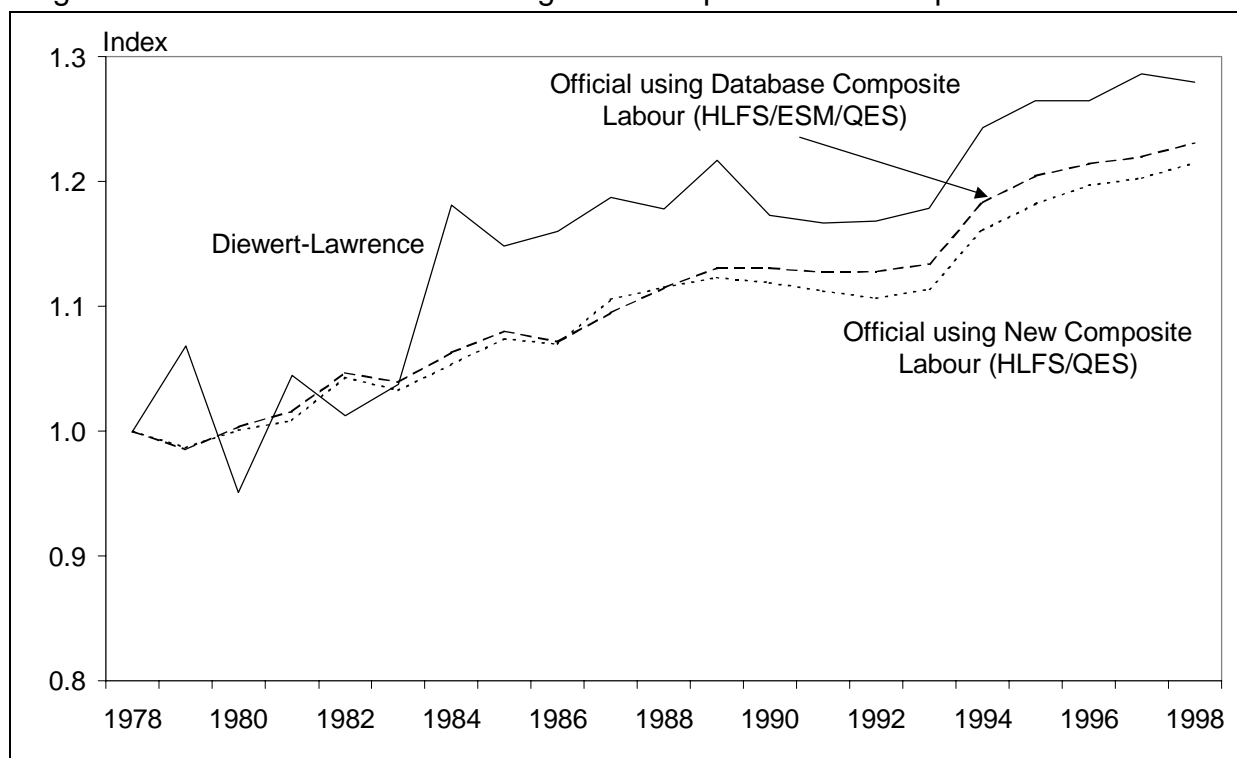


Figure 4.11: Official TFP Index Using New Composite Labour Input



This section has highlighted the importance of having accurate measures of labour input in forming TFP estimates. There is currently a range of estimates available for New Zealand from alternative sources with the range large enough to have a significant impact on measured TFP. Improving the quality of labour data should clearly be a high priority.

4.5 The Impact of Using Alternative Functional Forms

As discussed in chapter 2 and appendix A there are a range of index number techniques available to aggregate outputs and inputs together to form indexes of total output and total input. These correspond to a range of functional forms from the popular but highly restrictive Cobb–Douglas function through to the flexible translog function and the preferred method, the chained Fisher index. Depending on the characteristics of the data set, the choice of functional form can have a significant impact on the measured outcome. Since we are aggregating 20 outputs together to form our total output index and 60 inputs together to form our total inputs index, it is worthwhile examining the impact on measured TFP of using different indexing methods.

In table 4.7 we present official TFP indexes using 9 different indexing methods to form total outputs and total inputs indexes. The indexing methods reported are the Cobb–Douglas, Vartia (equivalent to Constant Elasticity of Substitution functional form), Laspeyres, Paasche, Fisher, Törnqvist, chained Laspeyres, chained Paasche and chained Fisher. The Cobb–

Douglas indexes were derived using the average expenditure shares for the entire period as weights.

Table 4.7: Official TFP Indexes Using Alternative Indexing Methods

Year	Cobb– Douglas	Fixed Base				Törnqvist	Chained Laspeyres	Chained Paasche	Chained Fisher
		Vartia	Laspeyres	Paasche	Fisher				
1978	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	0.988	0.985	0.985	0.986	0.985	0.985	0.985	0.986	0.985
1980	0.999	1.002	1.001	1.004	1.003	1.003	1.001	1.005	1.003
1981	1.004	1.012	1.012	1.012	1.016	1.012	1.015	1.016	1.016
1982	1.029	1.041	1.040	1.042	1.046	1.041	1.045	1.048	1.047
1983	1.019	1.032	1.033	1.032	1.039	1.032	1.039	1.040	1.039
1984	1.040	1.051	1.051	1.051	1.063	1.051	1.064	1.062	1.063
1985	1.057	1.066	1.067	1.065	1.080	1.066	1.081	1.079	1.080
1986	1.050	1.059	1.064	1.055	1.071	1.060	1.076	1.067	1.072
1987	1.071	1.084	1.086	1.083	1.094	1.084	1.098	1.091	1.095
1988	1.092	1.115	1.114	1.117	1.114	1.116	1.117	1.113	1.115
1989	1.110	1.132	1.127	1.138	1.130	1.132	1.133	1.128	1.131
1990	1.112	1.134	1.123	1.146	1.130	1.134	1.134	1.128	1.131
1991	1.109	1.130	1.128	1.136	1.127	1.132	1.133	1.122	1.127
1992	1.106	1.135	1.129	1.144	1.127	1.136	1.133	1.123	1.128
1993	1.112	1.133	1.123	1.145	1.133	1.134	1.140	1.128	1.134
1994	1.162	1.177	1.177	1.181	1.182	1.179	1.189	1.177	1.183
1995	1.187	1.195	1.191	1.201	1.204	1.196	1.210	1.199	1.204
1996	1.197	1.205	1.198	1.215	1.214	1.206	1.219	1.209	1.214
1997	1.207	1.217	1.205	1.228	1.219	1.217	1.224	1.215	1.220
1998	1.220	1.231	1.209	1.249	1.230	1.229	1.235	1.227	1.231

The TFP indexes obtained from the official database base case appear to be relatively insensitive to the choice of indexing method⁴. All the indexes lie in a relatively tight band with the exception of the Cobb–Douglas index which lies markedly below the other indexes except for the last two years when it exceeds the Laspeyres index. The unchained Paasche index also tends to be a limiting case lying slightly above the other indexes for most of the period. After 21 years the highest index (Paasche) exceeds the lowest index (Laspeyres) by 3.3 percentage points. This produces a spread of trend annual TFP growth rates from 1.16 per cent to 1.05 per cent. Excluding the Laspeyres and Paasche indexes reduces the index spread to 1.2 percentage points in 1998 and changes the spread of growth rates to 1.12 to 1.05 per cent. Given the past characteristics of the official database, the choice of index number

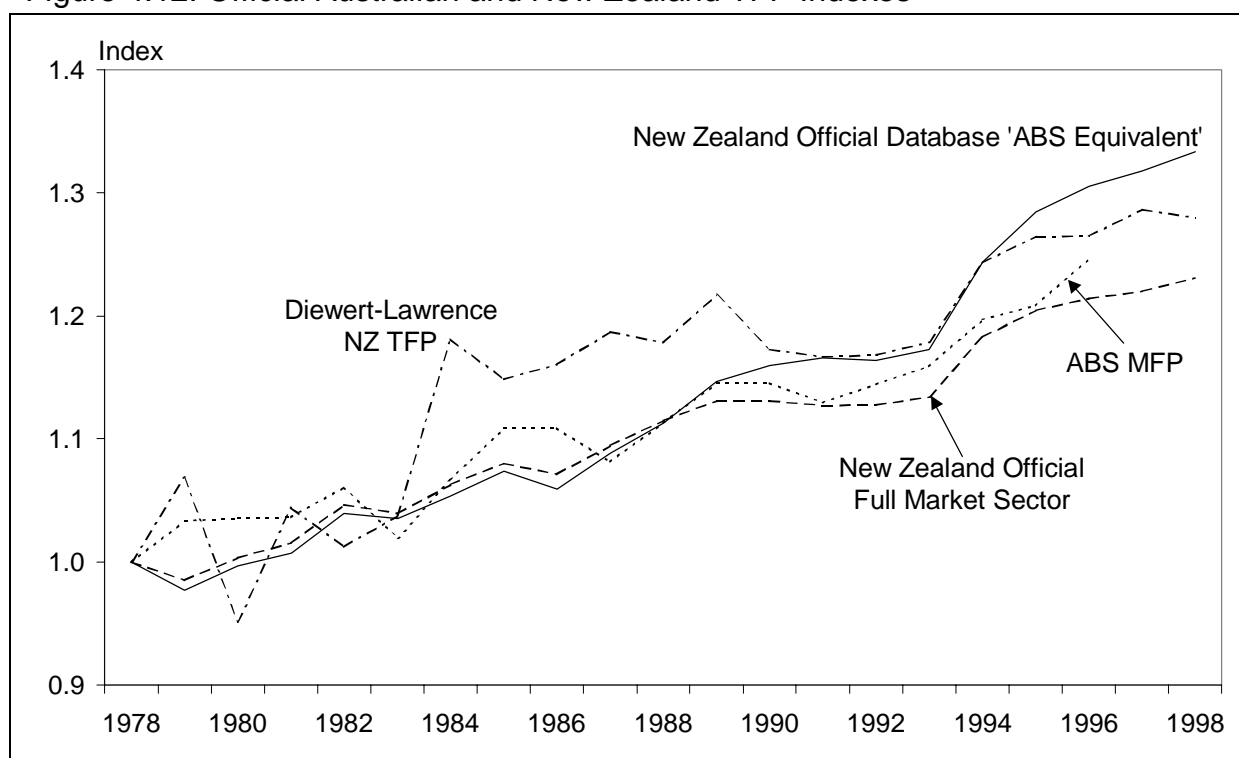
⁴ It should be noted that the index number approach will produce more volatile productivity estimates than econometric approaches using the same functional form.

technique and implied functional form does have an impact on measured TFP performance. However, as outlined in appendix A, the chained Fisher index has a number of superior features which should always make it the index of choice.

4.6 Comparing New Zealand and Australian Official Productivity

The ABS 'multifactor' productivity series for Australia is in many ways a hybrid of the Diewert–Lawrence and official database approaches to measuring productivity. As noted in section 3.4, the ABS index includes additional inputs such as agricultural land and inventories and uses the Törnqvist indexing procedure but it does not use producer prices. An important difference compared to both the Diewert–Lawrence and official New Zealand series described so far is that the ABS index excludes the hard to measure Finance and Community Services sectors.

Figure 4.12: Official Australian and New Zealand TFP Indexes



To maximise the scope for a like with like comparison we have calculated an official TFP index for New Zealand which excludes the Finance, insurance, real estate and business services industry and the Community, social and personal services industry and which takes the same weighted averages of the gross and net capital stocks as taken by the ABS. While some differences remain – for instance, the ABS includes Personal services but it is not possible to separate this component from the broader Community, social and personal services industry in the official database – the official 'ABS equivalent' TFP index for New Zealand comes relatively close to the coverage and specification of the ABS series.

Table 4.8: Official Productivity Indexes for Australia and New Zealand

Year	<i>ABS Australian Official Full Market</i>		<i>Official New Zealand 'ABS Equivalent'</i>		
	<i>MFP Index</i>	<i>NZ TFP Index</i>	<i>Output Index</i>	<i>Input Index</i>	<i>TFP Index</i>
1978	1.000	1.000	1.000	1.000	1.000
1979	1.033	0.985	0.988	1.011	0.977
1980	1.036	1.003	1.017	1.020	0.997
1981	1.037	1.016	1.026	1.018	1.007
1982	1.061	1.047	1.082	1.041	1.040
1983	1.019	1.039	1.094	1.056	1.035
1984	1.066	1.063	1.124	1.067	1.054
1985	1.109	1.080	1.190	1.108	1.074
1986	1.109	1.072	1.195	1.128	1.059
1987	1.081	1.095	1.223	1.124	1.088
1988	1.113	1.115	1.222	1.098	1.113
1989	1.145	1.131	1.219	1.063	1.147
1990	1.145	1.131	1.226	1.057	1.160
1991	1.129	1.127	1.215	1.042	1.166
1992	1.144	1.128	1.192	1.024	1.164
1993	1.159	1.134	1.206	1.029	1.173
1994	1.197	1.183	1.304	1.049	1.244
1995	1.208	1.204	1.388	1.080	1.284
1996	1.246	1.214	1.446	1.108	1.305
1997		1.220	1.487	1.129	1.318
1998		1.231	1.522	1.141	1.334

The official 'ABS equivalent' TFP index for New Zealand is presented in figure 4.12 and table 4.8 along with the ABS multifactor productivity index for Australia, the Diewert–Lawrence New Zealand TFP index and the official TFP index for the full New Zealand market sector. The 'ABS equivalent' New Zealand series is formed by aggregating the first 18 of our 20 industry production GDPs on the output side and the first 18 industry labour inputs and the weighted average of the gross and net capital stocks for the first 18 industries' Plant and equipment and Building and construction capital inputs.

The first point to note is that rebasing the ABS and Diewert–Lawrence New Zealand indexes to 1978 actually reverses the relative position of the two indexes in 1996 compared to figure 3.7. Productivity is at a low point in 1978 in the overall Diewert–Lawrence series and rebasing to that year has the effect of lifting the New Zealand series and improving relative performance for the subsequent period. The official TFP index for the full New Zealand market sector also compares favourably with the ABS Australian series.

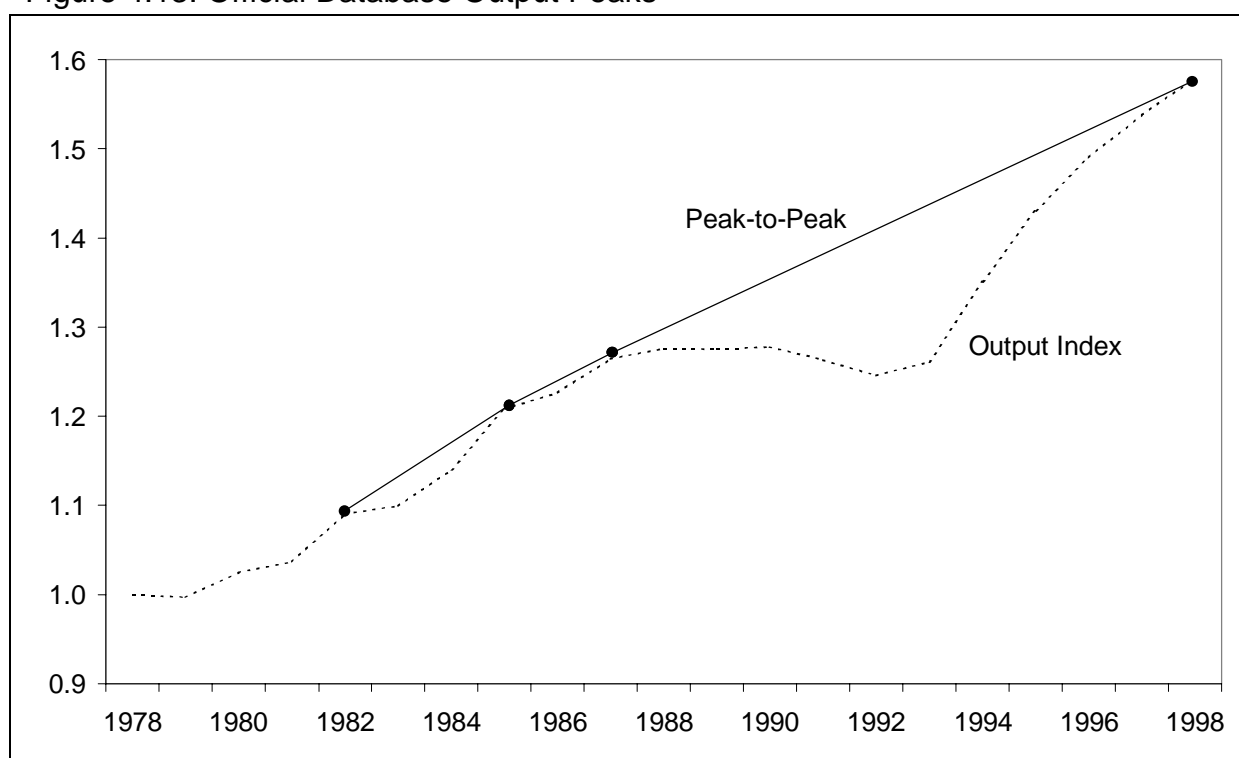
The significant difference comes when we compare the official 'ABS equivalent' New Zealand TFP index with the other indexes. Removing the Finance and Community services industries has the effect of substantially raising New Zealand's TFP performance from 1988 onwards relative to the full market sector official index. The gap between the two indexes has continued to expand with the official 'ABS equivalent' New Zealand TFP index lying 8 per cent above the official full market sector New Zealand TFP index in 1998. This increases the New Zealand TFP trend annual growth rate from 1.09 per cent for the full market sector to 1.56 per cent for the smaller 'ABS equivalent' sector. In 1996 the official 'ABS equivalent' New Zealand TFP index lies 5 per cent above the ABS Australian index.

These results certainly highlight the critical role played by industry coverage when assessing TFP performance. A small apparent change in industry coverage in this instance makes a substantial difference to measured productivity. It also highlights the urgent need to improve output and input measurement in key service sectors.

4.7 Peak to Peak Growth Rates

There are four points on the production based GDP output index which could be classified as peaks. These occur in 1982, 1985, 1987 and 1998 as shown in figure 4.13. The 1998 'peak' is somewhat problematic with output still increasing. However, we believe 1998 is likely to be a peak year given the recent downturn in international conditions and, indeed, in the Diewert–Lawrence database 1997 is clearly the peak year.

Figure 4.13: Official Database Output Peaks



Between the 1982 and 1985 peaks TFP grew at an annual rate of 1.05 per cent before slowing to a growth rate of 0.67 per cent between 1985 and 1987. The TFP growth rate then recovered to 1.07 per cent between the 1987 and 1998 peaks – close to the trend annual growth rate for the entire 20 year period of 1.09 per cent.

4.8 Testing for Structural Breaks

On the basis of 'eyeballing' the official base case TFP index from figure 4.1 (net capital stock with Philpott based lives) there appear to be distinct changes in the TFP growth rate around 1985 and 1993. We use the linear spline methodology outlined in section 3.6 to test for the statistical significance of these break points. We also again test separately for structural breaks in 1991.

Table 4.9: Testing for Structural Breaks

<i>Period</i>	<i>Variable</i>	<i>Coefficient</i>	<i>t-statistic</i>	<i>Growth Rate</i>
<i>Regression 1 – Official Base Case TFP</i>				<i>% pa</i>
	Constant	-0.0287	-3.468	
1978–1985	Time trend	0.0127	8.754	1.27
1985–1993	Spline 1	-0.0075	-1.743	0.52
1993–1996	Spline 2	0.0062	2.069	1.14
<i>Regression 2 – Official Base Case TFP</i>				<i>% pa</i>
	Constant	-0.0288	-3.310	
1978–1985	Time trend	0.0128	8.135	1.28
1985–1991	Spline 1	-0.0045	-1.586	0.83
1991–1996	Spline 2	0.0046	1.621	1.29
<i>Regression 3 – Official 'ABS Equivalent' TFP</i>				
	Constant	-0.0299	-2.868	
1978–1985	Time trend	0.0113	6.169	1.13
1985–1993	Spline 1	0.0040	1.363	1.53
1993–1996	Spline 2	0.0087	2.292	2.40
<i>Regression 4 – Official 'ABS Equivalent' TFP</i>				
	Constant	-0.0301	-2.723	
1978–1985	Time trend	0.0114	5.702	1.14
1985–1991	Spline 1	0.0033	0.919	1.47
1991–1996	Spline 2	0.0065	1.792	2.12

From table 4.9 we see that the structural break in 1985 is not statistically significant but the break in 1993 is significant (although not strongly so). The annual TFP growth rates fall from 1.27 per cent before 1985 to 0.52 per cent for the period from 1985 to 1993. It then recovers after 1993 to finish at 1.14 per cent. The reduction in the TFP growth rate post 1985 is consistent with the corresponding results from the Diewert–Lawrence database where TFP

growth falls following the initial reforms due to restructuring combined with tighter world conditions. With the official database, however, the upturn in TFP growth after the second round of reforms (including labour market reforms) in the early 1990s is less pronounced but more significant than it was using the Diewert–Lawrence database. Testing for a structural break in 1991 rather than 1993 leads to both the 1985 and 1991 breaks being statistically insignificant.

A similar pattern emerges with the official 'ABS equivalent' TFP index. This time there is again no structural break in 1985 but a stronger break in 1993. The coefficient on the first spline shows no sign of statistical significance while the second spline which takes effect at 1993 has a t–statistic of 2.3. The TFP annual growth rate is around 1.1 per cent from 1978 through to 1985 when it increases to 1.5 per cent. After 1993, however, the growth rates increases to 2.4 per cent. This means the more narrowly defined market sector TFP increased its growth rate after the first round reforms (although this increase was statistically insignificant) and then increased further (and significantly) following the labour market and other second round reforms implemented during the early 1990s. Again, testing for a break in 1991 rather than 1993 leads to both the 1985 and 1991 breaks being statistically insignificant although the TFP growth does again progressively increase through the period.

4.9 Comparisons with the OECD

The OECD regularly reports total factor productivity results for its member countries. These TFP changes are calculated using the OECD's own gross capital stock estimates and a relatively crude Cobb–Douglas technique. However, the OECD methodology and data sources do not appear to be well documented and different OECD publications report average percentage changes in TFP for different time periods, many of which are difficult to reconcile. Despite these limitations, the OECD productivity tables do present one of the few international comparisons covering a wide range of countries including New Zealand. In this section we compare the TFP results obtained in this study with two sets of OECD comparisons.

The first set of OECD comparisons cover 22 member countries for the long time period from 1979 to 1997 (OECD 1998a). Average annual rates of change obtained by the OECD and corresponding average annual rates of change from the current study are presented in table 4.10 for both New Zealand and Australia.

The OECD results indicate that New Zealand's productivity performance over the last three decades has been generally below average. The OECD finds that New Zealand's TFP declined by 1.4 per cent per annum on average between 1973 and 1979. The other countries whose TFP also declined during this period were Canada, Portugal and Switzerland. While Portugal's performance for the 18 years after 1979 turned around to produce a similar result

to New Zealand of around 1 per cent per annum, both Canada's and Switzerland's TFP continued to decline after 1979 according to the OECD. The OECD finds that Australia's TFP continued to grow during the critical 1973 to 1979 period at 1.2 per cent per annum.

Table 4.10: OECD Economic Outlook Average Annual Percentage Change in TFP

<i>Country</i>	<i>1960–73</i>	<i>1973–79</i>	<i>1979–97</i>
OECD Estimates	<i>% p.a.</i>	<i>% p.a.</i>	<i>% p.a.</i>
United States	1.9	0.1	0.6
Japan	5.6	1.1	1.2
Germany	2.6	1.8	0.6
France	3.7	1.6	1.3
Italy	4.4	2.0	1.2
United Kingdom	2.8	0.7	1.2
Canada	1.1	-0.1	-0.6
<i>Australia</i>	<i>2.2</i>	<i>1.2</i>	<i>0.9</i>
Austria	3.2	1.1	1.0
Belgium	3.8	1.3	1.0
Denmark	1.1	0.1	0.7
Finland	4.0	1.9	2.6
Greece	2.7	0.8	-0.2
Ireland	4.6	3.9	3.6
Korea		3.1	2.7
Netherlands	3.5	1.7	1.0
<i>New Zealand</i>	<i>1.6</i>	<i>-1.4</i>	<i>1.1</i>
Norway	2.2	1.3	0.6
Portugal	4.1	-0.7	1.0
Spain	3.3	0.7	1.7
Sweden	1.9	0.0	1.2
Switzerland	1.5	-0.7	-0.1
Current Study's Estimates – New Zealand			
Diewert–Lawrence		0.0	1.4
Official Database – Net Capital Stock			1.1
Official Database – Gross Capital Stock			0.9
Official Database – ABS Equivalent			1.5
Current Study's Estimates – Australia			
Diewert–Lawrence		2.3	1.1
ABS MFP		2.2	1.3

New Zealand's TFP growth during the 18 years after 1979 is on a par with most OECD countries including Australia, Japan, France, Italy and the United Kingdom. It is considerably ahead of the OECD's estimates for the United States, Germany and Norway (as well as

Canada and Switzerland as noted above). However, the OECD finds that Ireland, Finland and Korea had two to three times the TFP growth rate of New Zealand for this period.

Comparing the OECD estimates to those of the current study, the official database gross capital stock estimates which are probably most comparable to the OECD's methodology produce a fairly similar figure for the 18 years from 1979 (0.9 per cent versus the OECD's 1.1 per cent). However, this is the lowest of the growth rates obtained in the current study. The Diewert–Lawrence TFP database produces an annual TFP growth rate of 1.4 per cent compared to the OECD's 1.1 per cent while the official database using net capital stocks produces a growth rate of 1.1 per cent, the same as the OECD's reported growth rate for New Zealand. The ABS equivalent series which has a different coverage and is probably least comparable with the OECD estimates produces a higher average annual change of 1.5 per cent. Only Diewert–Lawrence TFP estimates are available for the 1973 to 1979 period and these produce a static TFP performance compared to the OECD's large negative figure of –1.4 per cent.

Table 4.11: OECD Economic Survey Average Annual Percentage Change in TFP

<i>Country</i>	<i>1970–79</i>	<i>1980–89</i>	<i>1990–96</i>
OECD Estimates	<i>% p.a.</i>	<i>% p.a.</i>	<i>% p.a.</i>
United States	0.8	1.0	0.5
Japan	2.0	1.7	–0.1
Germany	1.9	1.0	–0.6
France	2.1	1.7	0.6
Italy	2.1	1.3	1.2
United Kingdom	1.6	2.2	1.6
Canada	1.5	0.5	0.0
<i>Australia</i>	<i>1.2</i>	<i>0.7</i>	<i>1.6</i>
<i>New Zealand</i>	<i>–0.2</i>	<i>1.2</i>	<i>1.3</i>
Current Study's Estimates – New Zealand			
Diewert–Lawrence	0.0	1.5	0.6
Official Database – Net Capital Stock		1.4	1.0
Official Database – Gross Capital Stock		1.2	0.9
Official Database – ABS Equivalent		1.6	1.9
Current Study's Estimates – Australia			
Diewert–Lawrence	2.3	0.8	1.3
ABS MFP	2.2	1.1	1.2

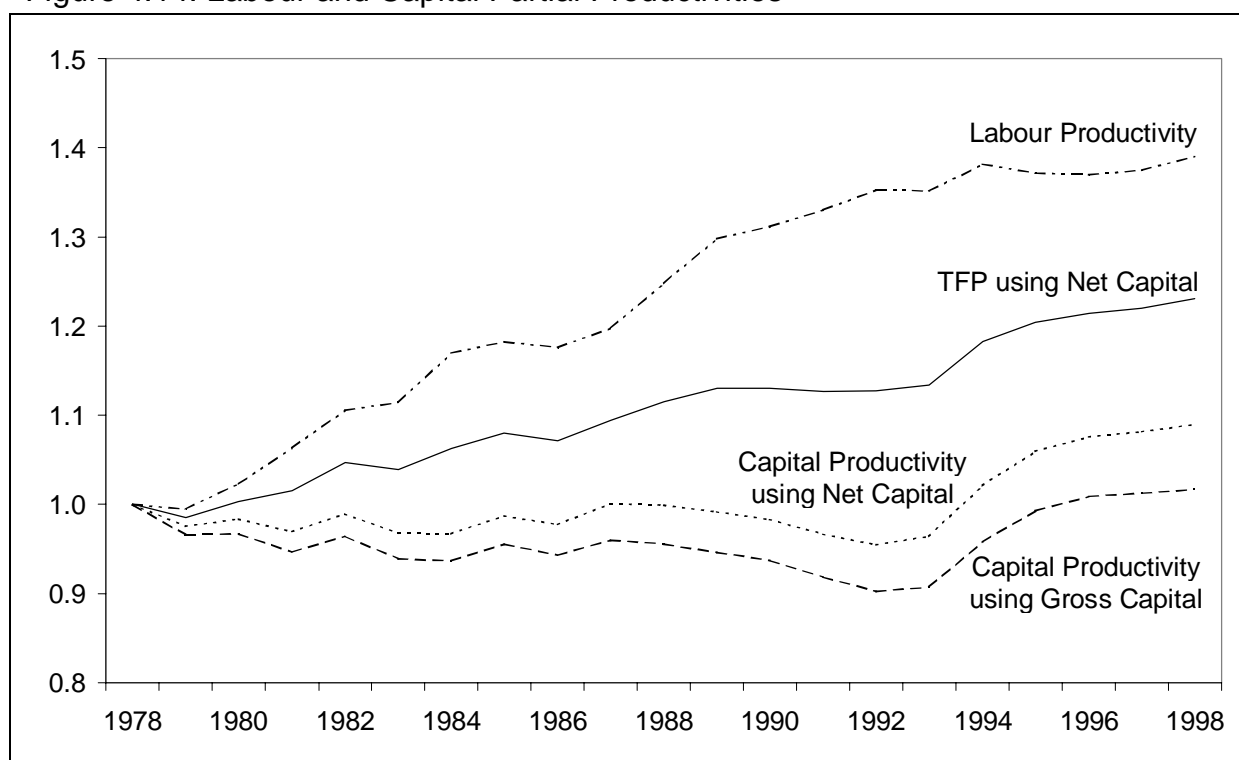
For Australia the Diewert–Lawrence and ABS MFP growth rates are almost twice those of the OECD for the 1973 to 1979 period while being slightly higher than the OECD for the 18 years after 1979.

In its latest *Economic Survey* of New Zealand, the OECD (1998b) presents a break down of its TFP average rates of change for each of the last three decades. These appear in table 4.11 along with comparable figures from the current study.

The OECD figures show a similar pattern for the individual decades although the two average change figures covering the period 1980 to 1996 are both higher than the Economic Outlook figure covering 1979 to 1997. The OECD average change for 1980 to 1989 is the same as our corresponding official database gross capital stock figure but the OECD figure for 1990 to 1996 is higher than our gross capital stock figure. The Diewert–Lawrence TFP database average change for the 1990 to 1996 period of 0.6 per cent is well below the OECD figure of 1.3 per cent but is drawn down by a 3.6 per cent fall in the Diewert–Lawrence TFP in 1990. If this year is excluded the Diewert–Lawrence average annual TFP change for 1991 to 1996 is also 1.3 per cent. The most notable figure from the table is the high annual rate of change of 1.9 per cent for the New Zealand ABS equivalent official database for the period after 1990. This again highlights the important impact sectoral coverage can have on measured TFP.

4.10 Partial Productivities and the Range of TFP Estimates

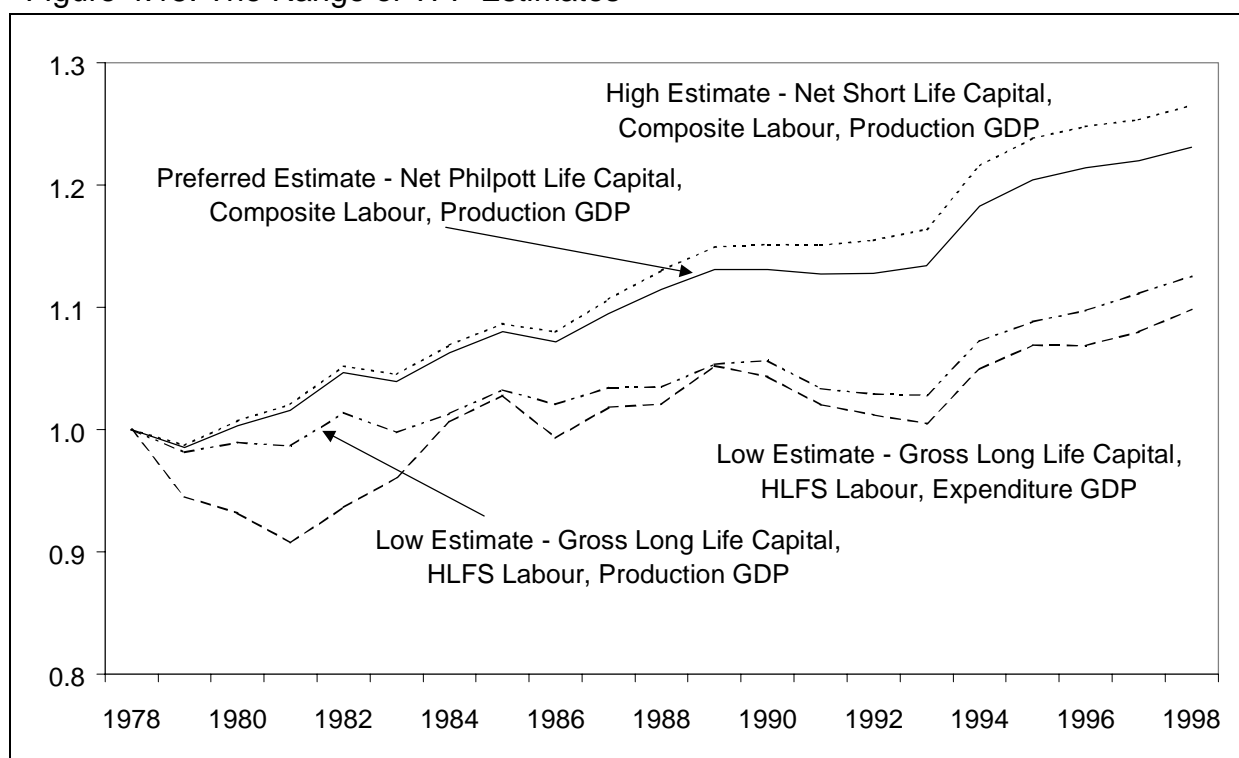
Figure 4.14: Labour and Capital Partial Productivities



In figure 4.14 and table 4.12 we present labour and capital partial productivities using the official database. As this chapter has highlighted, using different sources and specifications of the labour and capital inputs can produce a relatively wide range of TFP estimates. To simplify presentation we only present the labour and capital partial productivities for our preferred base case using the official database's composite two digit labour input and both net and gross capital stocks using Philpott lives.

As was the case with the Diewert–Lawrence database, labour partial productivity again increases faster than TFP which in turn increases faster than capital productivity. In this case labour productivity increases at a trend annual rate of 1.9 per cent while capital productivity using the net capital stock measure increases at a trend rate of 0.4 per cent. Capital productivity using the gross capital stock measure has a trend increase of 0.1 per cent. The small trend increases in capital productivity for the official database compared to the trend decrease in capital productivity from the Diewert–Lawrence database reflects the slower growth in the official databases capital stocks as illustrated in figure 4.2.

Figure 4.15: The Range of TFP Estimates



Finally, the potential range of TFP estimates it is possible to obtain using the official database and the sensitivity analyses reported in this chapter is illustrated in figure 4.15 and table 4.12. The highest TFP index results from combining net capital stock estimates using the short life assumption, the composite HLFS/QES/ESM labour input measure and production based GDP as the output measure. This TFP index produces a trend annual rate of growth over the 21 year period of 1.25 per cent. This compares to a trend rate of 1.09 per cent from our preferred

base case TFP index which has a similar specification except that it uses the Philpott length of life assumption.

Table 4.12: Partial Productivities and the Range of TFP Estimates

Year	<i>Labour</i>	<i>Net</i>	<i>Gross</i>	<i>Partial Productivity Indexes</i>			<i>TFP Index Range</i>		
	<i>Input</i>	<i>Capital</i>	<i>Capital</i>	<i>Labour</i>	<i>Net</i>	<i>Gross</i>	<i>High</i>	<i>Low</i>	<i>Low</i>
	<i>Index</i>	<i>Index</i>	<i>Index</i>		<i>Capital</i>	<i>Capital</i>		<i>(Expend.)</i>	<i>(Prod'n)</i>
1978	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	1.002	1.022	1.032	0.995	0.976	0.966	0.987	0.945	0.981
1980	1.001	1.042	1.060	1.023	0.983	0.967	1.007	0.932	0.989
1981	0.975	1.070	1.095	1.063	0.969	0.946	1.021	0.907	0.987
1982	0.986	1.102	1.131	1.106	0.989	0.964	1.052	0.937	1.014
1983	0.987	1.137	1.171	1.115	0.968	0.939	1.045	0.961	0.998
1984	0.975	1.179	1.217	1.170	0.967	0.937	1.069	1.006	1.013
1985	1.022	1.224	1.264	1.182	0.987	0.955	1.087	1.028	1.033
1986	1.043	1.255	1.301	1.176	0.977	0.943	1.080	0.993	1.021
1987	1.056	1.263	1.317	1.198	1.001	0.960	1.107	1.018	1.034
1988	1.022	1.277	1.335	1.248	0.999	0.956	1.130	1.021	1.035
1989	0.982	1.286	1.348	1.298	0.991	0.946	1.149	1.052	1.053
1990	0.974	1.300	1.364	1.311	0.983	0.937	1.152	1.043	1.056
1991	0.950	1.307	1.375	1.330	0.967	0.919	1.151	1.021	1.033
1992	0.921	1.305	1.381	1.352	0.955	0.902	1.155	1.012	1.029
1993	0.933	1.307	1.389	1.352	0.965	0.907	1.164	1.005	1.028
1994	0.978	1.322	1.410	1.381	1.022	0.958	1.216	1.050	1.072
1995	1.043	1.350	1.441	1.372	1.060	0.993	1.238	1.069	1.088
1996	1.088	1.386	1.477	1.370	1.076	1.009	1.248	1.069	1.097
1997	1.119	1.422	1.519	1.375	1.082	1.013	1.253	1.080	1.112
1998	1.136	1.450	1.553	1.390	1.089	1.017	1.265	1.098	1.126

The lowest TFP index results from combining gross capital stock estimates using the long life assumption, the HLFS labour input measure and expenditure based GDP as the output measure. This index produces a trend annual TFP growth rate of 0.70 per cent. However, as noted earlier the official expenditure based GDP estimates tend to fluctuate in the early years and so we also present the corresponding TFP measure with production GDP as the output measure. This produces a trend growth rate of 0.58 per cent – lower than that for the expenditure based TFP index even though the production based TFP index lies above the expenditure TFP index. This is due to the initial downward bulge in the expenditure based index. Consequently, while the individual sensitivity analyses reported in this chapter lead to some variation in TFP estimates, combining the different possibilities leads to a wider range

of TFP estimates. In spite of this range, however, a consistent underlying pattern of TFP performance emerges which is in turn largely consistent with that obtained from the Diewert–Lawrence database.

5. SECTORAL PRODUCTIVITY ESTIMATES FOR NEW ZEALAND

In this chapter we present the individual TFP indexes for each of the 20 market sector industries included in the official database. The industry level TFP indexes are formed using production GDP, the composite labour series and net capital stocks using the Philpott length of life assumptions. We calculate the real rate of return separately for each industry to ensure the value of the industry's inputs equals its value of output. The industry level TFP indexes tend to be more volatile than the aggregate market sector indexes and caution needs to be exercised in their interpretation due to likely classification and measurement problems. This applies particularly to the results for service industries.

5.1 The Sectoral Database

In constructing the market sector output, labour and capital variables from the official database as outlined in the preceding chapter and appendix C, we have attempted to include information on the 20 separate industries listed in table 4.1 wherever possible. Using the 20 production GDPs, the 20 industry labour hours series in the official database's composite labour sheet, 20 separate industry Plant and equipment capital inputs and 20 separate industry Building and construction capital inputs, we formed overall TFP by aggregating 20 outputs and 60 inputs into total output and total input indexes, respectively. In deriving the capital input user costs we solved equation (4) in the preceding chapter for the economy as a whole leading to a common real interest rate for all industries.

To form separate TFP indexes for the 20 industries we now take real production GDP as output, normalise it to equal one in 1978, and form a chained Fisher index of the three industry inputs – labour hours, Plant and equipment stocks and Buildings and construction stocks – using labour costs and capital user costs as weights. We then take the ratio of the industry's total output to total input indexes to form the industry's TFP index. The industry TFP indexes use our 'preferred base case' specification of production based GDP, the database's composite labour series and our net capital stock estimates.

One significant difference compared to the aggregate level estimates of the preceding chapter relates to the formation of the capital user costs. Since real rates of return will differ markedly across industries in any year, if we use the economy wide real rate of return derived in the last

chapter, the total value of inputs will be greater than outputs for those industries which actually earned a low return in the current year. Conversely, for those industries which earned a high real rate of return in the current year, using the economy wide real rate of return will lead to the value of their inputs being less than the value of their outputs. This will cause distortions to the relative weighting of the three inputs in forming the individual industry total input indexes. To overcome this problem we solve equation (4) from the preceding chapter separately for the real rate of return in each industry to ensure the value of the industry's inputs equals its value of output. These industry specific real rates of return are then used in forming the user costs for the industry. We later undertake a sensitivity analysis of the effect of using the economy wide as opposed to industry specific real rates of return.

It should be noted that our industry specific rates of return are not necessarily very accurate due to the incompleteness of the list of inputs. We have no information on each sector's utilisation of land, natural resources and inventory stocks. The omission of these inputs will lead to large upward biases in our estimated rates of return for sectors that use these inputs intensively. The analogous bias at the level of the market sector is not as large as we have seen in chapter 3 due to the fact that the omitted inputs are not large in the economy overall (although they are not insignificant).

It is important to express the need for caution in interpreting sectoral and industry productivity results. Sectoral information is likely to be less reliable than aggregate economy wide information. For instance, it is more difficult to obtain accurate value and quantity information at the sectoral or industry level. Problems involved with the use of sectoral data include the effects of changes in industrial classification, ie, if the nature of a firm's outputs changes over time, at some stage the firm may be assigned to a new industry. When this switch of industries occurs, the productivity statistics of both industries (the new and the former industry) will be inaccurate for the switch year¹. In these days of extensive restructuring, this effect could be significant.

Another problem is associated with the nature of statistical agency business surveys. One survey may collect information on the firm's value added, another survey will collect price information on outputs and intermediate inputs, another survey may collect labour information and yet another survey may collect investment and capital stock information, etc. The chances are very good that the resulting price and quantity information that is finally assembled for the industry or sector as a whole will not be coherent; ie, the price information

¹ Note that when capital is switched from industry 1 to industry 2 due to restructuring (or reclassification of firms in these industries), it is necessary to know the vintage structure of the capital stock leaving industry 1 in order to compute the new gross capital stocks in each industry. Note that this information on the vintage structure of shifted capital is not required to compute the restructured net capital stocks. All that is required is information on the total amount of capital shifted.

collected will not precisely pertain to the value information for the industry and thus the decomposition of value flows into their price and quantity components will not be accurate, leading to inaccurate productivity statistics.

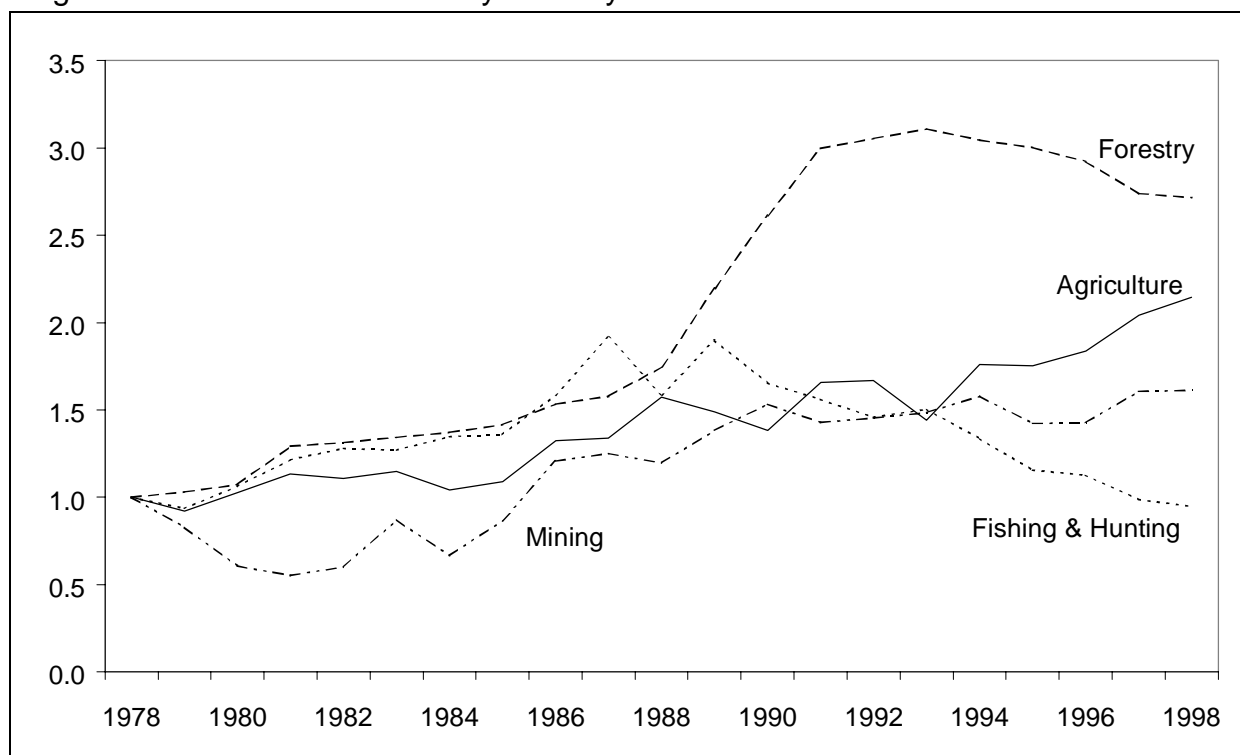
Classification problems are greatly magnified when we move to making international comparisons at the sectoral level. Each country will define its sectoral coverage a little differently and collect and construct information, particularly on capital stocks, in a different way. Greater reliance can usually be placed on more micro level and detailed benchmarking studies where more effort is put into ensuring like is being compared with like. Nevertheless, sectoral level productivity comparisons can be a useful starting point and in this chapter we report the TFP results for the 20 separate market sector industries including an examination of changes in productivity growth rates and a limited sensitivity analysis to changes in specification.

5.2 Sectoral TFP Indexes

The TFP indexes for our four primary industries are presented in figure 5.1. Agriculture has shown a relatively steady increase in productivity over the 20 years from 1978 to 1998. Downturns in TFP occurred in the mid 1980s, 1990 and 1993. Seasonal conditions and decisions to alter the timing of capital purchases, fertiliser application and building up or running down the livestock herd all have an important influence on the pattern of agricultural productivity. Overall, agricultural TFP increased at a trend annual rate of 3.9 per cent. Fishing and hunting's TFP, on the other hand, has had a mixed pattern with a steady increase up until 1987 and a steady decline since. Productivity almost doubled during the first decade before falling back below its original level by 1998. The overall trend TFP growth rate for the industry was 0.3 per cent. It should be noted that data for fishing and hunting is relatively difficult to obtain (see Keegan 1998) and so the resulting TFP estimates should be interpreted with extra caution.

Forestry TFP increased steadily until 1987 and then doubled in the space of five years. Corporatisation and privatisation of forestry assets caused substantial restructuring during this period. In the late 1980s there was significant price re-balancing between exotic and native timbers following the removal of price control (and artificially low prices) on native timbers. TFP then plateaued and then fell back slightly through til 1998. The overall trend annual TFP growth rate was a very high 6.4 per cent. However, a closer examination of the underlying data highlights a problem in the official database's composite labour series. Reported hours worked in Forestry almost halved in 1988 before continuing on a new lower trend reduction. Changes in industry classification do not appear to have been adequately allowed for.

Figure 5.1: New Zealand Primary Industry TFP Indexes

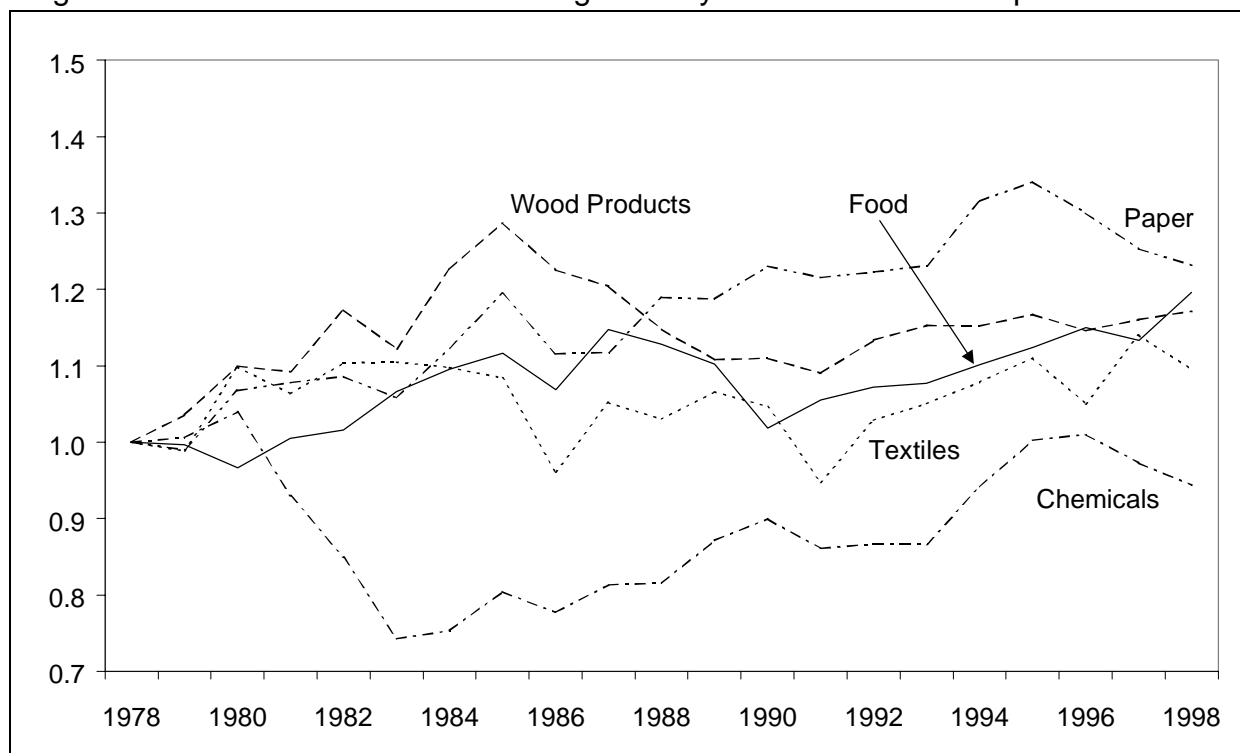


Mining TFP has also had a relatively high trend annual TFP growth rate of 4.9 per cent but this occurred because of a large downward bulge in TFP between 1978 and 1985. Corporatisation of Coalcorp after 1984 led to significant labour shedding and associated productivity improvements. The initial substantial fall in mining TFP may be explainable by a substantial increase in offshore gas field exploration (Chapple 1994). Because exploration is treated as a current expense in the national accounts it directly reduces industry GDP. A more accurate economic treatment of exploration expenditure would treat it as a form of investment depreciated over a number of years. This would not lead to such a large reduction in measured industry output in this situation. The subsequent recovery in TFP would have been aided by a substantial coal mine coming on stream and increased gold production.

The first five of the 9 manufacturing industry TFPs are presented in figure 5.2. The manufacturing productivity levels generally show less overall volatility than we saw with the primary industries. Food, beverages and tobacco TFP increased at a trend annual rate of 0.7 per cent over the 20 years but its 1997 level was only 13 per cent higher than its 1978 level. Textiles TFP also fluctuated in a narrow band and finished up only 10 per cent higher than its 1978 level after having fallen to 95 per cent of its 1978 level in 1991. The trend annual growth rate for Textiles' TFP was 0.2 per cent. Trade liberalisation and changing demand patterns are likely to have caused substantial excess capacity in this industry. Wood products' TFP showed more variability with a relatively steady increase up to 1985, a fall from then

until 1991 followed by a more modest upward movement. Wood products' TFP increased at an overall trend annual rate of 0.3 per cent.

Figure 5.2: New Zealand Manufacturing Industry TFP Indexes – Group One



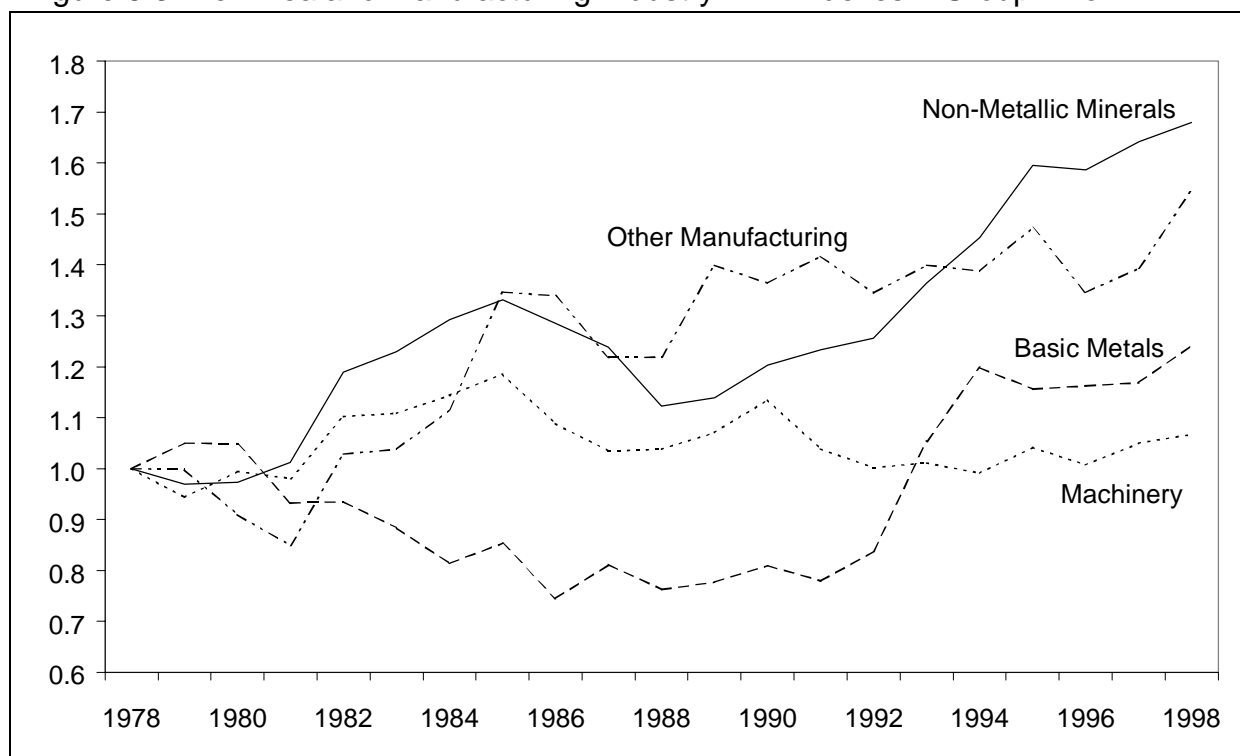
Paper products had the highest TFP growth rate of the first five manufacturing industries with a trend increase of 1.3 per cent. Growth was relatively steady up until 1995 after which the Paper industry TFP index declined by 8 per cent. Chemicals industry TFP behaved in an erratic way with a 30 per cent fall between 1980 and 1983 and relatively steady growth since then up until 1996. This industry was the focus of a number of the 'Think Big' projects of the Muldoon era. Overall, its TFP increased at a trend rate of a mere 0.3 per cent.

Of the remaining four manufacturing industry TFP indexes presented in figure 5.3 the Nonmetallic minerals industry showed the most consistent TFP increase. The TFP fall between 1985 and 1988 is likely to be associated with restructuring following trade liberalisation. Overall, Nonmetallic minerals TFP increased at a trend annual rate of 2.4 per cent. The residual Other manufacturing industry also showed relatively strong TFP growth with a trend annual increase of 2.4 per cent.

Basic metals industry TFP generally fell between 1978 and 1986 before plateauing at a lower level through until 1991. A rapid increase in measured TFP of around 50 per cent then occurred in the three years between 1991 and 1994 before again levelling off. While labour reforms around this time can be expected to have stimulated productivity growth, an increase in TFP of this magnitude in such a short space of time is highly implausible and more likely

highlights measurement error. Trend annual TFP change for Basic metals of 1.0 per cent is observed. The TFP of the Machinery (or Fabricated metals) industry fluctuates around its 1978 level for the entire 20 years and produces no trend change in TFP.

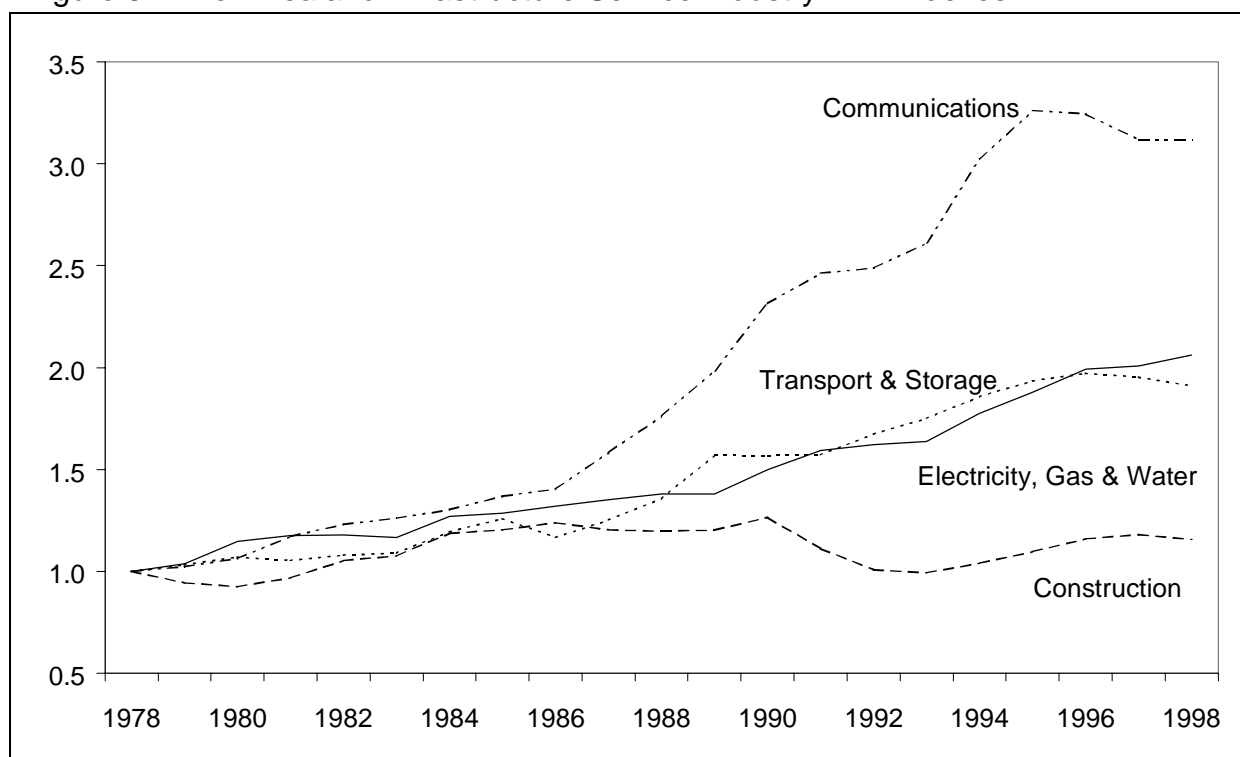
Figure 5.3: New Zealand Manufacturing Industry TFP Indexes – Group Two



The four infrastructure service industries shown in figure 5.4 all have strong TFP growth over the 21 year period. The Communications industry has a very high trend annual rate of TFP growth of 6.8 per cent. This will have been driven by a high rate of technological change combined with substantial restructuring associated with the privatisation of telecommunications and the introduction of competition to erstwhile government monopoly service providers. Recent work we have done in Australia indicates consistent annual TFP growth of around 5 per cent for a major telecommunications provider which plans further downsizing so TFP growth in the order of 7 per cent in New Zealand is certainly quite plausible. It is further supported by the detailed industry level estimates of Boles de Boer and Evans (1996) who estimate the annual productivity gain for Telecom NZ at roughly 9 per cent for the period 1987–1993.

The Transport and storage industry has also undergone major reform in New Zealand over the last 21 years with widespread corporatisation of government enterprises, privatisation of rail and air services and removal of restrictions, licensing and other regulations limiting competition. The beneficial effect of these reforms is reflected in a high trend annual TFP growth rate for this sector of 3.9 per cent.

Figure 5.4: New Zealand Infrastructure Service Industry TFP Indexes

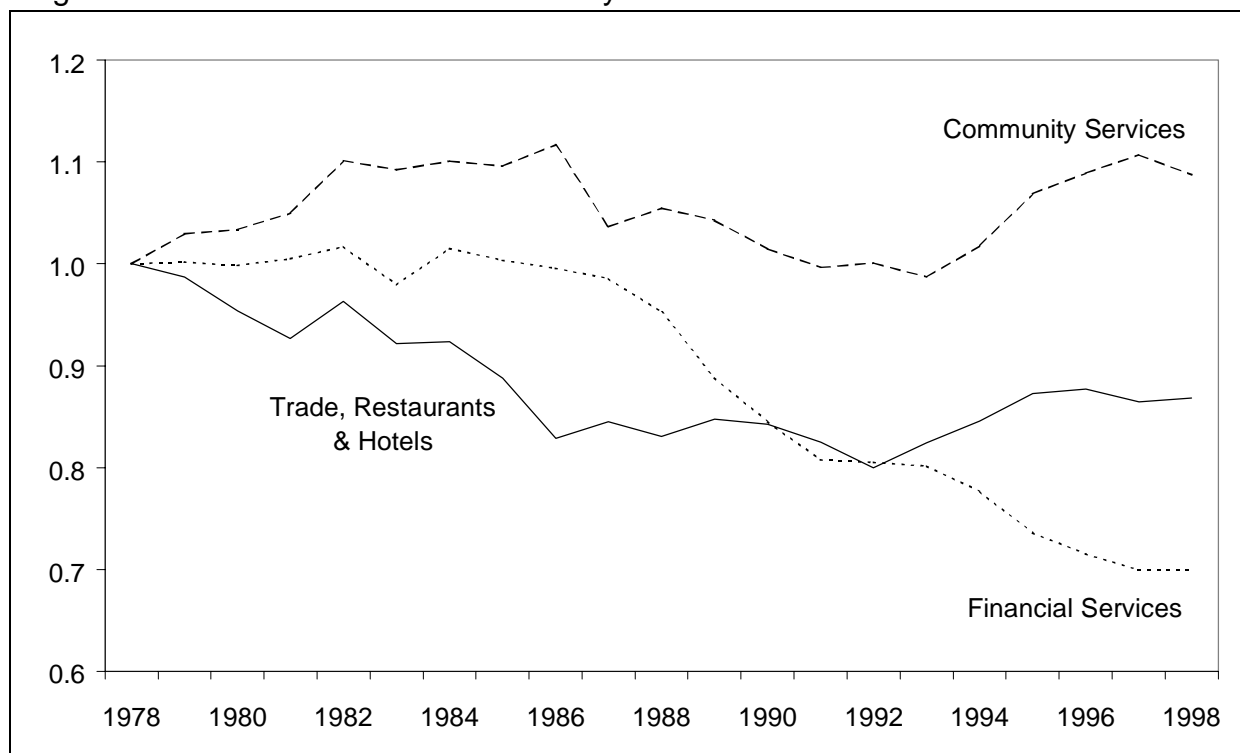


New Zealand also reformed its Electricity, gas and water industries with corporatisation of electricity followed by vertical and horizontal disaggregation and some introduction of competition. Privatisation and deregulation of gas utilities also occurred in the late 1980s and corporatisation and tendering out requirements have affected water supply operations. These reforms have led to a high trend annual TFP growth rate in this sector of 3.5 per cent. While showing less spectacular performance than the other sectors, the Construction sector has enjoyed a trend annual TFP growth of 0.6 per cent although it has been subject to cyclical downturns, particularly in 1980 and 1993.

The final set of three service sector TFP indexes are presented in figure 5.5. These are the sectors where current measurement problems are at their most severe. This is highlighted by the progressive decline in measured TFP of the Financial services sector whose trend annual rate of TFP change is -2.1 per cent. The reforms which occurred in this sector during the 1980s combined with the rapid change in the range and quality of the services offered by this sector make this result totally implausible. Rather, the answer can be found in the way output and investment are measured in the sector. Real output is approximated by a range of methods including changes in the number of transactions, property sales, insurance premiums and, in the case of business services, employment volume. These proxies will find it difficult to pick up quality changes and the emergence of new products in this rapidly evolving sector. The national accounts framework world wide has also found it difficult to handle industries where

interest income is a significant source of revenue. This issue will be explored further in chapter 7.

Figure 5.5: New Zealand Service Industry TFP Indexes



The estimated capital stock for Financial services has also increased at an implausibly fast rate, probably reflecting problems with addressing the increasing importance of leased capital assets. The NZSNA follows the same conventions as business accounting in distinguishing between financial and operational leasing. Financially leased assets are treated as being owned by the unit using the asset, while operationally leased assets remain fully accounted for by the owner. SNZ has indicated it has no information on the extent of the two types of leasing but accepts that there are likely to be significant values of operationally leased assets recorded within the Financial services industry. A similar situation is likely to occur with assets leased from overseas owners. This will artificially reduce the measured productivity of the Financial services industry while at the same time providing an artificial boost in measured productivity to the sectors where the assets are actually used.

The measurement problems experienced in this sector explain the difference we observe between the full market sector TFP index and that of the smaller 'ABS equivalent' sector of the preceding chapter and highlight the urgent need to devote resources to improving service sector measurement. This is not a problem confined to New Zealand. The ABS, for instance,

has to date only addressed the problem by excluding the 'hard to measure' sectors from its multifactor productivity index².

Table 5.1: Official Database TFP Indexes for Primary and Service Industries

<i>Year</i>	<i>Agriculture</i>	<i>Fishing and Hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Elect. Gas, Water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & Storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	0.920	0.935	1.029	0.827	1.037	0.943	0.987	1.032	1.023	1.002	1.030
1980	1.028	1.062	1.073	0.606	1.146	0.925	0.954	1.070	1.062	0.998	1.034
1981	1.133	1.214	1.291	0.551	1.177	0.967	0.927	1.054	1.171	1.005	1.050
1982	1.107	1.279	1.313	0.600	1.178	1.052	0.963	1.080	1.231	1.017	1.101
1983	1.146	1.269	1.343	0.871	1.166	1.076	0.922	1.090	1.261	0.980	1.092
1984	1.042	1.346	1.371	0.665	1.272	1.187	0.923	1.194	1.302	1.015	1.101
1985	1.087	1.359	1.415	0.867	1.285	1.204	0.888	1.258	1.369	1.004	1.096
1986	1.324	1.585	1.533	1.206	1.319	1.239	0.829	1.167	1.403	0.996	1.117
1987	1.337	1.917	1.577	1.249	1.352	1.203	0.845	1.252	1.584	0.985	1.036
1988	1.573	1.586	1.745	1.196	1.378	1.197	0.831	1.357	1.762	0.953	1.055
1989	1.490	1.899	2.196	1.382	1.380	1.202	0.848	1.570	1.985	0.888	1.043
1990	1.384	1.654	2.613	1.533	1.498	1.266	0.842	1.569	2.315	0.845	1.015
1991	1.657	1.559	2.997	1.427	1.593	1.112	0.825	1.572	2.463	0.808	0.996
1992	1.668	1.457	3.052	1.453	1.621	1.008	0.800	1.674	2.489	0.805	1.001
1993	1.441	1.504	3.109	1.485	1.637	0.994	0.825	1.751	2.612	0.802	0.987
1994	1.760	1.334	3.043	1.578	1.777	1.040	0.846	1.858	3.022	0.777	1.017
1995	1.754	1.155	3.002	1.422	1.879	1.096	0.873	1.935	3.262	0.736	1.069
1996	1.835	1.126	2.922	1.427	1.993	1.159	0.877	1.972	3.245	0.715	1.089
1997	2.040	0.986	2.738	1.606	2.010	1.180	0.865	1.954	3.118	0.699	1.107
1998	2.146	0.946	2.715	1.612	2.060	1.157	0.869	1.910	3.118	0.700	1.087
<i>Trend Annual TFP Growth Rates (%pa)</i>											
1978-98	3.87	0.25	6.34	4.92	3.50	0.63	-0.75	3.87	6.77	-2.11	0.03
1978-85	1.81	5.42	5.42	-1.09	3.37	3.55	-1.46	2.88	4.72	0.05	3.55
1986-98	3.55	-5.36	5.24	2.14	4.08	-0.80	0.39	4.26	6.98	-3.14	0.20

A similar problem is evident in the TFP index for Trade, restaurants and hotels which falls progressively between 1978 and 1992 to 80 per cent of its 1978 level before recovering to 87 per cent of its 1978 level in 1998. This produces a trend annual TFP change of -0.8 per cent. Again this is highly implausible given the growth in the range and quality of services provided by this sector. The explanation again likely lies in measurement problems. The

² While removing the sectors largely 'solves' the problematic output measurement issues, to the extent that inputs have been misallocated between sectors, the resulting 'ABS equivalent' series may also be biased.

techniques used to measure real output are unlikely to adequately account for quality changes and the introduction of new services nor the impact of reductions in margins over time.

Table 5.2: Official Database TFP Indexes for Manufacturing Industries

<i>Year</i>	<i>Food, beverages tobacco</i>	<i>Textiles</i>	<i>Wood & Wood Products</i>	<i>Paper & Paper Products</i>	<i>Chemicals</i>	<i>Non-metallic minerals</i>	<i>Basic metals</i>	<i>Machinery</i>	<i>Other manufacturing</i>
1978	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	0.997	0.989	1.035	0.990	1.006	0.970	1.050	0.944	0.999
1980	0.966	1.098	1.100	1.068	1.040	0.974	1.048	0.995	0.910
1981	1.005	1.063	1.092	1.078	0.930	1.012	0.933	0.981	0.849
1982	1.016	1.104	1.173	1.086	0.849	1.189	0.935	1.103	1.029
1983	1.066	1.105	1.122	1.058	0.743	1.229	0.884	1.109	1.038
1984	1.095	1.098	1.226	1.124	0.753	1.292	0.814	1.144	1.116
1985	1.116	1.084	1.288	1.194	0.804	1.332	0.854	1.186	1.347
1986	1.068	0.961	1.225	1.116	0.777	1.284	0.745	1.088	1.339
1987	1.147	1.052	1.204	1.117	0.813	1.239	0.812	1.035	1.218
1988	1.128	1.030	1.148	1.189	0.815	1.123	0.763	1.038	1.219
1989	1.102	1.066	1.108	1.187	0.871	1.140	0.777	1.071	1.400
1990	1.018	1.046	1.110	1.230	0.900	1.204	0.810	1.136	1.364
1991	1.055	0.948	1.090	1.215	0.861	1.234	0.779	1.039	1.417
1992	1.072	1.029	1.134	1.223	0.867	1.256	0.838	1.002	1.345
1993	1.077	1.051	1.153	1.231	0.866	1.364	1.054	1.011	1.400
1994	1.102	1.079	1.152	1.315	0.941	1.453	1.198	0.991	1.388
1995	1.124	1.110	1.167	1.341	1.002	1.596	1.156	1.042	1.473
1996	1.150	1.050	1.146	1.300	1.010	1.586	1.163	1.007	1.345
1997	1.133	1.140	1.161	1.253	0.973	1.642	1.169	1.050	1.393
1998	1.196	1.095	1.171	1.231	0.943	1.680	1.242	1.067	1.546
<i>Trend Annual TFP Growth Rates (%pa)</i>									
1978-98	0.68	0.16	0.30	1.28	0.25	2.36	1.01	0.03	2.43
1978-85	1.84	1.36	3.27	2.21	-4.85	5.12	-3.44	3.09	3.84
1986-98	0.51	0.85	0.00	1.12	1.89	3.23	4.87	-0.30	1.16

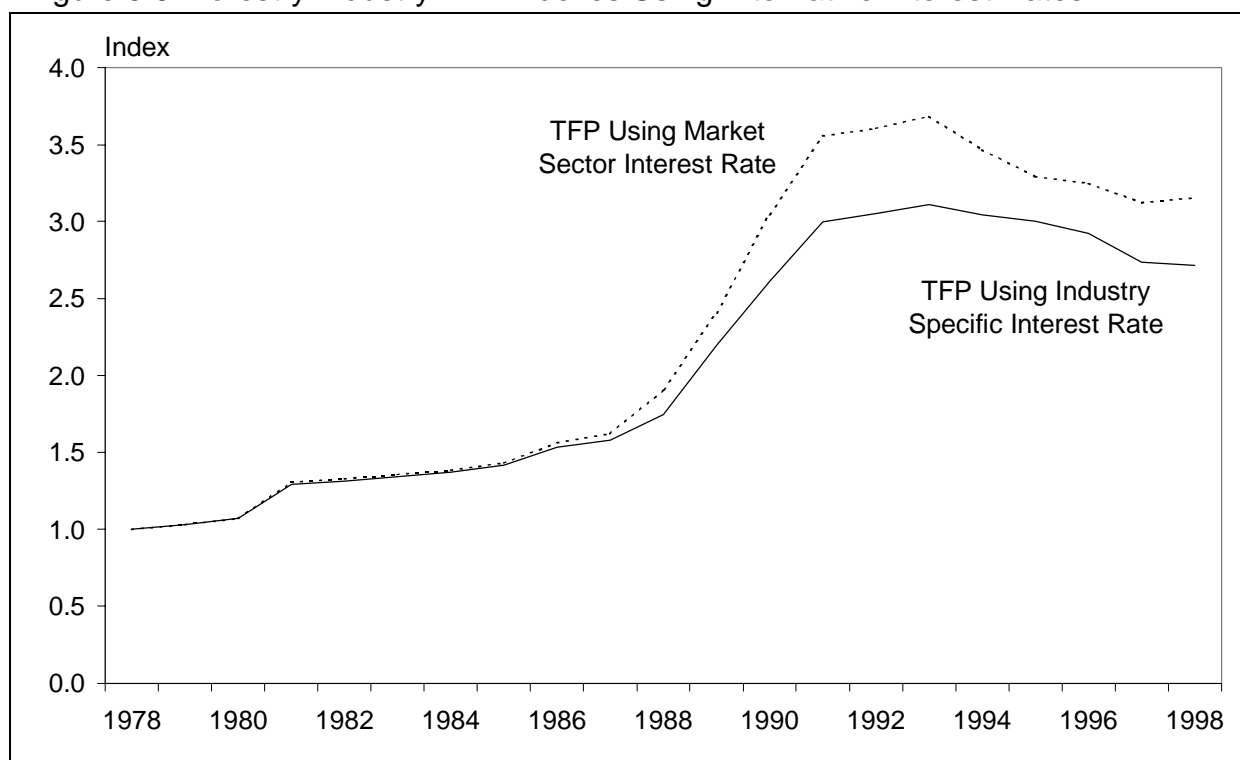
The TFP of the third hard to measure service sector, Community services, fluctuates in a band between its 1978 level and a level 10 per cent higher. This produces no trend annual change in this sector's TFP. Again, measurement problems are evident in this sector with real output measures being heavily dependent on labour hours worked indicators and output rather than outcome related indicators. The problems associated with service sector output measurement will be discussed in more detail in chapter 7.

The 20 individual industry TFP indexes are presented in tables 5.1 and 5.2.

5.3 Sectoral Sensitivity Analysis

In this section we will examine the impact of some of the major assumptions made in constructing the sectoral capital user costs and labour data. We have examined the impact of using gross and net capital stock measures on TFP in the preceding chapter and will not repeat that analysis here as the same pattern of results will be translated to the sectoral level. Given that we use the same starting values for both gross and net capital stock starting values in 1950 and the same length of life and depreciation assumptions as derived by Philpott (1992), the effect of using the gross capital stock as opposed to the net capital stock approach will be to increase the size of the measured capital stock through time and reduce the rate of productivity increase. Varying the assumed lengths of life and depreciation rates will also produce the same pattern as observed at the aggregate level.

Figure 5.6: Forestry Industry TFP Indexes Using Alternative Interest Rates



As noted at the start of this chapter, we have two alternative ways of forming industry user costs. One is to use the market sector wide real rate of return for all industries. The other is to use industry specific real interest rates which equate the value of outputs and inputs for each industry rather than for the market sector as a whole. The market sector wide real interest rate which equates the value of outputs to inputs starts at 13 per cent in 1978 and increases relatively smoothly through to 23 per cent in 1998. The majority of industry specific real interest rates lie relatively close to the market sector wide rate, particularly in manufacturing and agriculture. The most volatile industry specific real interest rate is that for Forestry. This

starts at a level similar to the market sector rate but increases to nearly 500 per cent in 1993 before swinging to a large negative value in 1994 and returning to large positive values in the last few years. This provides further evidence of the significant measurement problems in this industry alluded to earlier in regard to reported hours worked in the QES for Forestry.

The impact of this extreme volatility on measured TFP is shown in figure 5.6. The effect of using the market sector real interest rate is to increase Forestry TFP from 1987 onwards. By 1998 the Forestry TFP level was 16 per cent higher using the market sector rate compared to the Forestry specific interest rate. This is enough to increase the trend annual TFP growth rate from 6.3 per cent to 7.3 per cent. Using the generally lower market sector rate puts less weight on capital which increases over the period compared to the major reduction in labour reported in the QES based composite labour series. While this is an extreme example and is based on almost certainly anomalous labour data, the change has little impact on the pattern of TFP change. For other industries the shift from industry specific to the market sector real interest rate has far less impact on measured TFP. In all cases the impact is a minor change in TFP levels without any significant impact on the pattern of industry TFP change or relativities between industries.

We turn now to a discussion of the New Zealand literature on productivity measurement.

6. COMMENTS ON THE NEW ZEALAND PRODUCTIVITY LITERATURE

In this chapter we review several earlier studies of the productivity performance of the New Zealand economy and compare their results with those of the current report. The studies examined are Smith and Grimes (1990), Chapple (1994), Chapple and Mears (1995), Philpott (1995), Sarel (1996), Janssen (1996a,b; 1997), Färe, Grosskopf and Margaritis (1996), Hall (1996; 1998), Conway and Hunt (1998) and Maloney (1998). In the final section we review the standard growth accounting approach to estimating productivity growth commonly used in the earlier studies. This method is based on the use of the relatively inflexible Cobb–Douglas production function and hence results obtained with this methodology must be viewed with caution. Indeed, we find that when a more flexible functional form is used productivity growth rates change substantially and tend to closely approximate our index number based results.

There is little value added in making a detailed comparison of the recent New Zealand total factor productivity literature with the results that we have obtained in chapters 3 to 5, since the sensitivity analyses that we performed above show that a relatively wide range of TFP estimates can be expected as researchers alter their assumptions and databases. However, the recent New Zealand productivity literature has much that is valuable in it and it is useful to: (a) acknowledge the positive contributions of this literature and indicate where we have used similar techniques; (b) indicate where we think that there might be weaknesses in this literature and (c) discuss briefly various additional topics that this literature has addressed. Thus, in this chapter we briefly review a number of papers, starting with the earlier ones and proceeding to the most recent New Zealand productivity papers.

6.1 Richard Smith and Arthur Grimes (1990)

This paper compares New Zealand's productivity growth over the period 1950-1984 with that of the UK, USA, the Netherlands, France, Germany and Japan. It does a standard Solow (1957) Cobb–Douglas (1928) production function sources of growth decomposition for each of these countries. Real output growth is explained by: (a) growth of reproducible capital; (b) growth of labour and (c) growth in TFP. The authors found that New Zealand's TFP growth was less than those of the other countries.

The remainder of the paper suggests possible contributory factors that might help explain New Zealand's poor postwar TFP growth. We consider each of these suggested factors below.

The first explanatory factor that the authors suggest is New Zealand's relatively high inflation over the post war period:

“There are a number of channels through which high inflation may impact on the level of economic activity and also on the rate of economic growth. These channels include a possible reduction in savings due to distortions caused by interaction between inflation and the tax system. Inflation, particularly variable inflation, is also likely to have hindered the allocation of resources and so have reduced productivity.” Smith and Grimes (1990, p.144).

We agree with the above quotation. The fact that the system of business taxation did not (and still does not) index depreciation allowances and interest income for inflation heavily disadvantages investment in assets with long lives and leads to significant distortions in the intertemporal allocation of resources. Variability in inflation rates will also increase uncertainty about future prices and will tend to lead to a higher incidence of “mistakes” in investments and hence to lower productivity. Of course, with inflation now much lower, this factor is much less significant although it could be a positive contributory factor to the recent productivity surge. However, the relatively high levels of taxation on interest income remain a negative factor on the rate of capital accumulation (and hence growth of output) in New Zealand.

The second explanatory factor that the authors suggest for New Zealand's poor performance was a downward trend in its terms of trade. Smith and Grimes (1990, p.145) present a graph which shows a decline in New Zealand's terms of trade (an index of export prices divided by an index of import prices) which extends from 1950 (when the terms of trade were about 120) to 1986 (when the terms of trade were just above 70). From 1986 to 1989, their graph shows a recovery in the terms of trade to just under 90.

In figure 6.1 we present the New Zealand terms of trade using the Diewert–Lawrence TFP database. In chapter 3 we used the method of Diewert and Morrison (1986) and Fox and Kohli (1998) to decompose changes in nominal GDP into effects due to changes in the terms of trade, growth in labour and capital endowments, productivity change and changes in nontraded goods prices. That analysis indicated that for the period 1978 to 1997 changes in the terms of trade had a relatively minor impact on real GDP. Productivity change was the largest single contributor to increases in real GDP, all else unchanged, followed by increases in the economy's capital stock, increases in labour endowments and then changes in the terms of trade.

Figure 6.1 Diewert–Lawrence New Zealand Database Terms of Trade



As a third factor that might help to explain New Zealand's poor TFP performance, Smith and Grimes (1990, p.146) note New Zealand's traditional reliance on large scale regulation, market interventions by government and an environment of unproductive rent seeking on the part of special interest groups:

“Post-war New Zealand has been characterized by a high degree of border protection and insulation from the world economy. This environment has reduced competitive forces within the domestic market with a likely consequent negative effect on productivity growth.” Smith and Grimes (1990, p.147).

The TFP results we present in chapter 3 appear to support this assessment. This contrasts with Australia's TFP performance over this period which continued to grow steadily.

6.2 Simon Chapple (1994)

This study uses the standard Solow Cobb–Douglas methodology to calculate TFP for 20 New Zealand industries for the period 1972–1991. The data sources used are broadly similar to the sources we used to construct industry productivity measures in chapter 5. However, the data set that we use does not appear to contain as many anomalies that seem to be in the data set used by Chapple.

Figure 6.2: New Zealand Agricultural TFP Estimates, 1978–1991

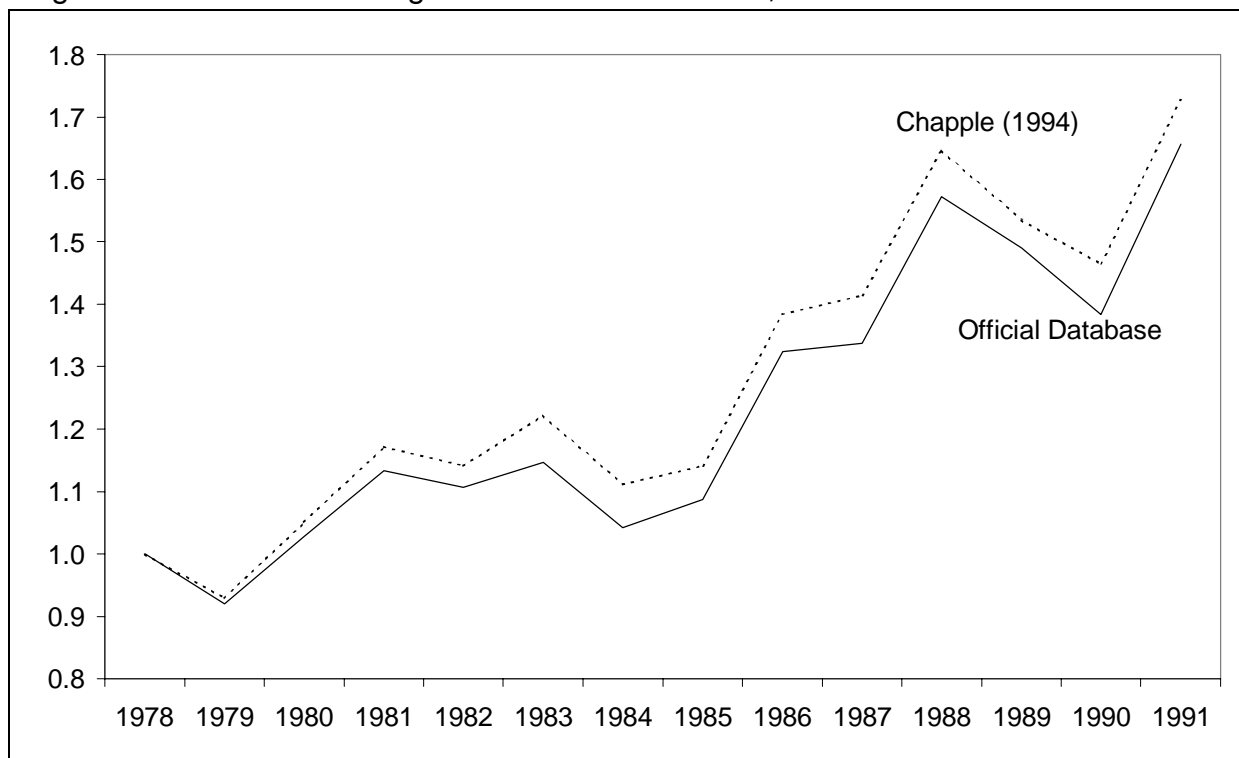
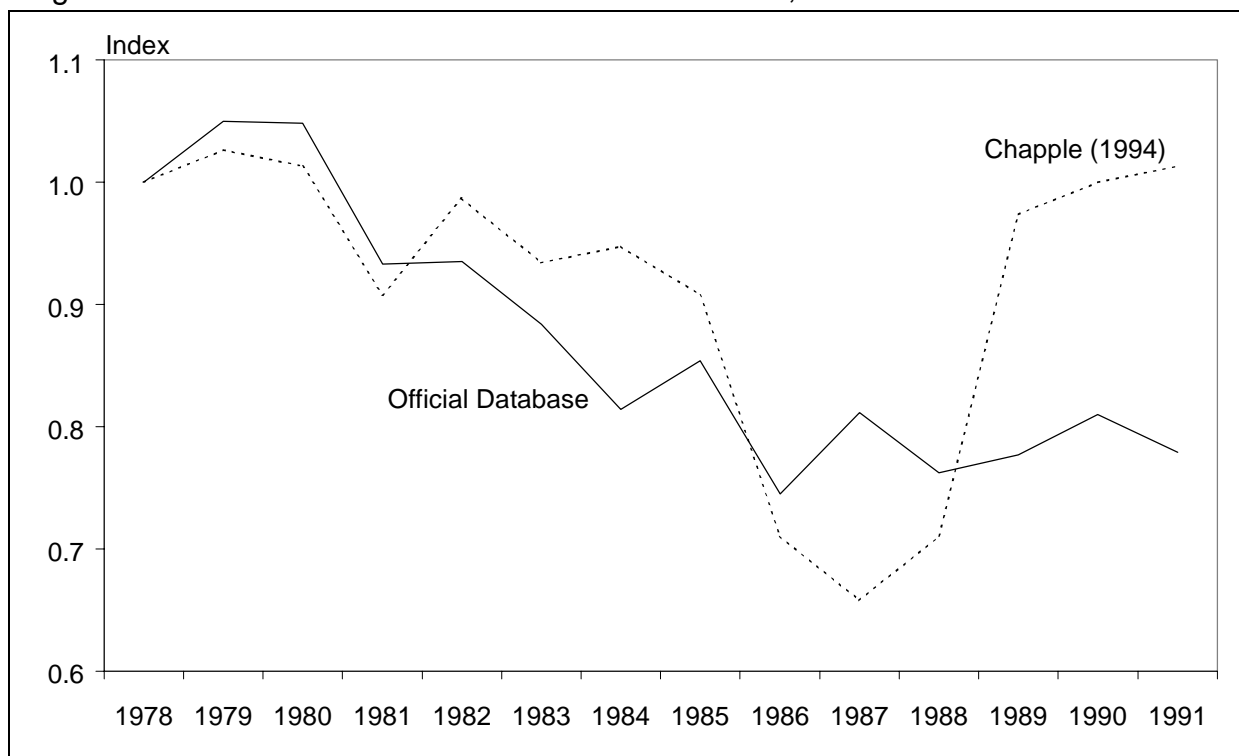


Figure 6.3: New Zealand Basic Metals TFP Estimates, 1978–1991



Chapple presents a graph for each industry showing TFP over time along with the partial productivities for labour and capital (which are output divided by labour input and output

divided by capital input, respectively). In chapters 3–5 above, we used similar diagrams to illustrate our versions of TFP by industry; however, we omitted the partial productivities since we believe that they are less meaningful.

In most cases the sectoral results we reported in chapter 5 using the ‘official’ database for the current project are reasonably close to Chapple’s results for the overlapping period 1978–1991. For instance, the two series for the Agriculture sector presented in figure 6.2 track each other very closely. For some industries, such as Basic metals presented in figure 6.3, there are more significant deviations between the two series.

Chapple also highlights some of the difficult measurement issues (such as the decomposition of operating surplus into labour, capital and depreciation components and the problem of quality changes in industry outputs) that make it difficult to measure productivity at the industry level:

“Gross operating surplus includes an element of depreciation, the estimates of which are necessarily crude. In addition, in many sectors of the economy, particularly those with a high proportion of owner–operated concerns, actually earned operating surplus contains a large portion of labour income.” Chapple (1994, p.16).

“It may well be that the GDP deflator [for trade, restaurants and hotels] is not picking up a number of quality changes in this sector which have occurred over the past twenty years. Thinking, for example, about quality differences in restaurants and hotels now and twenty years ago (in terms of range and quality of food and drink, opening hours, service, décor and so on) tends to give some anecdotal plausibility to such a hypothesis.” Chapple (1994, pp.33–34).

There appears to be a large amount of measurement error in the industry output data that Chapple utilised. Chapple (1994, pp.21–22) recognises this measurement error in the case of the Food, Beverages and Tobacco industry (where productivity goes from about 125 in 1974 to about 360 in 1976). But there seems to be similar anomalous results for fully 12 of the remaining industries where, in each case, productivity surges going from 1975 to 1976 and then falls back down to its trend level in the following year. The productivity pattern in Financial services is also unbelievable: it falls steadily from about 100 in 1972 to about 60 in 1991. In the case of Financial services, Chapple (1994, p.37) suggests that the price index used to deflate value added in Financial services may have substantially overstated sectoral inflation which, of course, leads to the observed anomalous results.

Statistics New Zealand (1996, p.28) can be used to partly explain the strangely unproductive behaviour of the Finance industry. Some of Financial services output is measured by labour

input and other parts are measured by the quantity of transactions which makes it difficult to pick up quality change in this industry where the range of services offered is evolving quickly. These are rather standard procedures utilised by statistical agencies. For example, when it is very difficult to measure the real output of an industry, a measure of real input (like labour) is often used as a proxy. Statistics New Zealand at present uses employment (at least in part) to measure the output of the following components of private sector production: Construction; Finance; Business services; and Other services. Every economist who uses the New Zealand industry database should read Statistics New Zealand (1996) to get an impression of the data quality in the different industries. For several sectors, the real output data are rather weak and no amount of econometric filtering or mathematical modelling will transform these data into useful inputs for an economic model. The poor quality of real output data for many service sector industries is no better in other countries as the following quotation indicates:

“The third and least satisfactory method [to measure industry real output] uses hours worked or input cost data to extrapolate base year gross product. These are used as the main or sole indicators to derive constant price gross product estimates for Public Administration and Defence; Finance, Property and Business Services; and Community Services. The ABS considers that these three industry divisions should be excluded from multifactor productivity analysis at this stage, for the same reason that they are excluded from labour productivity analysis.” Aspden (1990, p.4).

It is ironic that in recent years, employment growth in most OECD countries has been greatest in the service sector industries where outputs are measured the least accurately.

As we noted in chapter 5, an apparent rapid increase in the size of the Financial services industry's capital stock also contributes to our observed poor performance in this industry. This also appears to be the case in Chapple's study where capital productivity falls sharply while labour productivity only falls slightly. The increasing importance of leased capital and the allocation of part of it to the owning industry (Financial services) rather than the using industries is another likely source of measurement error.

6.3 Simon Chapple and Tracy Mears (1995)

This paper follows up on the earlier work of Chapple (1994) by revising and updating Philpott's (1991) pioneering estimates of the New Zealand capital stocks by industry and then calculating output–capital and capital–labour ratios for each industry for the time period 1950–1995. There are several useful insights and innovations in the paper.

Chapple and Mears (1995, p.3) utilise a gross capital stock approach to construct their sectoral estimates of capital input. We used a similar methodology to construct our gross

capital stocks. Their methodology works as follows. They use Philpott's (1991) estimates of the gross capital stock in each sector for 1950 as their starting stocks and then Chapple and Mears assume that these starting capital stocks 'die' smoothly each year by the amount $1/n$ where n is the assumed life of the asset. They compare their simplified 'linear' approach to the more accurate gross capital approach that utilises investment data by industry for the period prior to 1950 where it is available. This comparison was possible for the Manufacturing sectors for the Plant, machinery and transport equipment component of the aggregate capital stock. They report the results of their comparisons between their 'linear' method (which we use in this study) and the 'complete profile' method as follows:

“Using this approach in the sectors (manufacturing) where gross fixed capital formation data was sufficiently long and asset lives were sufficiently short to allow inference of the age profile of the capital stock in 1950 (i.e. for Plant, Machinery and Transport Equipment) gave very similar capital stock figures to the alternative approach using information regarding the manufacturing capital stock age profile. Occam's razor was applied and the simple linear approach was followed to allow for “deaths” in the starting capital stock.” Chapple and Mears (1995, p.3).

Chapple and Mears also use the simple 'sudden death' version of the gross capital stock model (also used in our empirical work reported earlier) rather than more complex models of the gross capital stock model that assume a distribution of retirements for each vintage of the capital stock:

“The assumption of “sudden death” was used regarding the point at which assets drop out of the capital stock. Philpott (1991) uses a more sophisticated assumption which assumes asset deaths are distributed around their average asset life. ... Since (a) we have no information regarding this distribution and (b) assuming alternative distributions appears to make little difference to the eventual capital stock estimates, Occam's razor was again applied to justify use of the sudden death assumption.” Chapple and Mears (1995, p.3).

We are entirely sympathetic to the thrust of the above quotations.

Chapple and Mears present graphs of the capital-labour ratios and output-capital ratios for the years 1950-1995 for the 20 industries they cover. For virtually all of their 20 industries, there is an upward trend in the capital-labour ratios; an exception is the Community services industry which trends up until about 1970, then trends down until 1986 and finally trends up to 1993. An interesting feature of their capital-labour ratios is that 16 of the 21 industries have a noticeable downward trend starting around 1991. This means that labour employment

increased more rapidly than the capital stock for the years following 1991 which is consistent with the decline in unemployment which started to occur around this time. It is also noteworthy the Employment Contracts Act, which made the labour market more flexible, was introduced in 1991. We have more faith in the capital–labour ratio information than the output–capital ratios which are less reliable due to the difficulties involved in measuring real output or real value added by industry.

Chapple and Mears also look at the computer price problem. In the mid 1980s Statistics New Zealand started using the US quality adjusted price index for computers (appropriately indexed for exchange rate movements) to deflate imports and gross investment in computers. This new indexing procedure leads to a more rapid growth of real investment and of the capital stock for machinery and equipment. As was mentioned in section 3.3 above, it does not affect real GDP much because real imports and real investment move in offsetting directions.

Chapple and Mears (1995, p.22) plot the official Statistics New Zealand Plant, machinery and transport equipment deflator and note that it gently trends down since 1986. They then do some rough calculations and take an average of equipment import prices and domestically produced machinery and equipment prices and find that their estimated overall deflator for PMTE gently trends up after 1986. They also find that their estimated index is quite close to the official index for the years 1978–1986. Under the assumption that the official index is biased and that their estimated index is correct, they recompute the capital stock for Textiles and graph the resulting capital–labour ratios and compare them to their initial estimates (which used the official PMTE deflators). Chapple and Mears (1995, p.23) found very little difference in the two graphs.

We are not convinced that Statistics New Zealand is ‘wrong’ on this issue, in any case. Statistics Canada also adopted the US computer price deflator around the same time as Statistics New Zealand and a similar flat to declining price deflator for the Machinery and equipment aggregate results for the 1980s and 1990s. However, due to the continuing rapid decline in the quality adjusted prices for computers, it will be necessary for Statistics New Zealand to rebase their investment price indexes *frequently* and, in the limit, it would be preferable to move to the chain system (which is rebasing every period).

Chapple and Mears (1995; 30) conclude with a ‘wish list’ of data priorities for Statistics New Zealand. Some of the items on their list are:

- separate asset deflators need to be developed for at least the two major asset classes by two digit industry. They give the following reason for this wish:
“The assumption made in the capital stock estimates calculated here that the basket of investment goods purchased by the Textiles sector is the same as that

purchased by Communications, or behaves in the same fashion, strains credibility.” Chapple and Mears (1995, p.30).

- more accurate investment deflators
- more accurate information on asset lives
- nominal capital formation by two digit sectors for the nonmanufacturing industries before 1950.

We concur with their wish list except for their last point; we think it would be very difficult for Statistics New Zealand to accomplish this task and the benefits would probably not outweigh the costs. However, in addition to the above wish list, we would add the following items:

- Information on the depreciation and scrapping of assets is also urgently required.
- In addition to more accurate investment price deflators, there is an even more urgent need for output price and intermediate input price deflators.

6.4 Bryan Philpott (1995)

As noted in chapters 4 and 5, Bryan Philpott has played a pioneering role in developing industry level data in New Zealand, particularly the development of capital data. In this paper Philpott presents standard Solow Cobb–Douglas estimates of TFP for 20 New Zealand industries (and various aggregates of these 20 industries) for the years 1960–1994. Philpott also aggregates his estimates over time for various subperiods. Only annual average TFP changes are presented. Many of his sectoral changes for the period before and after 1985 follow a similar pattern to our trend results reported in tables 5.1 and 5.2 although there are differences in the growth rates for each time period. At the aggregate level, Philpott’s average annual TFP change for the period after 1985 is 1.5 per cent.

6.5 Michael Sarel (1996)

This paper is similar to Smith and Grimes (1990) in that New Zealand’s input, output and TFP growth rates are compared to various countries. The time period covered in the Sarel paper is 1978–1996 and he uses the standard Solow Cobb–Douglas growth accounting methodology. Some of the innovations in the paper are:

- New Zealand’s performance is compared not only to the OECD countries Australia, France, Japan, the UK and the US but also to the Asian economies of Indonesia, Malaysia, the Philippines, Singapore and Thailand.
- An innovative approach is used to construct “effective” labour supplies that are adjusted for demographic differences across countries.

- He uses the 1995 NBER update for the Penn World Tables (see Summers and Heston (1991) for a description of this database) to construct output measures across countries for the years 1978–1992. For the years 1993–1996, these output data are projected forward using country specific national accounts data.

Sarel describes the advantages of using the Penn World Tables as follows:

“The major advantage of this data base is that it measures output per person in PPP [Purchasing Power Parity] adjusted 1985 dollars, meaning that this variable is, in principle, not affected by domestic prices of goods and services (both relative to other goods and services in the domestic economy and relative to prices denominated in a common currency in foreign economies).” Sarel (1996).

In our view, there are two major disadvantages to the use of the Penn World Tables in making international productivity comparisons:

- The microeconomic prices used to deflate the different components of output for the countries in the Penn data set are not as accurately determined as the microeconomic prices used by the individual country statistical agencies to deflate output components. When comparisons are made across countries, it is necessary to price a common basket of commodities across each country in the comparison set. Many commodities are country specific or at least area specific. Not all commodities are available in each country and even if they were, countries at different stages of development will consume very different baskets of these universally available commodities. For a more comprehensive list of measurement problems involved in making international comparisons, see Hill (1993, pp.393–394) and Diewert (1996a, p.249).
- The Penn World Tables rely on the Geary (1958)–Khamis (1970) index number formula for making the international comparisons of outputs. Diewert (1996a, p.257; 1996b, p.37) showed that the only aggregator functions that are exact for this index number formula are the inflexible, no substitution Leontief aggregator function and the infinitely substitutable linear aggregator function. In less technical terms, Hill (1982, p.54), Marris (1984, p.52), Hill (1995, ch. 4) and Diewert (1996b p.36) showed that the Geary–Khamis index number formula suffers from systematic substitution bias. This means countries whose price vectors are far from the large country dominated Geary–Khamis average world prices will end up with world shares of output that are biased downward.

To evaluate the stability of the real output levels contained in the Penn World Tables, consider the following experiment: start with the Tables that were constructed say in 1985. Using these Tables, output components are compared across countries using a common set of world prices (with country specific exchange rate factors). Now use country specific National

Accounts data to construct real output components for each country, going from 1985 to say 1990. Finally, use the 1990 version of the Penn World Tables to compare those real outputs by country and component with the corresponding 'national accounts' estimates for country real outputs by component. In many cases, there will be little correspondence between the two sets of estimates, casting some doubt on the usefulness of the Penn World Tables.

This lack of stability problem is very similar to the problems involved in constructing estimates of real GDP for a country using fixed price weights over a long period of time. If relative output prices do *not* move approximately proportionally over time, there can be large differences between fixed base Paasche and Laspeyres output indexes; ie, the choice of which set of base period prices to use can make a big difference to the resulting estimates of real output. With computer production being relatively large in the US, the rapidly declining price of computers made the fixed base estimates of real GDP untenable; every time the base period was changed, U.S. economic history had to be rewritten. This is what led the US to introduce the chain system of making real output comparisons (see Young 1992). Unfortunately, in making comparisons between countries, there is no immediate counterpart to the chain system (although Hill (1995; 1998) does develop an indirect counterpart).

To sum up, we believe the use of the Penn World Tables to compute country rates of growth in TFP will just lead to additional measurement error. It will generally be much more accurate to use country specific National Accounts data to compute country rates of productivity growth.

6.6 John Janssen (1996a,b; 1997)

Janssen (1996a) describes New Zealand's recent economic performance as follows:

“New Zealand's recent burst of GDP growth has been likened to ‘a growth bus’ - with strong employment growth indicating that lots of people have been catching a ride. However, a growth and jobs bus will only take us part of the way to our ultimate destination of higher living standards. What we also need is a productivity bus – the ‘magic bus’”. Janssen (1996a, p.2).

Using the standard Solow Cobb–Douglas methodology, Janssen (1996a) decomposes New Zealand's real GDP growth from 1955–56 to 1995–96 into the usual TFP growth, capital growth and labour growth components. He uses a constant capital share in GDP of 0.4 and a constant labour share of 0.6 to construct Cobb–Douglas estimates of aggregate input. Janssen (1996a, p.4) finds that New Zealand's average annual TFP growth rate over the entire 40 year period was 0.89 per cent but it was 1.32 per cent over the last 5 years in his sample period. These growth rates are similar those of the present study. The Diewert–Lawrence estimate for

the 27 years up to 1998 was 0.8 per cent and for the period from 1990 onwards we obtain around 1 per cent using the official database.

Janssen (1996a) makes several important observations. Firstly, he notes that growth accounting is *not* a theory of economic growth; ie, it simply tell us what has happened, not *why* it happened. He goes on to warn that comparisons of TFP studies should be treated with caution. For example, he notes that in Australia and New Zealand, the gross capital stock grows more quickly than the net capital stock and hence TFP estimates based on net stocks will look better than the corresponding gross stock estimates. His observation is consistent with the results of our productivity estimates reported in chapter 4 although the difference between the gross and net capital based estimates is not large and they follow a similar pattern.

Janssen (1996a) notes that the shift away from 'easy' to measure goods production to 'difficult' to measure services production may lead to output and productivity growth rates that are biased downwards. He attributes this point to Griliches (1994) who noted that the easy to measure part of US GDP declined from 49 per cent of current price GDP in 1947 to 31 per cent in 1990. As we noted earlier, statistical agencies sometimes use employment or other input measures to measure real output in some of the hard to measure service sectors, which will surely lead to output growth measures that are too low. Thus, when we dropped some of the hard to measure service sector industries, we found higher rates of productivity growth for New Zealand. For instance, from table 4.10 we see that moving from the standard official database estimates to our 'ABS equivalent' estimates increases the average annual TFP growth rate for the last 20 years from around 1.1 per cent to 1.5 per cent.

Janssen also notes that rapid technological change is occurring in many service sector industries and, hence, these industries might be expected to have high rates of productivity growth. We will revisit this point in chapter 7. He also suggests that an increasingly export oriented service sector that is competing in international markets might experience relatively high rates of productivity growth. Hence, it is important to measure outputs more accurately in these rapidly changing service sector industries.

Janssen notes that the Employment Contracts Act has made it easier to employ labour in a business upturn but the effect on measured productivity could be negative since the low priced labour drawn into employment may not be all that productive. This may be true but, on the other hand, it is better for society as a whole to have the previously unemployed working since they will surely produce something, which is better than their previous zero production. This is why we introduced our measure of 'social TFP', so that the benefits of reducing unemployment could be registered in a TFP measure.

Janssen also has some observations on the new methodological approach of Färe, Grosskopf, Norris and Zhang for productivity measurement:

“Färe, Grosskopf, Norris and Zhang (1994) show that changes in TFP can be decomposed into changes in efficiency and changes in technology. ‘Efficiency change’ is a measure of movements toward best practice, i.e., shifts toward the production frontier. In contrast technology change refers to changes in best practice, i.e., shifts of the production frontier. ...According to Färe et al, the growth accounting approach to TFP calculations implicitly assumes that observed production is always efficient, i.e., the economy is always operating on the production frontier. The growth accounting measure of TFP growth captures shifts in technology only. In the presence of inefficiency, the growth accounting approach gives a biased estimate of technology change.” Janssen (1996a, p.10).

Some of the assertions in the above quotation require elaboration. The growth accounting approach to productivity measurement that relies on the axiomatic index number approach rather than the economic approach does not *necessarily* assume that observed production is always efficient. It makes no assumptions about efficiency at all. In this axiomatic approach to productivity measurement (see section 5 in Appendix A), we simply take the ratio of an index number of output growth rates and divide by an index number of input growth rates. The axiomatic approach tries to pick the ‘best’ functional form for the index number formulae. Of course, the same index number formulae that seem ‘good’ from this perspective of this axiomatic approach also turn out to be ‘good’ from the perspective of the economic approach.

Furthermore, it is not completely appropriate to say that in the presence of inefficiency, the traditional growth accounting approach gives a *biased* estimate of technology change. In the presence of inefficiency, it is fair to say that the growth accounting estimates of productivity change will give a *combined estimate of the effects of technical change* (shifts in the best practice production frontier) *and improvements in efficiency* (movements toward the production frontier). However, the new approach to growth accounting suggested by Färe, Grosskopf, Norris and Zhang (1994) will give *precisely the same combined estimate of the effects of technical change and improvements in efficiency* that the traditional approach gives.

What is new in the Färe, Grosskopf, Norris and Zhang (1994) approach is their decomposition of the combined productivity change into efficiency movement and frontier shift components. Their approach is perfectly valid *provided that one can construct a valid measure of frontier shift* (or technical change). Unfortunately, it is usually very difficult to construct such a measure of frontier shift – how are we to know exactly where a country’s or

industry's or firm's best practice frontier is? Under carefully specified conditions, it is possible to make some guesses as to what the best practice frontier is – benchmarking and DEA (data envelopment analysis) have been developed precisely for this purpose. However, usually benchmarking and DEA studies are constructed at the firm level and every effort is made to compare like with like. That is, it is meaningful to construct benchmarking comparisons for firms producing a relatively homogeneous output like electricity (see Zeitsch and Lawrence (1996) and Diewert and Nakamura (1999)), coal mining (see Tasman Asia Pacific (1997)) or moving containers across the waterfront (see Lawrence, Houghton and George (1997)). However, at our present stage of knowledge, it is *very difficult* to determine what the best practice frontier is for an inhomogeneous industry that might be producing hundreds or thousands of very different products. It seems *impossible* to us to determine what the world best practice frontier is at any moment in time for an entire economy. Thus, we do not know how useful the Färe, Grosskopf, Norris and Zhang (1994) TFP decomposition will be for an entire economy. We will evaluate their methodology in more detail in the following section.

Janssen goes on to draw some valid theoretical inferences utilising the Färe and Grosskopf approach:

“For economies employing best international practice (i.e., on the frontier), productivity changes will be limited by the rate of technological progress. Economies which are off the frontier can have TFP growth rates exceeding the rate of technological progress if efficiency change is positive. Such economies can make use of positive efficiency change as a source of productivity growth. In addition, TFP change can be negative if efficiency change is negative and larger in absolute terms than technological progress.” Janssen (1996a, p.10).

Janssen (1996b) undertakes some of the same types of sensitivity analyses which we reported in chapters 3 and 4 and obtains similar results. He first recomputes TFP growth for the March years 1966–96 using essentially the expenditure and production measures of GDP growth that we described in chapter 4. Janssen finds much the same pattern that we found. The expenditure measure is much more volatile in the early years and the resulting TFP index generally lies below the TFP index based on production GDP.

Next, Janssen (1996b) considers a wide range of alternative measures for labour input. As we found in chapter 4, these alternative measures of labour input do not track each other very closely and so the induced TFP growth rates resulting from these alternative measures can vary significantly. What does emerge from both our analysis and Janssen's is that Statistics New Zealand urgently needs to construct wage indexes by industry and accurate measures of labour input, preferably wage weighted hours worked.

Finally, Janssen abandons the Solow method for computing the input aggregate (which uses the Cobb–Douglas index number formula using the average input shares over the sample period as weights) and switches to the Törnqvist (1936) formula to construct the input aggregate. As we indicate in sections 3 and 4 of appendix A, this index number formula is exact for a more flexible functional form for the underlying production or cost function than the restrictive Cobb–Douglas functional form. However, Janssen found the use of the Törnqvist input index led to a negligible change in his estimates of New Zealand TFP growth. We found in chapter 4 that the choice of index number formula made more difference to the TFP estimates than the negligible amount of change that Janssen found comparing the Cobb–Douglas index with the Törnqvist input index. One reason for this difference in results is that our index number comparisons were done at a much finer level of aggregation and we would expect differences in formulae to be more pronounced the finer the level of aggregation.

Janssen (1996b) raises a few more issues that should be noted:

“Although there is some debate on GDP measures, Treasury supports the view of Statistics New Zealand (SNZ) that the production based measure [of GDP] provides a better guide to movements in real GDP than the expenditure measure.” Janssen (1996b, p.3).

We are less certain that the production based measure of GDP is more accurate than the corresponding expenditure based measure. The final demand components of GDP are for the most part fairly accurately measured in value terms and most of these components have a deflator that is based on at least some information about the prices of these components. On the other hand, not only is nominal value added by industry probably poorly measured in many cases, it is *certain* that appropriate deflators for the two components of value added by industry (gross output and intermediate input usage) simply do not exist for the vast majority of New Zealand industries (see Statistics New Zealand (1996, p.27-28)). Thus, it is hard to see how accurate information on real GDP could emerge from such a weak base of information.

Janssen (1996b, p.3) correctly notes that we must use the production based measures of GDP output in order to compute sectoral productivity growth rates. However, in evaluating these sectoral TFP growth rates, it must be kept in mind that the real GDP components of most industries are constructed by index numbers that have very little basis in economic theory. Real output measures are constructed by deflating value added by a single deflator instead of deflating gross output and intermediate input separately. It is only farming, parts of electricity distribution, gas distribution and parts of the transportation sector that have real GDP output measures that are constructed using the theoretically appropriate double deflation

method. Even in these cases, the theoretically preferred superlative indexes like the Fisher ideal and Törnqvist are not used as deflators (see Statistics New Zealand (1996, pp.27–28)).

Janssen also alerts us to the problems involved in decomposing the operating surplus of the self employed into their labour and capital components:

“For some sectors of the economy, particularly those with a high proportion of owner operated concerns, actual earned operating surplus contains a large portion of labour income. ... It might be worth taking a closer look at the composition of the factor shares [in industries with a high proportion of self employment] and undertaking some cross country comparisons.” Janssen (1996b, p.8).

We concur with this. The System of National Accounts was not designed specifically with the needs of productivity analysts in mind. Hence the industry income side of the Accounts, with its simple decomposition into ‘wages and salaries’ plus ‘operating surplus’ is woefully inadequate for productivity measurement purposes. The ‘wages and salaries’ component does not include the labour hours of the self employed. Moreover, there is no provision in the pre 1993 Accounts for the decomposition of these two nominal values, ‘wages and salaries’ plus ‘operating surplus’, into their price and quantity components as there is on the output and intermediate input side, in theory at least. The post 1993 Accounts now have a provision for a proper price index for the employee part of labour input but the problems with respect to decomposing self employment income into labour and capital components still remain. Furthermore, there is still no proper user cost approach to the price of capital services in the present System of National Accounts.

Janssen (1996b, p.10) concludes his paper by asking three questions:

- How sensitive are aggregate TFP estimates to the removal of sectors such as agriculture and government?
- Are there sectoral differences in TFP growth rates that will explain movements in aggregate TFP?
- What can be done to address some of the output and input measurement issues?

As we have seen in earlier chapters, the aggregate TFP growth rates are relatively sensitive to the inclusion or exclusion of certain sectors. This is to be expected since TFP rates of growth are certain to be quite different across various sectors. Since the aggregate TFP growth rates can be regarded as aggregates of the industry TFP growth rates, it is obvious that the sectoral rates will ‘explain’ the aggregate rates. We will attempt to address Janssen’s last question in the final chapter of this report.

Finally, Janssen (1997) notes the problems that arise when fixed base price indexes are used to deflate nominal values for investment goods and capital inputs:

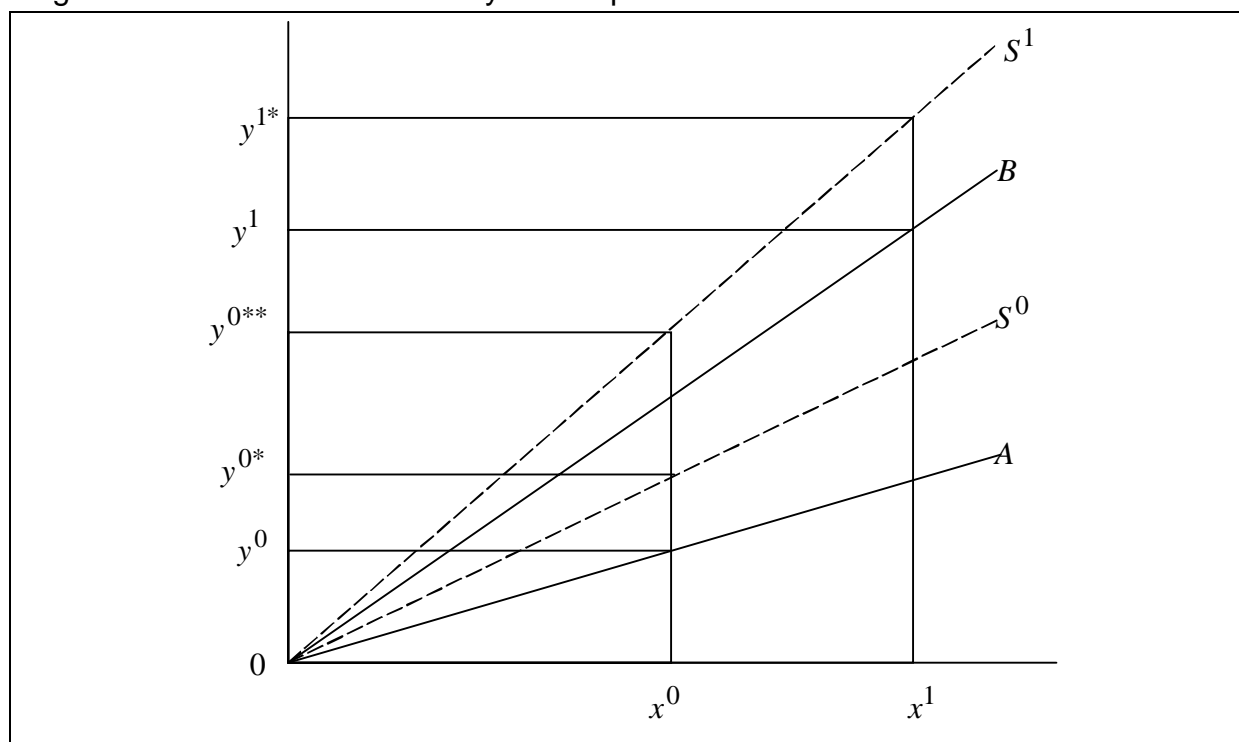
“However, on-going falls in the relative price of investment goods (especially computers) will, without further rebasing, start to reintroduce the problems in the measurement of real investment.” Janssen (1997, p.6).

In our view, the solution to these rebasing problems is straightforward: indexes should be rebased each year if possible. That is, Statistics New Zealand should move away from the use of fixed base indexes and toward the use of chain indexes.

6.7 Rolph Färe, Shawna Grosskopf and Dimitri Margaritis (1996)

Färe, Grosskopf and Margaritis (1996) calculate TFP growth (and its components) for 20 New Zealand industries for the March years 1972–94 using the new decomposition techniques of Färe, Grosskopf, Norris and Zhang (1994) that were referred to in the previous section.

Figure 6.4: The FGM Productivity Decomposition



Before we take a brief look at their results, it is necessary to understand the mechanics of their decomposition. We follow the example of Färe, Grosskopf and Margaritis (1996, p.80) and illustrate their TFP decomposition for the case of a one output, one input, constant returns to scale technology. We use the same notation that is used in section 2 of appendix A. The observed output of the firm or industry in periods 0 and 1 is y^0 and y^1 , respectively, while the observed input in periods 0 and 1 is x^0 and x^1 , respectively. In figure 6.1, the observed

period 0 output and input combination (y^0, x^0) is on the line OA while the period 1 output and input combination (y^1, x^1) is on the line OB, which has a higher slope than the slope of OA. As in our equation (3) of section 2 in appendix A, Färe, Grosskopf and Margaritis (1996, p.79) define their Malmquist productivity index as:

$$(1) \quad \text{TFP} = [y^1/y^0]/[x^1/x^0]$$

$$(2) \quad = [y^1/x^1]/[y^0/x^0].$$

Equation (1) defines TFP in terms of the rate of growth of output y^1/y^0 divided by the rate of growth of input x^1/x^0 (more precisely, y^1/y^0 is one plus the rate of growth of output and x^1/x^0 is one plus the rate of growth of input). The equivalent equation (2) defines TFP as the ratio of the output–input ratio in each period, which are the slopes of the lines OB, y^1/x^1 (for the period 1 observed data) and OA, y^0/x^0 (for the period 0 observed data). Since the slope of OB is greater than the slope of OA, observed productivity has risen going from period 0 to 1.

Färe, Grosskopf and Margaritis introduce a measure of shift in the best practice frontier technology for each period, TCH, or Technological CHange shift. Referring to figure 6.1, it is assumed that the period 0 best practice frontier is the line OS^0 and the period 1 best practice frontier is the line OS^1 . In terms of the figure, TCH is defined as:

$$(3) \quad \text{TCH} \equiv y^{0**}/y^{0*}.$$

Note that y^{0*} is the best practice output that could be produced in period 0 by using the observed period 0 input x^0 and y^{0**} is the best practice output that could be produced in period 1 by using the observed period 0 input x^0 . Thus, the ratio of these two best practice outputs (holding input constant) is a perfectly valid measure of the *shift* in the best practice frontier that has occurred going from period 0 to 1.

Färe, Grosskopf and Margaritis also introduce a measure of the shift in efficiency going from period 0 to 1, ECH, or Efficiency CHange. A measure of the efficiency of the firm or industry in period 0 is y^0/y^{0*} where y^0 is period 0 observed output and y^{0*} is the best practice output that could be produced in period 0 by using the observed period 0 input x^0 . Similarly, a measure of the efficiency of the firm in period 1 is y^1/y^{1*} where y^1 is period 1 observed output and y^{1*} is the best practice output that could be produced in period 1 by using the observed period 1 input x^1 . Taking the ratio of these two efficiency measures (which are measures of the closeness to the frontier in each period) yields the efficiency change measure:

$$(4) \quad \text{ECH} \equiv [y^1/y^{1*}]/[y^0/y^{0*}].$$

Examining the line OS^1 shows that

$$(5) \quad x^1/x^0 = y^{1*}/y^{0**}.$$

With the above definitions in hand (actually, their definitions are complicated but they reduce to definitions (1), (3) and (4) in our present simplified model), Färe, Grosskopf and Margaritis show that:

$$\begin{aligned}
 (5) \quad ECH \times TCH &= \{[y^1/y^{1*}]/[y^0/y^{0*}]\} \times \{y^{0**}/y^{0*}\} \\
 &= [y^1/y^0] \times [y^{0**}/y^{1*}] \quad \text{cancelling terms} \\
 &= [y^1/y^0] / [x^1/x^0] \quad \text{using (5)} \\
 &\equiv TFP \quad \text{using (2)}.
 \end{aligned}$$

The interpretation of this is that the observed growth in TFP is equal to the product of the efficiency change ECH (movements toward the frontier in each period) times technological change TCH (movements of the frontier).

Although there are no theoretical problems with the decomposition (5), there can be practical problems. The main problem is this: TFP can be defined using observable data on an industry's inputs and outputs using (1) or (2) above, *but in order to evaluate ECH defined by (4) or TCH defined by (3), we must have reasonably accurate measures of the best practice frontiers in each period.* In terms of figure 6.4, the best practice frontier in period 0 is the line segment OS^0 and in period 1 is OS^1 . How did Färe, Grosskopf and Margaritis construct their best practice frontiers for their 20 industries? Evidently, they just used a variant of DEA analysis, *assuming that the value added outputs of each industry can be produced by every other industry.* This seems to be a rather untenable assumption to say the least and hence we suspect that their measures of efficiency change and technical progress are essentially worthless. The following quotation seems to indicate that we are not misinterpreting their work:

“It is also possible that the growth accounting results will differ from those based on the Malmquist index as there is no attempt in the former approach to make multilateral comparisons. That is, each sector is compared only to itself in previous periods, not to a common benchmark (the overall market sector frontier) which is used in the calculation of the Malmquist index.” Färe, Grosskopf and Margaritis (1996, p.90).

Their Malmquist TFP indexes should be free from interpretation difficulties and Färe, Grosskopf and Margaritis (1996, p.83) report that the unweighted mean of their TFP indexes over 20 industries and over the March years 1973–94 was 1.46%. Of course, an unweighted mean of TFP growth rates over industries is not very meaningful because some industries are tiny and some are very large. For instance, taking an average of the Färe, Grosskopf and Margaritis industry growth rates weighted by their average GDP shares for the period 1978 and 1997 produces a growth rate of only 0.4 per cent instead of 1.46 per cent. This difference

is driven in part by the large share of GDP accounted for by the Trade, restaurants and hotels industry which has negative TFP growth.

Färe, Grosskopf and Margaritis (1996; 85) report that their *unweighted* average of industry annual TFP growth rates for the pre reform years 1972–84 was 0.7 per cent and for the post reform years 1984–94 was 2.4 per cent. For some industries, there are large differences between the Färe, Grosskopf and Margaritis industry TFP growth rates and our industry TFP rates reported in chapter 5. In particular, they find overall negative TFP growth rates over the 1973–94 period for the following industries: Textiles, apparel and leather; Wood and wood products; Fabricated metals and products; Other manufacturing; Construction; Trade, restaurants and hotels; Finance and business services and Community and personal services. In addition, for the March years 1973–84, Färe, Grosskopf and Margaritis find negative productivity growth for the above 8 industries (with the exception of Construction). They also find 4 additional industries with negative TFP growth over the 1973–84 period: Fishing; Paper; Minerals and Basic Metals. It will be necessary to do additional research to determine if their rather different sectoral results are due to their DEA methodology or the use of a different data set.

6.8 Viv B. Hall (1996)

There is a wealth of information and sensible policy advice in Hall (1996) and we cover only a few of the highlights. The most important methodological innovation in the paper is its emphasis on reporting peak to peak rates of productivity growth. The problem with reporting TFP average growth rates over short periods (say less than 8 years) is that the economy could be at the start of a long expansion (or contraction) and thus TFP average growth rates will be biased upward (downward) as changes in the level of capacity utilisation of the capital stock are not allowed for. Measuring TFP on a peak to peak basis attempts to capture points where capacity utilisation is at consistently high levels. We have reported a variety of peak to peak results in our applied work in the previous chapters.

Hall (1996, p.43) attempts to look at TFP growth rates before the reform period (1978–85) and during and after the reforms in the New Zealand economy (1985–1993). He finds that the pre reform average annual rate of TFP growth was 1.2 per cent and the post reform average rate was only 0.4 per cent. However, Hall's post reform period excludes the productivity surge in the 1993–1998 period.

Hall also looks at New Zealand's sectoral TFP average growth rates for 20 industries over the period 1972–1991 and over the pre reform period 1973–83 and the post reform period 1984–91. As is usual in New Zealand sectoral productivity studies, he finds that TFP varies widely. In particular, he finds that the following 5 industries have negative average productivity growth rates over the 1972–91 period: Wood and wood products; Textiles, apparel and

leather; Trade, restaurants and hotels; Fabricated metal and metal products and Finance and business services. Perhaps this is a consequence of his use of Chapple's (1994) industry data set which is likely to have a considerable amount of measurement error.

Hall also mentions the positive role of a favourable change in the terms of trade over the reform period:

“It is also clear that New Zealand has been relatively fortunate in its terms of trade since 1985–86. From a value of 919 in 1985–86, the index increased to 1118 by 1993–94.” Hall (1996, p.57).

Our application of the Diewert and Morrison (1986) and Fox and Kohli (1998) methodology to decompose nominal GDP growth into components including changes in the terms of trade in chapter 3 showed that while an improvement in the terms of trade between 1986 and 1990 added to real GDP, the terms of trade effect has been relatively unimportant since the early 1990s, particularly during the period of the more recent productivity surge.

6.9 Paul Conway and Ben Hunt (1998)

This paper examines New Zealand's productivity performance in relation to the performance of the US economy using quarterly data from the fourth quarter of 1985 to the second quarter of 1997 using “cyclically adjusted” measures of TFP. Their results indicate that the trend growth rate of TFP in New Zealand does shift upward around the end of 1991 and hence there is some evidence of convergence with the technological leader, the US.

This is the first paper reviewed in this chapter that uses quarterly data. The authors also use relatively sophisticated econometric techniques in their paper compared to the rather simple tools used by ourselves and the other researchers that we have reviewed. However, the use of quarterly data leads to a new set of measurement problems. The authors assume that each quarterly observation is a more or less statistically independent observation. However, as shown in Statistics New Zealand (1996) many quarterly series are trended annual series and, hence, are not statistically independent.

It is generally known that every economy experiences large seasonal variations. What is not generally known is that statistical agencies use a wide variety of methods to seasonally adjust their data (see Turvey (1979)). Hence, seasonally adjusted series tend to be works of art rather than being scientifically reproducible series. There are also severe conceptual problems involved in making month to month or quarter to quarter comparisons when some commodities are available in some periods but not other periods. Hence, the measurement problems that statistical agencies face when constructing sub annual price and quantity indexes are severe.

Quantities vary significantly over quarters and months. Hence, working with quarterly data will inevitably involve working with very noisy data. Conway and Hunt (1996, p.7) attempt to deal with the noisiness problem by using the Hodrick–Prescott filter to *smooth* their data. However, the smoothing method chosen is bound to be somewhat arbitrary and this leads to a lack of reproducibility in econometric work; ie, different investigators will casually choose different filters, leading in many cases to quite different results.

Conway and Hunt cite the New Zealand pre and post reform TFP estimates of several authors, including those of Färe, Grosskopf and Margaritis (1996). The FGM estimates are reported as an annual average TFP growth rate of 0.75 per cent for the pre reform period 1972–84 and the annual average TFP growth rate of 2.4 per cent for the post reform period 1985–94. However, as noted above, these are unweighted averages of the industry growth rates and bear no resemblance to the corresponding weighted estimates.

On a more positive note, there are several very useful techniques described by Conway and Hunt, some of which we used. They use the equivalent to the spline technique that we used to test for structural breaks except that they run their regressions in difference form whereas we run ours in level form. They also graph the effects of changing the starting values for their net capital stock by plus or minus 10 per cent and of changing their depreciation rates by plus or minus 10 per cent. The effects of *increasing* the starting value of the capital stock by 10 per cent is to shift the graph of the stock *up* by 10 per cent at the start of their sample period but then over time, the difference between the new series and the base series gradually diminishes. Similarly, the effects of *decreasing* the starting value of the capital stock by 10 per cent is to shift the graph of the stock *down* by 10 per cent at the start of their sample period but then over time, the difference between the new series and the base series gradually diminishes. On the other hand, a 10 per cent *increase* in depreciation rates leads to a new capital stock series that is *below* the base case capital stock and the new series diverges away from the base series over time. Finally, a 10 per cent *decrease* in depreciation rates leads to a new capital stock series that is *above* the base case capital stock and the new series diverges away from the base series over time. This diagram of Conway and Hunt clearly shows that a wide range of average TFP growth rates can be generated by the strategic choice of starting values for components of the capital stock and by choosing depreciation rates strategically. While the development of “official” Statistics New Zealand estimates for capital stock components will not eliminate the inherent variability of TFP depending on the capital estimates used, it will provide a more consistent starting point for productivity studies.

6.10 Viv B. Hall (1998)

Hall (1998) provides a nice overview of New Zealand's reform process. On New Zealand's productivity performance, Hall notes:

“Not surprisingly, TFP performance has varied widely across sectors, and some sectors have been more effected by aggregate domestic and international business cycle movements than others. ... First, eight sectors show improved TFP performance when the average for 1985–93 is compared with that for 1978–85, whereas the average outcome for 11 sectors is worse. Secondly, by focussing on performance in the 1987–92 contraction phase, one can identify six star performers as: Basic Metal Industries; Communications; Mining and Quarrying; Transport and Storage; Forestry and Logging; and Agriculture. Further detailed research would be required to establish or reject causal linkages, but *prima facie* these sectors have all been directly or indirectly affected in significant ways by major microeconomic reforms and restructuring over the past decade, and by increased exposure to more internationally competitive trade and financial conditions.” Hall (1998; 9).

Comparing Hall's list of 'star' performers with our sectoral TFP growth rates for 1986–97 in tables 5.1 and 5.2, there is a close correspondence. Mining and quarrying is the only one of Hall's 'stars' that is not showing strong growth in the post reform era in our results and we would also add Nonmetallic minerals to the list.

Again, we would urge caution in taking any New Zealand *sectoral* productivity numbers too seriously at this stage because of the possibility (indeed *probability*) of significant measurement errors in the New Zealand industry data for outputs, labour inputs and even capital inputs. There is also the problem of significant *missing* inputs for many sectors. Land inputs are obviously important for Agriculture and Hotels, natural resource inputs are important for Mining and inventory stock inputs are important for the Retail and Wholesale trade sectors. Unfortunately, these inputs are *missing* from all of the data bases used by the New Zealand researchers whose work we have reviewed in this chapter.

Hall is appropriately cautious in interpreting the work of Färe, Grosskopf and Margaritis (1996) who reported large post reform increases in TFP:

“Färe, Grosskopf and Margaritis (1996) have also undertaken a comprehensive study of productivity growth at the sectoral level. They utilized the Data Envelopment Analysis technique, which allowed them to compute a constant returns to scale Malmquist productivity index to reflect TFP, and its efficiency and technical change components. There has been relatively limited experience in interpreting these measures empirically, especially for individual sectors

which are compared to an aggregate best practice frontier for the New Zealand market sector. As a result, their individual sector results are currently seen as controversial and should be interpreted with considerable caution.” Hall (1998, p.9).

As we indicated in section 6.9, the large increase in the productivity of the New Zealand economy in the post reform period reported by Färe, Grosskopf and Margaritis (1996) appears to be an artefact of their use of *unweighted averages* of the individual industry TFP growth rates.

6.11 Tim Maloney (1998)

Maloney summarises the purpose of his monograph as follows:

“Since 1984, New Zealand has initiated reforms in almost every sector of its economy. Yet no single piece of legislation has been more controversial both at home and overseas than the Employment Contracts Act (ECA). This legislation fundamentally altered the very nature of the industrial relations system in this country. The purpose of this study is to estimate empirically some of the effects the ECA may have had on the New Zealand labour market during its first five years of existence.” Maloney (1998, p.1).

The specific effects of the ECA that Maloney studied are outlined in the following quotation:

“Did this legislation lead to an increase or decrease in overall employment, wages and labour productivity in this economy? These are the specific questions addressed in this study.” Maloney (1998, p.2).

Thus, Maloney's study overlaps our study to a limited extent in that we have applied our spline methodology to New Zealand's productivity performance and we found a significant break in the total factor productivity performance of the economy from 1993 to the present (using the official data base). This improvement in New Zealand's TFP performance could be due to the Employment Contracts Act, given that it took a couple of years for the effects of the act to percolate through the economy, but the improvement could be due to other factors as well. In particular, Maloney noted that the National Government undertook numerous changes to social welfare programs about the same time that the Employment Contracts Act came into effect:

“Most of these benefit reforms took effect on 1 April 1991, six weeks prior to the implementation of the ECA. Perhaps the most important changes were a series of reductions in basic benefits under the Unemployment Benefit (UB) and Domestic Purposes Benefit (DPB). Although the extent of the benefit cuts varied between programmes and across demographic groups by age, sex,

marital status and number and ages of children in the household, they averaged approximately 9.5%. Other changes saw the introduction of a 26-week stand-down period for people who left employment voluntarily or were dismissed for misconduct, an increase in the minimum age of eligibility from 16 to 18 for both UB and DPB and a tightening in associated work-test provisions. In addition to these 1991 reforms, the unemployment benefit had been reduced in 1989 by 26% for those aged 16 or 17, the minimum age of eligibility for Superannuation was gradually raised from 60 to 65 beginning in April 1992, and various changes to income exemptions and tax surcharges under Superannuation took place over this period." Maloney (1998, p.91).

The above quotation indicates that it is going to be difficult to disentangle the effects of the Employment Contracts Act from other reforms, which took place around the same time.

We turn now to a description of some of the highlights of the individual chapters in Maloney (1998).

In chapter 2, Maloney describes two alternative models of the effects of unions on labour markets. The first model is the traditional monopoly model of trade union behaviour. In this model, employers react passively to a union wage demand, taking the union determined wage as fixed and choosing an employment level which will maximise profits; ie, employers are on their demand curve for labour. The trade union chooses its optimal wage by trading off less employment against a higher wage. The second model that Maloney describes is the efficient bargaining model of McDonald and Solow (1981). This model allows both parties to bargain simultaneously over employment and the wage rate and under certain conditions, both the union and the employer could be made better off compared to the outcome in the traditional monopoly model. In this second model of union behaviour, the employer will generally not be on the traditional demand for labour function; ie, the outcome of the bargaining process will generally not be technically efficient. Maloney summarises his discussion of the two models as follows:

"Both models of trade union behaviour have merit. On the one hand, there is strong theoretical support for the efficient bargaining model. It produces a set of Pareto optimal agreements that unambiguously dominate those generated under the monopoly model. On the other hand, there is some empirical support for the monopoly model. Many collective contracts overseas indicate that wages are set by these agreements, while employment levels are either explicitly or implicitly left up to the discretion of the firm ..." Maloney (1998, p.16).

If the second model of union behaviour is true, then the firm facing the union will generally not be technically efficient. However, Maloney notes that even in the first monopoly model of union behaviour, the existence of work rules can lead to technical inefficiency and a loss of productivity:

“The idea is that trade unions tend to reduce labour productivity by creating barriers to a flexible work environment and implementing restrictive work practices. By requiring unnecessary tasks to be done (commonly referred to as ‘featherbedding’), or by requiring that necessary tasks be done in an inefficient manner (e.g., breaking jobs down into narrowly defined tasks, and reserving these tasks for different groups of workers), labour demand curves would be shifted inward, reducing productivity at every level of employment. This effect would be compounded if trade unions fostered an antagonistic relationship between workers and management. Any reduction in communication and cooperation between the parties could have detrimental effects on productivity. The basic idea is that trade unions could cause firms to operate less efficiently than they otherwise would given the mix of inputs in the production process. In the lexicon of the economist, the firm is operating inside its production frontier.” Maloney (1998, pp.17–18).

Thus in chapter 2, Maloney sets the stage for the rest of his study. The analysis presented in this chapter suggests that there is a presumption that the ECA will lead to a reduction in unionisation in the New Zealand economy, an increase in productivity, an increase in employment but the effects on wages are indeterminate. However, Maloney does not state that economic theory definitely implies the above predictions. He is appropriately cautious:

“In the end, economic theory is essentially agnostic as to the effects of either unionisation or the ECA on employment, wages or labour productivity. Ultimately, all of these labour market effects are empirical questions.” Maloney (1998, p.21).

Thus, in the remainder of his study he looks at the above issues empirically.

In chapter 3, Maloney computes the union density rates (proportion of union members to full time equivalent employment) for Australia and New Zealand from the first quarter of 1989 to the last quarter of 1995. Maloney summarises his results as follows:

“Aggregate union density in both countries fell during the last four years of this sample period. Immediately prior to the ECA, the unionisation rate in New Zealand was 45.4%. The comparable figure was slightly higher at 48.7% in Australia at the same time. By 1995, unionisation had declined to 24.9 and 38.3% in the two countries respectively. Thus, over the post ECA period, aggregate union representation fell by 20.5 percentage points in New Zealand and by 10.1 percentage points in Australia.” Maloney (1998, p.24).

Maloney later argues that since legislation similar to the ECA was never enacted in Australia, perhaps 20.5 minus 10.1 or 10.4 percentage points of the decline in unionisation in New Zealand could be attributed to the Employment Contracts Act, since Australia was subject to the same broad trends as New Zealand (with the exception of the ECA):

“The key is that the two countries are similar in terms of geographic location and cultural links to the United Kingdom and the basic structures of their respective economies.” Maloney (1998, p.33).

However, Maloney also notes that there were some changes in the industrial relations system and other economic reforms in Australia over this period which may have been responsible for the drop in Australia's union density.

From our point of view, the most important point made in chapter 3 is that union membership in New Zealand started to decline rapidly around the time that the ECA came into effect. The decline in union membership was roughly linear over the period 1991–1995 (Maloney 1998, p.25).

In chapter 4, Maloney looks at the trend in real wages from the first quarter of 1986 to the first quarter of 1996. His aggregate results can be summarised as follows:

“In the first year following the ECA, total-time hourly earnings rose by 1.7%. But in the five years since this legislation, average [real] wages have remained essentially unchanged.” Maloney (1998, p.40).

In chapter 5, Maloney looks at the trend in both the number employed in the New Zealand economy and in the number of hours worked. Maloney summarised his results as follows:

“The comparison of the average statistics between the first two quarters of 1991 and the first two quarters of 1996 defines the relevant post ECA period. There were estimated gains of 210,100 jobs, and 8.49 million hours of work over this five year period. This represents an increase in employment and hours of work of 14.3% and 17.0% respectively.” Maloney (1998, p.70).

These are large increases but Maloney notes that not all of this increase in employment can be attributed to the Employment Contracts Act:

“Our best estimate is that the decline in union density and the increase in output attributable to this legislation can account for between 12.0 and 17.9% of the increase in employment between the first half of 1991 and the first half of 1996, which in turn can be attributed to the ECA. This translates into an increase of between 25,200 and 37,600 new jobs over this period.” Maloney (1998, p.89).

However, Maloney's analysis did not take into account business cycle effects, changes in the terms of trade, changes in tax, tariff and superannuation policy and, most importantly, changes in the pace of innovation and technical progress (which is extremely difficult to model). But it does seem likely that the ECA did have had a substantial positive effect on employment in New Zealand.

We turn now to a review of chapter 7, which looks at New Zealand's labour productivity performance. Maloney presents a graph of Australia and New Zealand's aggregate labour productivity (GDP divided by hours worked) from the first quarter of 1986 to the first quarter of 1996. He summarises his results as follows:

“Between the first half of 1986 and the first half of 1991, labour productivity in New Zealand grew at an average annual rate of 1.46%. During the same period, labour productivity in Australia grew at an average annual rate of just 0.66%. Between the first half of 1991 and the first half of 1996, labour productivity growth in New Zealand fell to an average annual rate of 0.25%. During the same period, labour productivity growth in Australia accelerated to an annual average rate of 1.74%.” Maloney (1998, p.104).

Recall that Australia often excludes certain hard to measure sectors from its productivity computations so the comparisons with Australia may not be comparing like with like. Also, Maloney's data shows that New Zealand's labour productivity is quite volatile. In particular, it appears that there was a rapid increase in labour productivity from the beginning of 1986 to the beginning of 1989 (it grew from 100 to about 113), then there was a pronounced decline to the beginning of 1991 (113 to about 108) and then productivity bounced along erratically to end up at about 112. Thus, average rates of labour productivity over a period can conceal a considerable amount of variation within the period.

There is another important difficulty associated with the use of the labour productivity concept: it is not invariant to the amount of capital that is being used in production. Maloney notes this problem:

“A key explanatory variable, used in this study for the first time, is the Capital-to Hours–Worked ratio. The derivation of the regression model from a Cobb–Douglas production function in chapter 2 showed that, in order to isolate the effects of union density and the ECA on labour productivity, we must hold constant this measure of the capital–labour ratio.” Maloney (1998, p.102).

Thus, Maloney makes use of a Cobb–Douglas production function to help him specify an appropriate functional form for the determinants of industry labour productivity. We will briefly outline this methodological approach and apply it using our aggregate official data base. We can then explain why we prefer our index number approach to the measurement of productivity over the more familiar Cobb–Douglas production function approach used by Maloney and many others.

If we allow for Hicks neutral technological change, the Cobb–Douglas production function can be written as follows:

$$(6) \quad Y = ce^{\beta t} L^{1-\alpha} K^{\alpha}$$

where Y is aggregate real output, c is a constant, β is the amount of annual technical progress (typically β is around 0.01), t is a time trend, L is real labour input, K is real capital input and α is a technological parameter (typically equal to capital's share of output which is around 0.3 to 0.5). Thus, there are three unknown parameters in (6): c , α and β . If we take logarithms of both sides of (6) and rearrange terms, we obtain the following estimating equation:

$$(7) \quad \ln(Y/L) = \ln c + \beta t + \alpha \ln(K/L).$$

We append normally independently distributed error terms to the right hand side of (7) with mean 0 and constant variance σ^2 . Now we are in a position to apply least squares linear regression techniques to (7). Table 6.1 below lists the year, real output Y and its price p , labour input L and its price w , and capital input K and its rental price r . In order to make our results as comparable as possible to the empirical results derived by Maloney, we have used our preferred aggregate official database (production GDP, composite labour and net capital using Philpott lives) rather than our preferred Diewert–Lawrence database. We have also neglected land, natural resources and inventories in the empirical work reported in this section so that our regression results will be as comparable as possible to those of Maloney.

The results of running the linear regression model (7) are summarised in Table 6.2.

In Figure 6.5 below, we graph the left hand side variable in equation (7), $\ln(Y/L)$, along with its predicted value. It is evident that there are breaks in the trend at observations 12, 16 and 17. This suggests that we generalise the model given by (7) above to the following model, which allows for differential rates of technical change over different time periods:

$$(8) \quad \ln(Y/L) = \ln c + \beta_1 t_1 + \beta_2 t_2 + \beta_3 t_3 + \beta_4 t_4 + \alpha \ln(K/L)$$

where t_1 is a linear time trend over the entire 21 observations (specifically, t_1 can be written as the vector $[1, 2, \dots, 21]$); t_2 is zero for observations 1 to 12 and then is 1 in observation 13, 2 in observation 14, ..., and is 9 in observation 21 (ie, t_2 is 0 until observation 13 and then it is a linear time trend); t_3 is zero for observations 1 to 16 and then trends linearly; and t_4 is zero for observations 1 to 17 and then trends linearly.¹

Table 6.1: Aggregate Output, Labour and Capital (Official Data Base)

<i>Year</i>	<i>Y</i>	<i>p</i>	<i>L</i>	<i>w</i>	<i>K</i>	<i>r</i>
1978	12.482	1.000	6.253	1.000	6.229	1.000
1979	12.447	1.132	6.268	1.138	6.368	1.092
1980	12.791	1.292	6.262	1.328	6.491	1.266
1981	12.942	1.474	6.098	1.598	6.664	1.401
1982	13.611	1.704	6.166	1.911	6.867	1.662
1983	13.727	1.909	6.169	2.090	7.079	1.881
1984	14.233	2.062	6.094	2.154	7.343	2.208
1985	15.075	2.208	6.388	2.282	7.621	2.454
1986	15.311	2.475	6.522	2.640	7.819	2.645
1987	15.782	2.813	6.602	3.083	7.870	3.056
1988	15.927	3.030	6.393	3.568	7.954	3.200
1989	15.918	3.252	6.142	3.843	8.012	3.516
1990	15.951	3.404	6.093	3.979	8.095	3.712
1991	15.769	3.462	5.938	4.111	8.142	3.708
1992	15.552	3.498	5.761	4.177	8.130	3.731
1993	15.739	3.563	5.834	4.229	8.142	3.858
1994	16.863	3.655	6.116	4.245	8.237	4.331
1995	17.858	3.733	6.522	4.305	8.411	4.589
1996	18.605	3.822	6.804	4.409	8.632	4.781
1997	19.201	3.887	6.997	4.530	8.859	4.847
1998	19.711	3.901	7.103	4.655	9.029	4.855

The model defined by (8) is a linear spline model. The parameter β_1 represents the average annual total factor productivity improvement for the economy for observations 1–12; ie, for the years 1978–89. On the other hand, for observations 13–16 (ie, the years 1990–93), the average annual rate of TFP improvement is $\beta_1 + \beta_2$. Thus, β_2 is the *change* in TFP going from 1989 to 1990. For observation 17 (ie, the March year ending in 1994), the annual rate of TFP improvement is $\beta_1 + \beta_2 + \beta_3$. Finally, for observations 18–21, the average annual rate

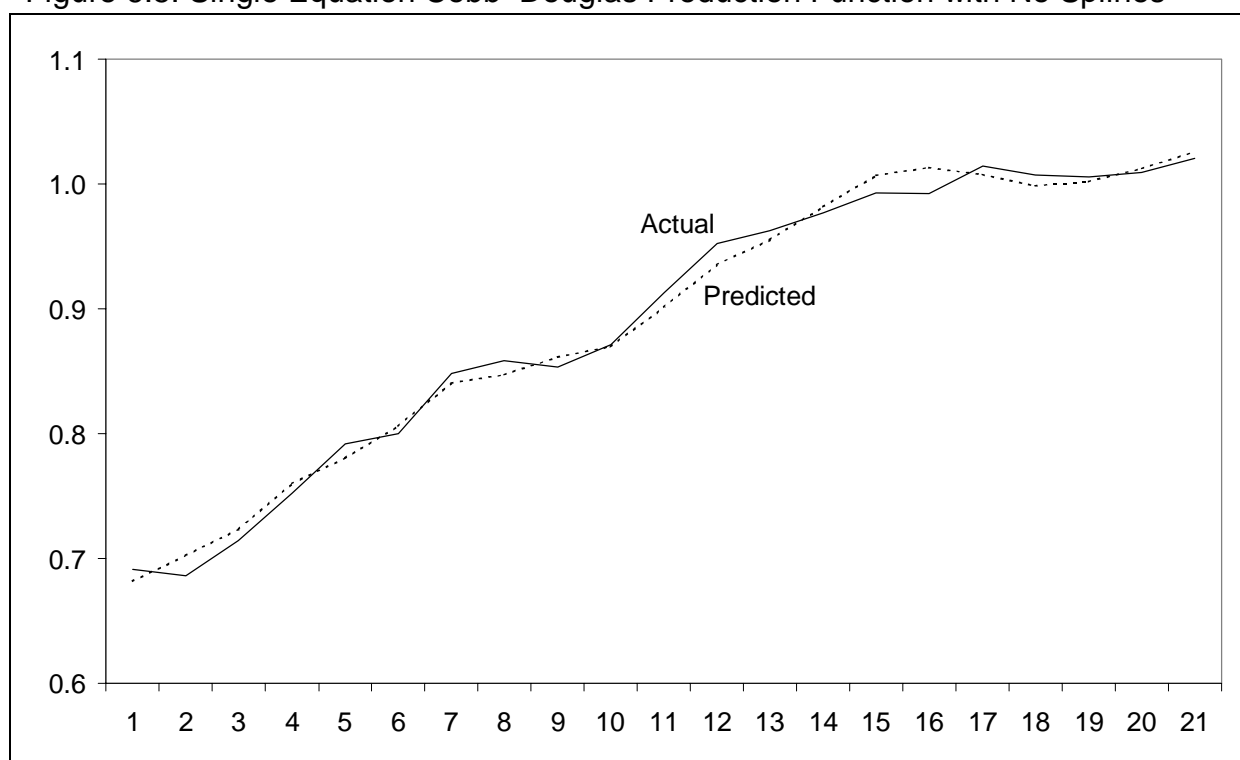
¹ Our visual inspection technique that was used to determine the break points where the model switches from one rate of technical progress to another rate could be improved upon. In particular, we could have used the model selection techniques of Fox (1998, pp.237–239) but time limitations prevented us from implementing this computer intensive approach.

of TFP improvement is $\beta_1 + \beta_2 + \beta_3 + \beta_4$. Thus, if any β coefficient is significantly different from 0, then we have evidence that the average annual rate of TFP has changed going from the previous time interval to the time interval associated with that β coefficient. Note that (8) is still a linear regression model. The results of estimating model (8) are listed in Table 6.3.

Table 6.2: Single Equation Cobb-Douglas Production Function Estimates

<i>Coefficient name</i>	<i>Estimate</i>	<i>Standard error</i>	<i>t-ratio</i>
α	0.475	0.04451	10.67
β	0.011	0.00073	15.56
Inc	0.672	0.00538	124.90
Durbin-Watson	1.53	Residual sum	-0.65E-15
Von Neumann ratio	1.61	Residual variance	0.12E-03
Rho	0.21	R-square	0.99

Figure 6.5: Single Equation Cobb-Douglas Production Function with No Splines

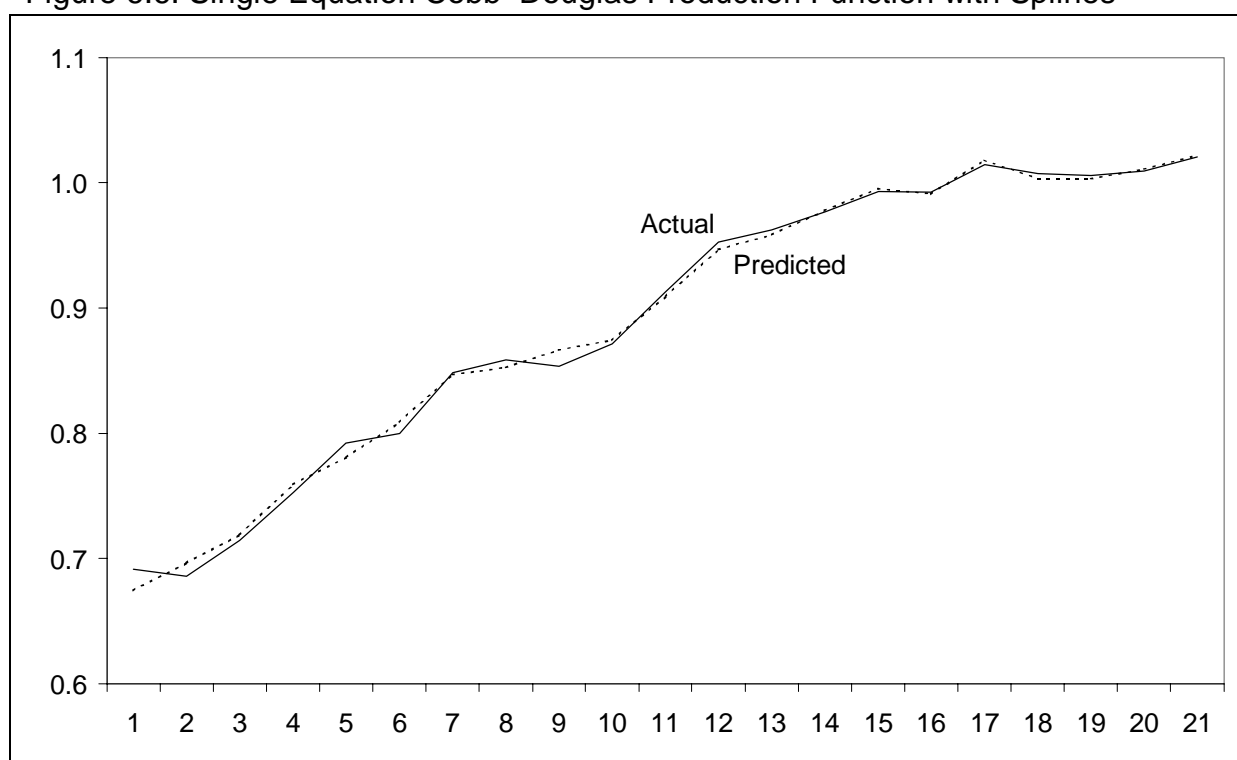


In Figure 6.6 below, we graph the left hand side variable in equation (8), $\ln(Y/L)$, along with its predicted value.

Table 6.3: Single Equation Cobb–Douglas Estimates with Splines

<i>Coefficient name</i>	<i>Estimate</i>	<i>Standard error</i>	<i>t-ratio</i>
α	0.550	0.10120	5.44
β_1	0.011	0.00242	4.65
β_2	-0.009	0.00241	-3.91
β_3	0.045	0.01383	3.25
β_4	-0.038	0.01195	-3.17
Inc	0.665	0.00517	128.70
Durbin–Watson	2.32	Residual sum	-0.49E-15
Von Neumann ratio	2.43	Residual variance	0.65E-04
Rho	-0.30	R-square	0.9963

Figure 6.6: Single Equation Cobb–Douglas Production Function with Splines



Obviously, the single equation regression model (8) works relatively well; the R^2 is high (0.9963), autocorrelation is not too bad and all of the parameters are significantly different from zero. The only troublesome aspect to the above results is the relatively high value for the share of capital parameter, α , which turned out to be about 0.55 (which is similar to the results that Maloney (1998, p.107) obtained in his analogous regressions). The above regressions give us average TFP growth rates of 1.1 per cent per year for the years 1978–89, 0.18 per cent per year for the years 1990–93, 4.7 per cent for the March year ending in 1994 and 0.9 per cent per year for the years 1995–98.

Maloney runs regressions that are similar to (7) and (8) above except that he uses quarterly *industry* data instead of annual aggregate data (and then he adds industry dummies and runs a large panel regression). As we observed in earlier sections of this chapter, we are reluctant to use the industry data due to the problem of measurement errors in both the labour, capital and output data. In his models without macro controls, Maloney has as his dependent variable the log of industry output divided by industry hours and he has industry dummy variables, time and the log of the industry capital–labour ratio as independent variables. This is exactly analogous to our aggregate model (8), except for the shift to quarterly data and industry variables.

In addition to the above variables, however, Maloney also includes the following variables: the log of aggregate real GDP; dummy variables for quarters 1,2 and 3 to control for seasonal fluctuations; an industry union density membership variable and a phase in of the ECA variable. It seems likely that there are several time trending variables (time, real GDP and for the post 1990 period union density has a linear like trend) in Maloney's regressions and thus it is likely that problems of multicollinearity could occur; ie, the results of interest are sensitive to which auxiliary variables are included in the regression. Maloney hints at the possibility that these problems may be present:

“Again, the most important findings from these regressions relate to the estimated results on union density and the phase-in of the ECA. The estimated coefficients on the phase–in variable for the ECA are positive, but insignificant in all four regressions. Thus, we find no evidence for any direct effects of the ECA on labour productivity across all industries. However, it should be noted that these estimated coefficients are quite ‘volatile’, and depend on the inclusion of other independent variables in the regression.” Maloney (1998, p.110).

However, Maloney is quite unequivocal about the strength of his union density findings:

“At the other extreme, the coefficient estimates on union density are quite robust. They are consistently positive and significant at better than a 1% level under any specification, including whether or not instrumental variable techniques are used for unionisation. These positive coefficient estimates suggest that labour productivity increases with union density. ...we estimate that the cumulative impact of this indirect effect over the five years in the post–ECA period has been a reduction in labour productivity by between 1.57 and 2.94%.” Maloney (1998, p.110).

We are not so certain that the above conclusion is the last word on the subject but, on the other hand, Maloney's results are not entirely inconsistent with the results of our aggregate model (8), which implied that TFP growth was 0.18 per cent per year for the years 1990–93, 4.7% for the March year ending in 1994 and 0.9% per year for the years 1995–98. Thus, in the early years of the post ECA era, the TFP performance of the New Zealand economy was not good and Maloney's models could be reflecting that 'fact'.

However, Maloney's regressions and our regressions based on (7) and (8) are all based on a single equation Cobb–Douglas methodology. We will conclude this section by developing some further implications of the Cobb–Douglas production function and productivity methodology. We will demonstrate that the use of a Cobb–Douglas production function to model technology can lead to *very unreliable estimates of both technical progress and the amount of substitutability in the economy*. Hence, policy conclusions that are drawn on the basis of empirically estimated Cobb–Douglas production functions must be regarded with a great deal of caution.

Suppose we now assume short run profit maximising behaviour on the part of producers; ie, conditional on their holdings of capital, they choose output Y and labour L to maximise revenue less labour cost. If the aggregate production function is the Cobb–Douglas function defined by (6), then the optimal competitive labour demand L^* is obtained by solving the following unconstrained maximisation problem:

$$(9) \quad \max_L pce^{\beta t} L^{1-\alpha} K^\alpha - wL.$$

The use of elementary calculus leads to the following demand for labour function:

$$(9) \quad \ln L^* = \alpha^{-1} [\ln(1-\alpha) + \ln c + \beta t + \ln(p/w)] + \ln K.$$

Since K is treated as a fixed exogenous variable, equation (9) can be rearranged to yield the following slightly nonlinear estimating equation:

$$(10) \quad \ln[L^*/K] = \alpha^{-1} [\ln(1-\alpha) + \ln c + \beta t + \ln(p/w)].$$

If we substitute (9) into (6), we get optimal short run supply, Y^* :

$$(11) \quad \ln Y^* = \alpha^{-1} [(1-\alpha)\ln(1-\alpha) + \ln c + \beta t + (1-\alpha)\ln(p/w)] + \ln K.$$

Since K is treated as a fixed exogenous variable, equation (11) can be rearranged to yield the following nonlinear estimating equation:

$$(12) \quad \ln[Y^*/K] = \alpha^{-1} [(1-\alpha)\ln(1-\alpha) + \ln c + \beta t + (1-\alpha)\ln(p/w)].$$

The system of nonlinear equations defined by (10) and (12) was estimated using the nonlinear regression package in SHAZAM. The results appear in Table 6.4.

Table 6.4: Multiple Equation Cobb–Douglas Production Function with No Splines

<i>Coefficient name</i>	<i>Estimate</i>	<i>Standard error</i>	<i>t-ratio</i>
α	0.542	0.00653	82.97
Inc	0.677	0.00962	70.40
β_2	0.010	0.00086	11.42
Log likelihood	79.86		
<i>Labour Demand Equation</i>			
Durbin–Watson	0.19	Residual sum	-0.98E-02
Von Neumann ratio	0.20	Residual variance	0.13E-01
Rho	0.86	R-square	0.003
<i>Output Supply Equation</i>			
Durbin–Watson	0.29	Residual sum	-0.41E-02
Von Neumann ratio	0.31	Residual variance	0.26E-02
Rho	0.79	R-square	0.550

The parameter estimates are not all that different from the single equation Cobb–Douglas estimates that were listed in Table 6.2 above; the share of capital parameter α has changed from 0.47 to 0.54 and the annual average TFP growth parameter β has changed from 1.1 per cent to 0.98 per cent per year. However, some of the weaknesses of the Cobb–Douglas functional form are now apparent from the above regressions with the fit in each equation being very poor. However, it is possible that our spline techniques could improve the fit. An inspection of the two regression equations suggested that there were breaks in the trend of each regression at observations 8, 11 and 15. Thus the term β_i in equations (10) and (12) was replaced by the sum of the terms $\beta_1 t_1 + \beta_2 t_2 + \beta_3 t_3 + \beta_4 t_4$ as in equation (8) above. Of course, the t variables have been altered to match up with our new break points. The results of our new system of estimating equations are reported in Table 6.5.

The fitted values and the dependent variables for each equation are graphed in Figure 6.7 with the labour equation at the top of the graph. It can be seen that the addition of splines (ie, different rates of Hicks neutral technical change for different periods) has not really improved the fit in either equation very much. A comparison of Tables 6.3 and 6.5 shows that moving from a single equation Cobb–Douglas model of production to a systems approach dramatically changes our estimates of technical change.

Table 6.5: Multiple Equation Cobb–Douglas Production Function with Splines

<i>Coefficient name</i>	<i>Estimate</i>	<i>Standard error</i>	<i>t-ratio</i>
α	0.543	0.00666	81.53
Inc	0.693	0.01363	50.87
β_1	0.007	0.00197	3.76
β_2	0.007	0.00421	1.68
β_3	-0.011	0.00445	-2.42
β_4	0.011	0.00326	3.40
Log likelihood	84.52		
<i>Labour Demand Equation</i>			
Durbin–Watson	0.20	Residual sum	0.96E-01
Von Neumann ratio	0.21	Residual variance	0.11E-01
Rho	0.87	R-square	0.064
<i>Output Supply Equation</i>			
Durbin–Watson	0.36	Residual sum	0.34E-01
Von Neumann ratio	0.38	Residual variance	0.16E-02
Rho	0.77	R-square	0.691

Figure 6.7: Multiple Equation Cobb–Douglas Production Function Model with Splines

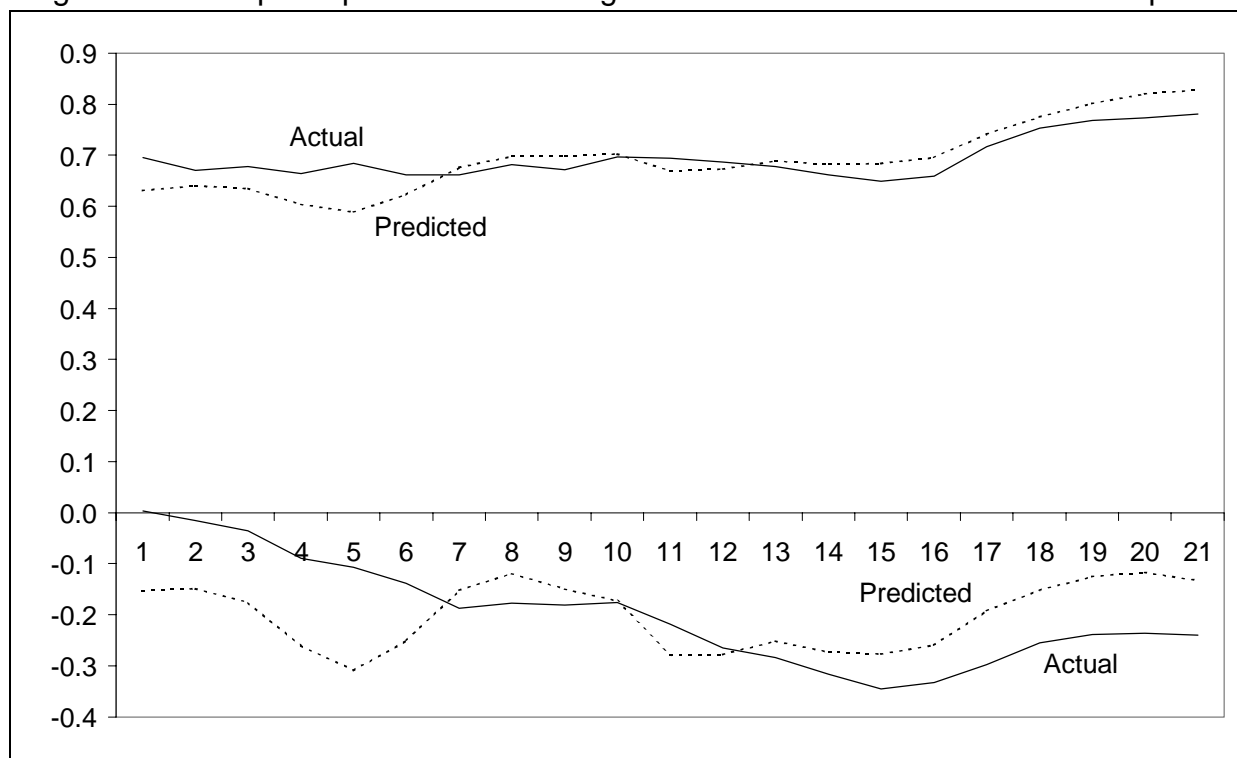


Figure 6.7 indicates to us that the Cobb–Douglas functional form is simply not flexible enough to adequately model producer behaviour once we move to a systems approach to parameter estimation. Note that we prefer the systems approach to the single equation

approach because the systems approach makes maximum use of the available information. Put another way, the systems approach *doubled* the degrees of freedom available to estimate the unknown parameters without increasing the number of parameters. The Cobb–Douglas functional form is inflexible in two separate ways: (a) it imposes a unitary elasticity of substitution between every pair of inputs and (b) it cannot allow for differential rates of technical progress across inputs and outputs. We conclude this chapter by showing how the use of a more flexible functional form can overcome these defects of the Cobb–Douglas functional form.

The functional form that we shall use is the normalised quadratic functional form introduced by Diewert and Wales (1987; 1992). Recall the short run profit maximisation problem defined by (9) above. For a general functional form for the production function, the solution to (9) may be written as a function of the price of output, p , and the wage rate, w , say $\pi(p,w)$, times the fixed level of capital, K . The function $\pi(p,w)$ is the economy's *unit profit function*; it gives the optimal operating surplus or gross return to the efficient use of one unit of capital. Using a result that was initially due to Hotelling, it can be shown that the economy's optimal short run supply function, $Y(p,w,K)$, is equal to the partial derivative of $\pi(p,w)$ with respect to the output price p times the level of capital K ; ie, we have:

$$(13) \quad Y(p,w,K) = [\partial\pi(p,w)/\partial p] K.$$

Similarly, it can be shown that the economy's optimal short run labour demand function, $L(p,w,K)$, is equal to the partial derivative of $\pi(p,w)$ with respect to the wage rate w times the level of capital K ; ie, we have:

$$(14) \quad L(p,w,K) = [\partial\pi(p,w)/\partial w] K.$$

Equations (13) and (14) can be used as estimating equations once a functional form for the unit profit function $\pi(p,w)$ has been picked. We shall use the *normalised quadratic functional form* which is described in some detail in Diewert and Wales (1987; 1992), Lawrence (1989), Kohli (1991; 1993) and Fox(1996; 1998). In the present one output, one variable input case, this functional form reduces to the following one:

$$(15) \quad \pi(p,w) \equiv a_1 p + a_2 w + (1/2)b\{[p^2 - 2pw + w^2]/[p + w]\} + c_1 p t + c_2 w t$$

where a_1 , a_2 , c_1 , c_2 and b are unknown parameters. In order for the unit profit function to satisfy the appropriate theoretical curvature conditions (ie, $\pi(p,w)$ must be a convex, linearly homogeneous function of p and w), the parameter b must be nonnegative. (If $b = 0$, then the $\pi(p,w)$ defined by (15) reduces to a no substitution Leontief unit profit function). The parameter c_1 is an output specific technological progress parameter while c_2 is a labour specific technological progress parameter. Thus, in comparison to the bare bones Cobb–Douglas functional form defined by (6) above, which had only *one* technological progress

parameter β , the normalised quadratic functional form has *two* such parameters. Moreover, the bare bones Cobb–Douglas functional form defined by (6) had no free substitution parameter (the elasticity of substitution between labour and capital is fixed at unity) whereas in (15), the substitution parameter b can be chosen so that any theoretically admissible elasticity of substitution between labour and capital can be attained.

Differentiating (15) with respect to p leads to the following estimating equation for the short run output supply function (recall (13) above):

$$(16) \quad Y/K = a_1 + c_1 t + b\{p^* - w^* + (1/2)p^{*2} - p^*w^* + (1/2)w^{*2}\}$$

where $p^* \equiv p/(p+w)$ is the normalised price of output and $w^* \equiv w/(p+w)$ is the normalised wage rate. Similarly, differentiating (15) with respect to w leads to the following estimating equation for the short run labour demand function (recall (14) above):

$$(17) \quad L/K = a_2 + c_2 t + b\{w^* - p^* + (1/2)p^{*2} - p^*w^* + (1/2)w^{*2}\}.$$

Table 6.6: Estimates for the Normalised Quadratic Model with no Splines

<i>Coefficient name</i>	<i>Estimate</i>	<i>Standard error</i>	<i>t-ratio</i>
a_1	1.934	0.02407	80.37
b	1.069	0.43897	2.43
c_1	0.013	0.00261	4.87
a_2	-0.959	0.01729	-55.45
c_2	0.007	0.00232	3.11
Log likelihood	87.15		
<i>Labour Demand Equation</i>			
Durbin–Watson	0.34	Residual sum	-0.34E-08
Von Neumann ratio	0.35	Residual variance	0.15E-02
Rho	0.86	R-square	0.80
<i>Output Supply Equation</i>			
Durbin–Watson	0.51	Residual sum	0.77E-08
Von Neumann ratio	0.54	Residual variance	0.30E-02
Rho	0.73	R-square	0.54

Note that equations (16) and (17) are linear in the 5 unknown parameters. However, we used the nonlinear regression package in SHAZAM to estimate (16) and (17) as a system of estimating equations for two reasons: (i) the parameter b appears in both equations so a systems approach is appropriate and (ii) if the estimated b turned out to be negative, then it would be necessary to replace b by a squared parameter, say b^2 , and then estimating (16) and (17) would be a nonlinear regression model. The results of estimating (16) and (17) are listed in Table 6.6. Note that the estimated b coefficient is positive.

The estimated parameters are significantly different from zero and the fit has improved from our earlier Cobb-Douglas systems models. We now see if the fit can be improved by using our earlier spline technique; ie, we change the time trend term c_1t in (16) above to $c_1t_1+d_1t_2+e_1t_3+f_1t_4$ and we change the time trend term c_2t in (17) above to $c_2t_1+d_2t_2+e_2t_3+f_2t_4$ where, as usual, t_1, \dots, t_4 are linear spline variables that are zero until a break point is reached and then they have linear trends. By visually inspecting the plots for the preliminary regressions described in Table 6.6, we set our break points to be observations 8, 11 and 15, which correspond to the years 1985, 1988 and 1992, respectively. The results for our normalised quadratic model with splines are listed in Table 6.7.

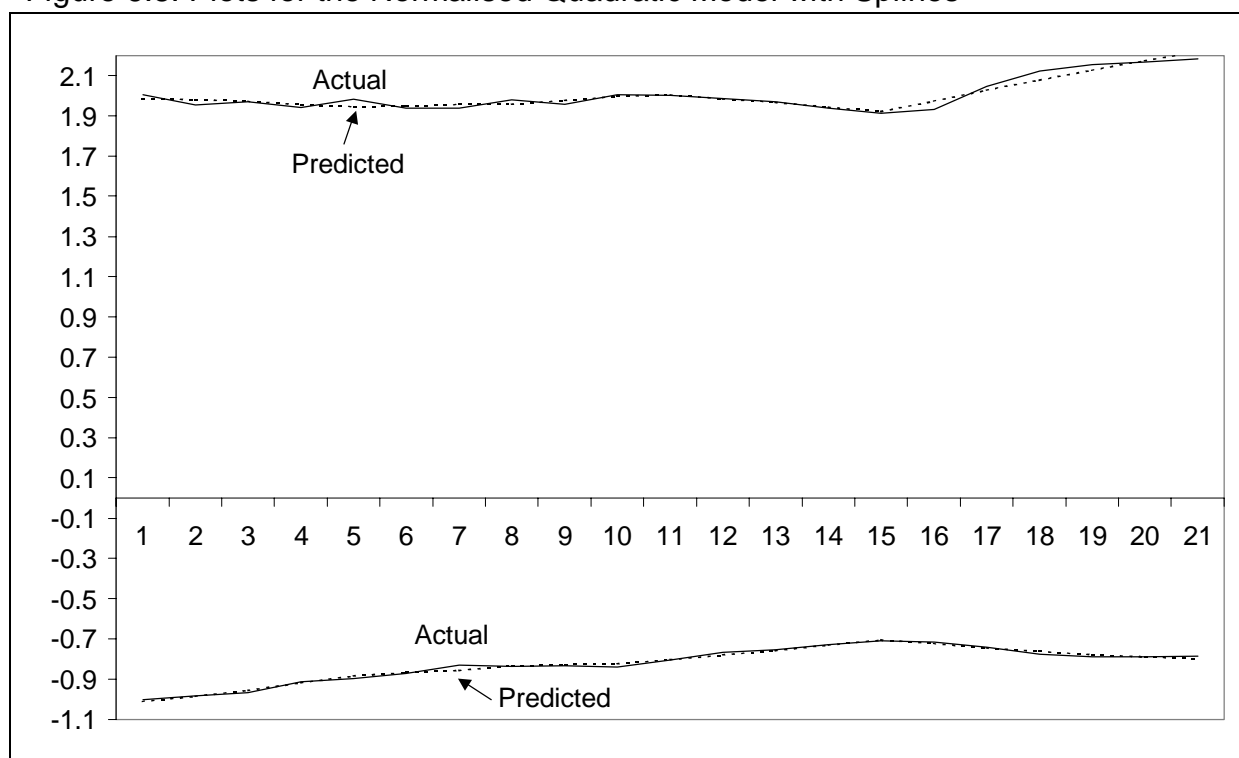
Table 6.7: Estimates for the Normalised Quadratic Model with Splines

<i>Coefficient name</i>	<i>Estimate</i>	<i>Standard error</i>	<i>t-ratio</i>
a_1	1.984	0.01466	135.40
b	0.536	0.16714	3.21
c_1	-0.003	0.00330	-0.76
d_1	0.029	0.00970	3.01
e_1	-0.047	0.01184	-3.94
f_1	0.069	0.00849	8.17
a_2	-1.011	0.00676	-149.55
c_2	0.024	0.00151	15.72
d_2	-0.025	0.00467	-5.38
e_2	0.025	0.00559	4.47
f_2	-0.039	0.00382	-10.23
Log likelihood	121.37		
<i>Labour Demand Equation</i>			
Durbin-Watson	1.79	Residual sum	-0.27E-08
Von Neumann ratio	1.88	Residual variance	0.97E-04
Rho	0.06	R-square	0.99
<i>Output Supply Equation</i>			
Durbin-Watson	1.90	Residual sum	-0.33E-07
Von Neumann ratio	1.99	Residual variance	0.48E-03
Rho	-0.03	R-square	0.93

Comparing Tables 6.6 and 6.6, it can be seen that there is a huge improvement in the statistical properties of the two estimating equations: the log likelihood has increased from

87.1 to 121.4, autocorrelation has vanished and the R^2 for the two equations have jumped from 0.5387 and 0.7956 to 0.9258 and 0.9864, respectively. (These R^2 are relatively high since we have divided Y and L by K to reduce heteroskedasticity problems). In both models, virtually all of the coefficients are significantly different from zero. The dependent variables and their fitted values for the normalised quadratic model with splines are plotted in figure 6.8 with the output equation this time being at the top of the graph.

Figure 6.8: Plots for the Normalised Quadratic Model with Splines



Compare Figures 6.6 and 6.7 it can be seen that the Cobb–Douglas model with splines is very much dominated by the normalised quadratic model with splines. *The Cobb–Douglas functional form is simply not flexible enough to model adequately trends in the New Zealand economy.*

We now examine some of the implications of the parameter estimates listed in Table 6.7 above. The technical change parameters for the output equation are c_1 , d_1 , e_1 , and f_1 . If these parameters are positive, then it means that technical progress is *increasing* the amount of output that can be produced from the same inputs of labour and capital. The technical change parameters for the labour equation are c_2 , d_2 , e_2 , and f_2 . If these parameters are positive, then it means that technical progress is *decreasing* the amount of labour that is required to produce the same output using the same amount of capital. Thus in either case, a positive coefficient is ‘good’ for the economy in the sense that it indicates an efficiency improvement.

From Table 6.7, we see that c_1 is negative (which indicates a *loss* of output productivity) while c_2 is positive (which indicates a *gain* in labour productivity). Thus, for observations 1 to 8, (the years 1978–85), the overall effect on productivity is indeterminate. For observations 9 to 11, (the years 1986–88), d_1 is positive (which indicates an *improvement* in output productivity) while d_2 is negative (which indicates a *loss* of in labour productivity compared to the earlier period). For observations 12 to 15, (the years 1989–92), e_1 is negative (which indicates a *loss* of output productivity compared to the earlier period) while e_2 is positive (which indicates a *gain* in labour productivity compared to the earlier period). Finally, for observations 16 to 21, (the years 1993–98), f_1 is positive (which indicates an *improvement* in output productivity) while f_2 is negative (which indicates a *loss* of labour productivity compared to the earlier period).

Note that the estimated coefficients for f_1 and f_2 are both rather large in magnitude compared to the other technical progress parameters. This means that for the years 1993–98, technical progress in New Zealand was *biased* towards the production of more output while at the same time, it was *biased* towards the use of more labour input. Given that there was a severe unemployment problem prior to the introduction of the ECA, the bias towards the use of more labour input (for the years 1993–98) was good news for the New Zealand economy. Note that the Cobb–Douglas production function is simply not flexible enough to capture these bias effects in the direction of technical change.

The discussion in the above paragraphs indicated that for each of our four subperiods, the direction of technical progress moved in opposite directions; ie, either output productivity improved and labour productivity worsened or vice versa. Thus, it is necessary to have an overall measure of technical change which will aggregate the two partial measures of technical change. If we write the unit profit function as an explicit function of time, say $\pi(p,w,t)$, then a suitable measure of the overall improvement in productivity in period t , say τ^t , can be defined as the incremental value of the increase in output plus the decrease in labour input going from period $t - 1$ to period t , divided by the value of output in period t . This definition works out to be the partial derivative of $\pi(p,w,t)$ with respect to time t (evaluated at the period t prices p^t and w^t) times capital employed in period t , K^t , divided by the value of output in period t , $p^t Y^t$; ie, we have:

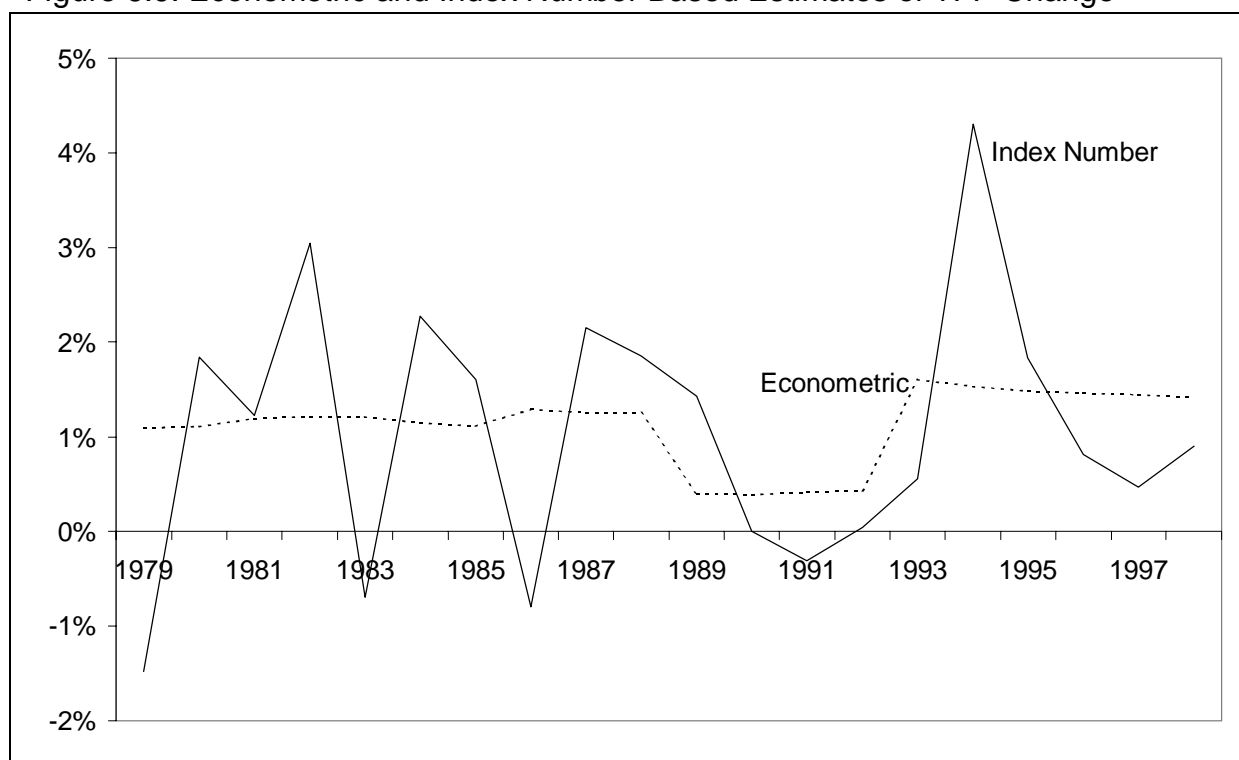
$$(18) \quad \tau^t \equiv [\partial \pi(p^t, w^t, t) / \partial t] K^t / p^t Y^t \quad ; \quad t = 1, 2, \dots, 21.$$

The technical progress measures τ^t defined by (18) should be comparable to our earlier index number estimates of the productivity change, T^t say, using the official data base.² These two series are graphed in figure 6.9 in change form and in figure 6.10 in index form. The index

² Diewert and Wales (1992, p.718) and Fox (1996, p.953; 1998, pp.242–243) also compare index number estimates of productivity change with their econometric counterparts.

number based changes fluctuate more than the smooth econometric changes but follow a similar pattern. The degree of correspondence between the two sets of estimates is highlighted in figure 6.10 where the two TFP indexes very closely correspond with the econometric index being a smoothed version of the index number based index.

Figure 6.9: Econometric and Index Number Based Estimates of TFP Change



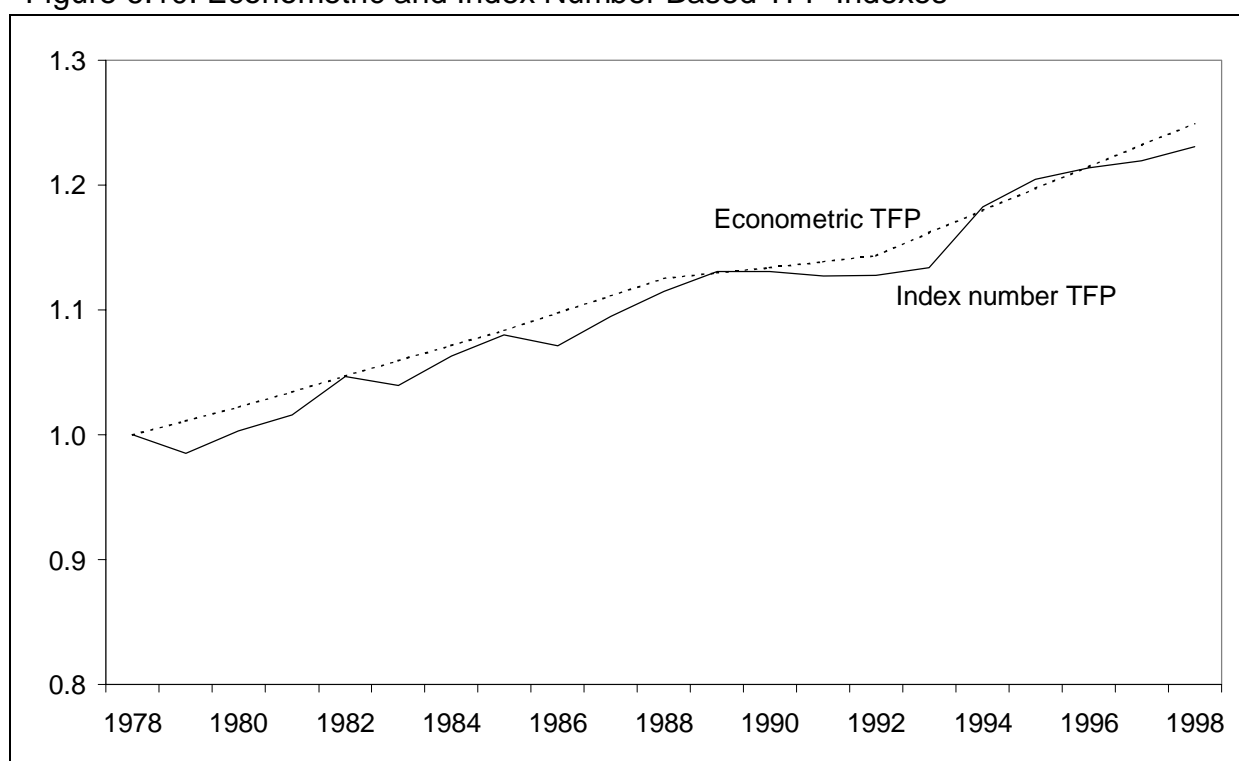
For the entire 21 year period, the (arithmetic) average annual TFP improvement in the New Zealand economy was 1.12 per cent per year using the econometric based estimates τ^t . For the years 1978–85, the average TFP improvement was 1.14 per cent per year. For the years 1986–88, the average annual rate of TFP improvement increased slightly to 1.26 per cent per year. For the years 1989–92, the TFP growth rate fell dramatically to an average rate of 0.41 per cent per year. Finally, for the final years in our sample 1993–98, the average econometric based TFP growth rate bounced back to 1.49 per cent per year.

Our conclusion at this point is that Maloney's strong conclusions about the effects of the ECA rest on the use of a Cobb–Douglas production function methodology and, as we have demonstrated in this section, this functional form is simply not flexible enough to adequately describe the trends in the New Zealand economy. The use of a more flexible functional form may well lead to a different conclusion than the one that Maloney obtained.

This review has served to compare the econometric approach to the measurement of productivity change with the index number approach. The main advantage of the index number approach to the measurement of TFP is its *reproducibility*; ie, different investigators

will obtain the *same* productivity estimates (provided that they use the same data and use a superlative index number formula to aggregate up the data). On the other hand, econometric estimates of TFP change will be much more open to challenge. Different econometricians will choose different functional forms for the production function or the dual unit profit function or the dual unit cost function; different econometricians will choose different break points for the splines and different econometricians will choose alternative stochastic specifications and methods of estimation. These differences will lead to different estimates of TFP.

Figure 6.10: Econometric and Index Number Based TFP Indexes



Another advantage of the index number approach is that it will give an accurate measure of the TFP change for *each* year whereas the econometric approach can only give 'accurate' measures for groupings of years. However, the econometric method does have the advantage that the *sources* of the productivity gains can be estimated; ie, we can determine if technical change is labour saving or output augmenting and so on. The index number method can cast no light on these questions. Thus, the choice of which approach should be used depends ultimately on what question is being addressed.

New Zealand has undertaken an unparalleled range of reforms over the past 15 years. The accumulated New Zealand literature has made a good contribution to understanding how the economy has responded to these reforms.

7. MEASUREMENT PROBLEMS

We commence our review of measurement problems by looking at the classification of outputs and inputs we have used in this study. We find that there is no systematic separate information on gross outputs and intermediate inputs at the sectoral level and the sectoral information on labour is not consistent across sources. There is no official capital stock series by sector at present although it is possible for researchers to construct their own net stock estimates and there is no systematic information available on sectoral stocks of land and inventories or on resource depletion. Improving the information available on the economy is a prerequisite for informed policy advice and analysis. We go on to look at several important emerging areas of likely measurement error. These include: the transfer of erstwhile consumption expenditures to business intermediate expenditure; price index biases (including substitution bias, elementary index bias, outlet substitution bias, quality adjustment bias and new goods bias); and, more appropriate output measurement for service sector industries (including industries involving interest, margin industries and industries involving risk). All these areas involve potentially large sources of measurement error in the official statistics. Allocating sufficient resources to overcoming these measurement problems should be a high priority for all countries.

7.1 Introduction

In this chapter, we survey some of the recent literature on measurement problems that statistical agencies face in attempting to construct accurate measures of real industry output and real GDP components.

In section 7.2, we survey the data requirements necessary to measure the total factor productivity of an industry reasonably accurately. Accurate price and quantity information on 7 main classes of inputs and outputs are required.

In section 7.3, we note that even if we have accurate information on the 7 classes of inputs and outputs discussed in section 7.2, there are still *classification* problems that can cause problems. For example, as an increasing number of workers become self employed contractors, there will be a tendency for former consumption expenditures to show up as

business intermediate expenditures. This switch of categories can have a major impact on measured GDP growth over time.

In section 7.4, we provide a reasonably comprehensive survey of the recent literature on possible upward biases in consumer price indexes. We conclude that the evidence is fairly compelling that these biases are present but it is not yet certain whether these biases have become worse in recent years.

In section 7.5, we review the recent literature applying to the user cost of money concept to measuring banking sector outputs. It is likely that this new approach to measuring Finance sector outputs will yield much higher rates of growth for industry output.

In section 7.6, we review statistical agency approaches to the measurement of the real output of margin type industries. We derive a new argument that the traditional single deflation technique used to measure real output in these industries could have a substantial downward bias associated with its use.

In section 7.7, we briefly review some of the measurement problems that are associated with the measurement of outputs in industries where the outputs have a substantial risk factor associated with them. Examples of such industries are the Insurance and Gambling industries.

Finally, in section 7.8, we provide a general review of some of the difficult measurement problems that are faced by statistical agencies in these times of rapid change in economic structure.

7.2 The Data Requirements for Measuring Total Factor Productivity

In our discussion of the New Zealand literature on productivity measurement, we noted that the accurate measurement of total factor productivity requires information on more than just outputs, labour inputs and capital inputs. In this section, we spell out what the data requirements are. We require accurate price and quantity information on at least seven classes of inputs and outputs to measure the TFP of a firm, industry or group of industries.

7.2.1 Gross Outputs

In principle, we require information on all the outputs produced by the industry for each time period in the sample along with the average price received by the industry in each period for each of the outputs. In practice, period by period information on revenues received by the industry for a list of output categories is required along with either an output index or a price index for each output. In principle, the revenues received should *not* include any commodity taxes imposed on the industry's outputs, since these tax revenues are not received by producers in the industry.

7.2.2 Intermediate Inputs

Again, in principle, we require information on all the intermediate inputs utilised by the industry for each time period in the sample along with the average price paid by the industry for each of the inputs. In practice, period by period information on costs paid by the industry for a list of intermediate input categories is required along with either an intermediate input quantity index or a price index for each category. In principle, the intermediate input costs paid *should* include any commodity taxes imposed on the intermediate inputs, since these tax costs are actually paid by producers in the industry.

We are advocating the double deflation approach to the construction of real value added. This is essentially the approach we used in chapter 3 to construct our expenditure based estimates of market sector real GDP. We used a superlative index number formula to simultaneously aggregate over gross output components and intermediate input components. In the index number formula, we index the quantity of each intermediate input component (including imports) with a *negative* sign; all other prices and quantities are positive. An alternative procedure would be to separately construct quantity indexes of outputs and intermediate inputs (this is the first stage of aggregation) and then aggregate the first stage aggregates using the same index number formula (the aggregate intermediate input is indexed with a negative sign)¹.

Statistics New Zealand describes the double deflation method for constructing real value added as follows:

“After the two flows, gross output and intermediate consumption, are expressed in constant prices, one is deducted from the other. This method is known as double deflation. Conceptually, it is the ideal approach since it specifically takes into account changes in the volumes of both inputs and outputs during the production period.” Statistics New Zealand (1996, p.23).

The major classes of intermediate inputs at the industry level are:

- materials
- business services
- leased capital.

The current input–output framework deals reasonably well *in theory* with the flows of materials but not with intersectoral flows of contracted labour services or rented capital

¹ Diewert (1978, p.889) showed that if a superlative index number formula is used for each aggregation, then the single stage procedure will approximate the two stage procedure to the second order. He also showed that this theoretical result held to a close approximation in an empirical example using Canadian consumption data. If the Laspeyres index is used at each stage of aggregation, then the single stage procedure will be exactly equal to the two stage procedure.

equipment. In practice, however, even the intersectoral value flows of materials are largely incomplete in the industry statistics. The following quotation indicates that there is little accurate information on these *value flows* of intermediate inputs let alone accurate price or quantity deflators for them:

“Double deflation, however, is not suitable to all practical situations. It demands a high level of reliability in the current price production accounts and in the price and quantity data used for deflation. In those situations where the data may not meet the required standard, the technique introduces the possibility of numerous and compounding measurement errors. For example, in those industries where the value added is the difference between two relatively large flows subject to measurement error, value added in constant prices derived by double deflation may fluctuate widely over time because of the cumulative effect of the errors. ... Until recently the data required for double deflation has not been widely available in New Zealand. The Producers Price Index, although covering most of the economy, has not been available at a sufficient level of detail, especially for inputs. Similarly, there are only limited cases where input volume data is available.” Statistics New Zealand (1996, p.23).

This lack of information means the current input–output accounts will have to be greatly expanded to construct reliable estimates of real value added by industry. At present, there are no surveys (to our knowledge) on the interindustry flows of business services or for the interindustry flows of leased capital. Another problem is that using present national accounts conventions, leased capital resides in the sector of ownership, which is generally the Finance sector. This leads to a large overstatement of the capital input into Finance and a corresponding underestimate of capital services into the sectors actually using the leased capital.

It should be noted that at the level of the entire market economy, intermediate inputs collapse down to just imports plus purchases of government and other nonmarket inputs. This simplification of the hugely complex web of interindustry transactions of goods and services explains why we think that the real GDP final demand expenditures approach to measuring aggregate output is more accurate than the GDP real value added industry approach.

7.2.3 Labour Inputs

Using the number of employees as a measure of labour input into an industry will not usually be a very accurate measure of labour input due to the long term decline in average hours worked per full time worker and the recent increase in the use of part time workers. However, even total hours worked in an industry is not a satisfactory measure of labour input

if the industry employs a mix of skilled and unskilled workers. Hours of work contributed by highly skilled workers generally contribute more to production than hours contributed by very unskilled workers. Hence, it is best to decompose aggregate labour compensation into its aggregate price and quantity components using index number theory as we did in chapter 3. The practical problem faced by statistical agencies is: how should the various categories of labour be defined? Alternative approaches to this problem are outlined in Jorgenson and Griliches (1967), the Bureau of Labor Statistics (1983), Denison (1985), Jorgenson, Gollop and Fraumeni (1987) and Jorgenson and Fraumeni (1989; 1992). Dean and Harper (1998) provide an accessible summary of the literature in this area.

Another important problem associated with measuring real labour input is finding an appropriate allocation of the operating surplus of proprietors and the self employed into labour and capital components. There are two broad approaches to this problem:

- If demographic information on the self employed is available along with hours worked, then an imputed wage can be assigned to those hours worked based on the average wage earned by employees of similar skills and training. Then an imputed wage bill can be constructed and subtracted from the operating surplus of the self employed. The reduced amount of operating surplus can then be assigned to capital.
- If information on the capital stocks utilised by the self employed is available, then these capital stocks can be assigned user costs and then an aggregate imputed rental can be subtracted from operating surplus. The reduced amount of operating surplus can then be assigned to labour. These imputed labour earnings can then be divided by hours worked by proprietors to obtain an imputed wage rate.

The problems posed by allocating the operating surplus of the self employed are becoming increasingly more important as this type of employment grows. As far as we can determine, little has been done in New Zealand to resolve these problems although New Zealand is not alone in this. Fundamentally, the problem appears to be that the current System of National Accounts (SNA) does not address this problem adequately.

7.2.4 Reproducible Capital Inputs

We have discussed some of the problems associated with measuring capital inputs in chapters 4 and 5 and the four appendices. We summarise some of this material below.

When a firm purchases a durable capital input, it is not appropriate to allocate the entire purchase price as a cost to the initial period when the asset was purchased. It is necessary to distribute this initial purchase cost across the useful life of the asset. National income accountants recognise this and use depreciation accounts to do this distribution of the initial cost over the life of the asset. However, national income accountants are reluctant to

recognise the *interest* tied up in the purchase of the asset as a true economic cost. Rather, they tend to regard interest as a transfer payment. Thus the *user cost* of an asset (which recognises the opportunity cost of capital as a valid economic cost) is not regarded as a valid approach to valuing the services provided by a durable capital input by national income accountants. However, if a firm buys a durable capital input and *leases or rents* it to another sector, the induced rental is regarded as a legitimate cost for the using industry by national income accountants. It seems very unlikely that the leasing price does not include an allowance for the capital tied up by the initial purchase of the asset; ie, *market rental prices include interest*. Hence, it seems reasonable to us to include an imputed interest cost in the user cost of capital even when the asset is not leased. Put another way, interest is still not accepted as a cost of production in the SNA, since it is regarded as an unproductive transfer payment. But interest *is* productive; it is the cost of inducing savers to forego immediate consumption.

The treatment of capital gains on assets is even more controversial than the national accounts treatment of interest. In the national accounts, capital gains are not accepted as an intertemporal benefit of production but if resources are transferred from a period where they are less valuable to a period where they are more highly valued, then a gain has occurred; ie, capital gains are productive in our view.

However, the treatment of interest and capital gains pose practical problems for statistical agencies. For example, which interest rate should be used?

- An ex post economy wide rate of return which is the alternative used by Christensen and Jorgenson (1969; 1970) and ourselves in chapters 3 and 4?
- An ex post firm or sectoral rate of return? This method was used in chapter 5.
- An ex ante safe rate of return like a Federal Government one year bond rate?
- Or should the ex ante safe rate be adjusted for the risk of the firm or industry?

Similarly, should the capital gains term of the user cost be an ex ante expected capital gain (which is the 'right' concept from the viewpoint of trying to model economic behavior) or should it be an ex post actual observed capital gain (which is the 'right' concept from the viewpoint of attempting to measure ex post economic performance)? In chapter 3, we used a 'pure' ex post approach. However, in chapters 4 and 5, we used a 'mixed' approach in that we used ex post rates of return but we computed these real rates of return using the implicit assumption that the capital gains rate on each of our two assets was the same. This introduces an element of ex ante smoothing into our estimates.

Since the ex ante user cost concept is not observable, the statistical agency will have to make somewhat arbitrary decisions in order to construct expected capital gains. This is a strong disadvantage of the ex ante concept. On the other hand, the use of the ex post concept will lead to rather large fluctuations in user costs, which in some cases will lead to negative user costs, which in turn may be hard to explain to users. In chapter 3, we did encounter negative ex post user costs for some assets. However, a negative user cost simply indicates that instead of the asset declining in value over the period of use, it rose in value to a sufficient extent to offset deterioration. Hence, instead of the asset being an input cost to the economy during the period, it becomes an intertemporal output. For further discussion on the problems involved in constructing user costs, see Diewert (1980, pp.470–486). For evidence that the choice of user cost formula matters, see Harper, Berndt and Wood (1989).

The distinction between depreciation (a decline in value of the asset over the accounting period) and deterioration (a decline in the physical efficiency of the asset over the accounting period) is now well understood² but has still received little recognition in the latest version of the SNA.

A further complication is that our empirical information on the actual efficiency decline of assets is weak. We do not have good information on the useful lives of assets. The UK statistician assumes machinery and equipment in manufacturing lasts on average 26 years while the Japanese statistician assumes machinery and equipment in manufacturing lasts on average 11 years; see the OECD (1993, p.13). The uncertainty about the length of asset lives has recently been reduced with the SNZ (1998) analysis of survey based information on asset lives. This new information should lead to more accurate and objective estimates for capital stocks being used in New Zealand industries. The problems involved in measuring capital input are also being addressed by the Canberra Group on Capital Measurement, which is an informal working group of international statisticians dedicated to resolving some of these measurement problems.

A final set of problems associated with the construction of user costs is the treatment of business income taxes: should we assume firms are as clever as Hall and Jorgenson (1967) and can work out their rather complex tax-adjusted user costs of capital or should we go to the accounting literature and allocate capital taxes in the rather unsophisticated ways that are suggested there?

² In terms of the discussion in appendix D, the decline in efficiency mentioned in this section is equal to the decline in the vintage rental price.

7.2.5 Inventories

Because interest is not a cost of production in the national accounts and the depreciation rate for inventories is close to zero, most productivity studies neglect the user cost of inventories. This leads to misleading productivity statistics for industries where inventories are large relative to output, such as retailing and wholesaling. In particular, rates of return that are computed neglecting inventories will be too high since the opportunity cost of capital that is tied up in holding the beginning of the period stocks of inventories is neglected.

The problems involved in accounting for inventories are complicated by the way accountants and the tax authorities treat inventories. These accounting treatments of inventories are problematic in periods of high or moderate inflation. A treatment of inventories that is suitable for productivity measurement can be found in Diewert and Smith (1994). We have followed their treatment in chapter 3 and appendix B.

These accounting problems seem to carry over to the national accounts in that for virtually all OECD countries, there are time periods where the real change in inventories has the opposite sign to the corresponding nominal change in inventories. This is logically inconsistent.

7.2.6 Land

The current SNA has no role for land as a factor of production, perhaps because it is thought that the quantity of land in use remains roughly constant across time and hence it can be treated as a fixed, unchanging factor in the analysis of production. However, the quantity of land in use by any particular firm or industry does change over time. Moreover, the price of land can change dramatically over time and thus the user cost of land will also change over time and this changing user cost will, in general, affect correctly measured productivity. For example, for the period 1955–1987, the price of land (or more precisely, the price of nonreproducible tangible assets) in Japan grew approximately 16% per year. Inserting a user cost of land into the aggregate productivity formula for Japan (versus just omitting land from the computation) leads to a 0.5% per year increase in Japanese total factor productivity. However, it should be mentioned that the user cost concept used to obtain this result was of the type used in chapters 4 and 5 above; ie, an ex post economy wide rate of return was computed under the assumption that all assets had the same rate of capital gains. If an actual ex post user cost concept is used, then it is likely that omitting land would have a much smaller effect as was the case when we omitted land for New Zealand in chapter 3. It is important not to neglect the role of land when computing the total factor productivity of a producer unit as it can have a significant impact under some conditions.

Land ties up capital just like inventories (both are zero depreciation assets). Hence, when computing ex post rates of return earned by a production unit, it is important to account for

the opportunity cost of capital tied up in land. Neglect of this factor can lead to biased rates of return on financial capital employed. Thus, our industry rates of return and TFP estimates tabled in chapter 5 may not be accurate for sectors like agriculture which are land intensive.

Finally, property taxes that fall on land must be included as part of the user cost of land. In general, it may not be easy to separate the land part of property taxes from the structures part. In the national accounts, property taxes (which are input taxes) are lumped together with other indirect taxes that fall on outputs which is another shortcoming of the current SNA.

7.2.7 Resources

Examples of resource inputs include:

- depletion of fishing stocks, forests, mines and oil wells
- improvement of air, land or water environmental quality (these are resource “outputs” if improvements have taken place and are resource “inputs” if degradation has occurred).

The correct prices for *resource depletion* inputs are the gross rents (including resource taxes) that these factors of production earn. In chapter 3, we attempted to account for forestry and oil and gas depletion but we were unable to form estimates of mining and fishing depletion. Resource rents are usually not linked up with the depletion of resource stocks in the national accounts although Statistics Canada is developing statistics for forest, mining and oil depletion.

The pricing of *environmental inputs or outputs* is much more difficult. From the viewpoint of traditional productivity analysis based on shifts in the production function, the ‘correct’ environmental quality prices are marginal rates of transformation while, from a consumer welfare point of view, the ‘correct’ prices are marginal rates of substitution; see Gollop and Swinand (1998).

The environmental situation is somewhat analogous to the case of a government enterprise that is told to provide services at prices well below marginal cost. In this case, it is useful to have an addendum to the accounts that revalues the subsidised goods and services at market (ie, at consumer) prices and this treatment would also be useful in the case of environmental goods and services. The problem with this suggestion is that it is much more difficult to estimate the appropriate consumer or producer environmental prices than it is to estimate the market price of a state subsidised good like housing. Some techniques that could perhaps be used to estimate appropriate environmental prices and quantities are:

- engineering studies (for the determination of producer environmental prices)
- epidemiological studies (for the determination of consumer environmental prices)

- econometric and statistical techniques may also be useful in determining these producer and consumer environmental prices.

Given the importance of natural resources to the New Zealand economy and given the example of Statistics Canada in developing resource depletion accounts for Canada, Statistics New Zealand should be encouraged to start constructing resource accounts for New Zealand.

7.2.8 Conclusions

The above seven major classes of inputs and outputs represent a *minimal* classification scheme for organising information to measure TFP at the sectoral level. In common with most other statistical agencies, the database that is presently available from Statistics New Zealand falls short of this minimal required level in the following ways:

- There is no systematic *separate* information on gross outputs and intermediate inputs at the sectoral level. The present constant dollar value added estimates of industry output are primarily based on single indicators (eg, gross output deflated value indexes, gross output volume indexes, physical activity indicators or movements in employment) instead of the theoretically more appropriate double deflation method (see Statistics New Zealand (1996, pp.23–28)).
- The sectoral information on labour is not consistent across sources.
- There is no official capital stock series by sector at present although it is possible for researchers to construct their own net stock estimates.³
- There is no systematic information available on sectoral stocks of land and inventories or on resource depletion.

If government wants to understand how policy changes affect the real economy, it is first necessary to *measure* what has happened to the economy in the past as policy changes occurred. To fill in the above data gaps, it would be necessary to expand Statistics New Zealand's budget considerably. This is one area of government expenditure that cannot be readily filled by the private sector.

There are also additional types of capital that should be distinguished in a more complete classification of commodity flows and stocks such as knowledge or intellectual capital, working capital or financial capital, infrastructure capital and entertainment or artistic capital. Knowledge capital, in particular, is important for understanding precisely how process and product innovations (which drive TFP) are generated and diffused. However, the methodology in these areas has yet to be developed operationally.

³ It is not possible to construct completely accurate sectoral gross capital stocks due to the restructuring and change of industry problems. When a firm is moved from one sector to another, its vintage capital stocks must also be moved. In our data set, these interindustry movements occasionally show up as negative investments. However, we have no information on the vintage capital structure of these intersectoral shifts.

We turn now to a discussion of some other measurement issues. The material in the next four sections draws on Diewert and Fox (1998; 1999).

7.3 Business Intermediate Expenditures versus Consumption Expenditures

Suppose a firm gives an employee the right to use a company car for both business and personal use. The employee's business travel expenses, the depreciation on the car and at least part of the firm's interest cost in financing the purchase of the car will appear in the national accounts as a combination of business intermediate expenditures on goods and services and as primary input expense. In any case, these expenditures will be a negative contribution to GDP; ie, they will reduce GDP. On the other hand, if the firm simply paid more salary to the employee so that the employee was able to purchase a car, then the same car that was a negative increment to GDP would become a positive increment; ie, the worker's purchase of the car would appear in consumer final demand expenditures. Other examples of business intermediate expenditures that could be classified as final consumption expenditures (at least in part) are:

- entertainment expenses
- company gyms and daycare centres
- internet connection fees and telephone bills
- home loans.
- business travel.

There are other examples of such possible misclassification of final demand expenditures as business intermediate expenditures. The negative impact of pollution control and environmental preservation regulations on (incorrectly) measured productivity growth have been examined by McConnell (1979), Malkiel (1979), Nordhaus (1982), Mairesse (1982) and Baily and Gordon (1988). Estimates of the contribution to the induced reduction in output growth from these sources range from 0.2% to 0.5% per year. In other words, the current SNA counts business expenditures on pollution control as an intermediate business expense (which reduces GDP) but it fails to record any benefits from these expenditures in an appropriate system of environmental accounts.

As the shift from employee status to self employed status increases, we would expect an increasing degree of underestimation of GDP due to the above phenomenon. Ross Gittins (1998) notes that in Australia over the period 1985 to 1997, the proportion of own account workers rose from 28 per cent to 33 per cent. Citing a recent study by John Buchanan and Cameron Allen on the implications for tax revenue of the growth of contractors in the construction industry, Gittins reports the following:

“Using figures supplied by Professor Patricia Apps, of Sydney University, they estimate that when a construction industry worker on \$52,000 a year goes from being an employee to a contractor, he’s able to cut his annual tax bill from \$14,000 to \$7,400. In the example, he does this by generating more than \$20,000 worth of business deductions. One trick is to pay his wife a salary of \$6,000 a year. But most of the rest comes because expenses formerly classed as private now become business items: motor vehicle expenses, telephone, insurance premiums and materials.” Gittins (1998).

Gittins goes on to cite some similar estimates from the UK:

“These estimates receive broad support from the experience in Britain. There, the proportion of construction industry workers who were contractors rose in the 13 years to 1993 from 29 per cent to 45 per cent. The loss of public revenue was estimated at between \$4 billion and \$8 billion a year.” Gittins (1998).

The above quotations alert us to another set of classification problems: how should Statistics New Zealand allocate motor vehicle expenses (and the associated fuel taxes), telephone expenses, insurance premiums and purchases of materials (particularly of building materials that might be used for household renovations) between the business sector and the household sector? For instance, if a fraction of home renovation expenditures simply show up as business intermediate expenditures instead of being registered as an increase in household investment, then nominal and real GDP will be understated. There is no easy answer to this question.

Finally, improvements in workplace safety and amenities also have the effect of increasing business expenditures without a compensating increase in consumer benefits being registered in the data; ie, the effect of these expenditures is to make labour supply less burdensome. Thus, there is a need to quality adjust the measured labour supply so that these increased workplace amenities get recorded as benefits as well as costs. This factor has been used as a partial explanation for the productivity slowdown by Summers (1982, p.167), and Baily and Gordon (1988, p.409).

Thus, even if Statistics New Zealand could provide us with accurate information on sectoral gross outputs and intermediate inputs, this is not the end of the story. Some proportion of the intermediate input expenditures will be incorrectly classified or, at least, some of these intermediate expenditures should have benefits registered somewhere else in the accounts.

7.4 The New Goods Problem and Bias in Consumption Components

In recent years, there has been an increasing interest in price measurement issues, stimulated in part by the release of the Boskin Commission Report on possible bias in US consumer price index components; see Boskin, Dullberger, Gordon, Griliches and Jorgenson (1996). In recent years, it has become clear that the consumer price indexes of most statistical agencies have a considerable amount of upward bias in them. There is no reason to think that New Zealand CPI components are immune to this upward bias. Thus, it is very likely that the New Zealand expenditure based estimates of real GDP are biased downward. An upward bias in the CPI will generally translate into a downward bias in the growth of aggregate output and hence a downward bias in measured TFP. An increase in CPI bias will lead to an increase in TFP bias. There is no consensus on whether CPI bias is increasing. Diewert and Fox (1998; 1999) make the case for an increasing amount of bias in price indexes while others like Triplett (1997; 1999) are more sceptical. In any case, we will present a brief review of recent empirical evidence on the possible size of bias in the Consumer Price Index⁴. We will follow the example of Gordon (1993) and Diewert (1995a,b) and discuss possible sources of bias in consumer price indexes in five categories:

- substitution bias
- elementary index bias
- outlet substitution bias
- quality adjustment bias
- new goods bias.

7.4.1 Substitution Bias

Substitution bias is the difference between a superlative index number formula (such as the Fisher or Törnqvist discussed in appendix A) which allows the basket to change as prices change and the fixed basket Laspeyres formula which is the basis for the CPI. This substitution bias is usually computed at higher levels of aggregation, say at the level of 10 to 200 major commodity groupings. However, the bias estimates produced by Aizcorbe and Jackman (1993) and Shapiro and Wilcox (1997) for the US used 207 commodities for 44 US regions or 9108 commodities in all. The estimates of Manser and McDonald (1988), Balk (1990; 82), Aizcorbe and Jackman (1993) and Shapiro and Wilcox (1997) suggest that this upper level substitution bias adds about 0.2 to 0.3 of a percentage point to the 'typical' CPI

⁴ Recent studies which provide overviews of the bias literature include Dalén (1992; 1998), Gordon (1993), Crawford (1993; 1998), Lebow, Roberts and Stockton (1994), Silver and Ioannidis (1994), Diewert (1995a,b; 1996a,c; 1998), Oulton (1995; 1998), Armknecht (1996), Boskin, Dulberger, Gordon, Griliches and Jorgenson (1996; 1998), Cunningham (1996), Moulton (1996), Shapiro and Wilcox (1996; 1997), Wynne and Sigalla (1996), Lequiller (1997), Moulton and Moses (1997), Reinsdorf and Moulton (1997), Abraham, Greenlees and Moulton (1998), Hoffmann (1998) and various papers and comments in the May 1997 issue of the *American Economic Review*.

per year. Hoffmann (1998, p.32), on the other hand, finds that the German upper level substitution bias is only about 0.05 to 0.1 percentage points per year. However, Hoffmann's study was done at a relatively high level of aggregation and there is reason to expect the bias to increase as the degree of disaggregation increases.

7.4.2 Elementary Index Bias

Elementary index bias arises from the use of an inappropriate method for aggregating price quotes at the lowest level of aggregation. It can be regarded as the microeconomic counterpart to the substitution bias that occurs at the higher level of aggregation.

Traditionally, statistical agencies have aggregated up price quotes at the lowest level of aggregation using either the Carli formula (an arithmetic average of the ratios of the price quotes pertaining to two situations with current period prices in the numerator and base period prices in the denominators of the ratios) or the Dutot formula (an arithmetic average of the current period price quotes divided by the arithmetic average of the corresponding base period quotes for the stratum under consideration). The use of the Carli formula will lead to a definite upward bias⁵ in the elementary price index, a bias that the Dutot formula does not possess. Irving Fisher commented on the widespread use of the Carli formula by statistical agencies as follows:

“In fields other than index numbers it is often the best form of average to use. But we shall see that the simple arithmetic average produces one of the very worst of index numbers. And if this book has no other effect than to lead to the total abandonment of the simple arithmetic type of index number, it will have served a useful purpose.” Fisher (1922, pp.29–30)

Unfortunately, Fisher's plea was not heeded until relatively recently and the harmonized system price indexes recently introduced by European Union member countries prohibits the use of the Carli formula. Another elementary index number formula that has been used recently by both Statistics Canada and the US Bureau of Labor Statistics is the Jevons formula (which is the geometric mean of the price ratios in place of the arithmetic mean used in the Carli formula). Since a geometric mean is always less than the corresponding arithmetic mean (unless all prices move in strict proportion over time), it can be seen that the use of the Jevons formula in place of the Carli formula will lead to lower CPI component inflation rates and hence to a lower overall CPI inflation rate. For a discussion on the economic and axiomatic properties of the various elementary index number formulae in general use today, see Dalén (1992) and Diewert (1995a).

⁵ Fisher (1922; 66 and 383) showed that the Carli index failed the *time reversal test*; ie, if we compute the elementary price index going from period 0 to 1 using the Carli formula and then compute the index going from period 1 back to period 0, we end up at a higher level of prices than we started with unless all prices move proportionally over time.

With respect to numerical estimates of the likely size of elementary index bias, there is no consensus. The work of Reinsdorf (1993; 1998) and Reinsdorf and Moulton (1997) suggests that elementary index bias added about 0.35 to 0.5 of a percentage point per year to the US CPI in the period 1978–1995. In recent years, there have been a number of studies using *scanner data*; ie, detailed data on the sales, price and quantities of a scanner coded commodity in a market area. The use of these very detailed data enable the researcher to either calculate a unit value (ie, a market wide average price for the commodity for a time period) for a specific commodity or to evaluate a superlative index number for a group of closely related commodities (eg, brands of coffee sold in a market area). Then the unit values or superlative indexes can be compared to the corresponding official component of the CPI. Diewert described the methodology as follows⁶:

“Due to the computer revolution, it is now possible to undertake some experiments which could help to determine the extent of the substitution bias. Retail outlets that have computerised price and quantity information on their sales could be sampled. Detailed microeconomic price and quantity vectors p^i and q^i could be constructed and the Laspeyres, Paasche and Fisher indexes defined by (2)-(4) above could be calculated and compared with corresponding official consumer or producer price indexes that covered the same range of goods. Such firm oriented experiments could provide useful information on the size of the substitution bias.” Diewert (1993a, p.59).

Some of the annual bias estimates that have emerged, in percentage points per year, are:

- 3.0%; pharmaceutical preparations (drugs) in the US; Berndt, Griliches and Rosett (1993)
- 1.1% ; television sets in the UK; Silver (1995)
- 0.8%; chocolate bars in France; Saglio (1995)
- 0.4%; 29 food groups in France; Saglio (1995)
- 1.5%; coffee in the US; Reinsdorf (1996)
- 4.5%; ketchup (tomato sauce), toilet tissue, milk and tuna in the US; Bradley, Cook, Leaver and Moulton (1997)
- 1.0%; fats, detergents, frozen fish and breakfast cereals in Sweden; Dalén (1997)
- 1.0%; coffee in the Netherlands; de Haan and Opperdoes (1997)
- 3.0%; coffee in the US; Hawkes (1997).

⁶ Diewert tried to interest Statistics Canada in scanner data studies for the past decade but with no success until recently when other agencies started to undertake research in this area.

It should be noted that for most of the above studies, the annual upward bias in the corresponding official CPI component is a combination of elementary index bias and outlet substitution bias, which will be considered in the next section. The above bias estimates are disconcertingly high. If there were only one or two studies that found such high biases, they could be dismissed as being unrepresentative but as more studies are done and they *all* find bias, there is cause for concern. Possible explanations for this rather consistent pattern of substantial bias include:

- Statistical agency sampling techniques are somehow not representative (or, alternatively, the commodities chosen for scanner data studies are not representative).
- The bias is caused by outlet substitution bias; ie, statistical agencies price commodities from an outlet sampling frame that overweights traditional higher cost outlets and underweights innovative new discount outlets. Over time, as sales in the traditional outlets decline relative to the new outlets, the prices collected by the statistical agency become less representative.
- Consumers are purchasing an increasing proportion of their goods and services *on sale*. Many statistical agencies instruct their price collectors to *ignore* sale prices and thus again, the prices collected are not representative of average transaction prices.

Further research is clearly required in this area.

7.4.3 Outlet Substitution Bias

As noted above, *outlet substitution bias* is the bias that occurs when consumers shift their purchases from high cost outlets to lower cost outlets for the same commodity. Bias in CPI components occurs due to the following phenomenon. When the statistical agency notices a new outlet and adds it to its sampling frame, the first period price quote that is collected from the discount outlet is ignored in the computation of the index for that first period. When the second period quote from the discount outlet is available, the new outlet price ratio for the past two periods is averaged together with the price ratios from the existing outlets. Thus, any absolute drop in the price of the new outlet compared to existing outlets in the sample is *ignored*. This leads to outlet substitution bias.

Traditional index number theory dismissed the possibility of significant outlet substitution bias because it was argued that consumers would arbitrage across outlets and the outlet specific prices for the same commodity would reflect their quality, taking the service and location characteristics into account. As a long run proposition, the traditional view seems satisfactory. However, in the rapidly changing economy of today, it may be several years before a typical consumer discovers that prices are indeed lower in a discount outlet than the prices for the same commodities in the traditional outlet. Thus, the traditional outlet can hang on for years until declining market share forces it into bankruptcy. In the meantime, there is a

danger that the price collector will continue to sample the relatively high prices in the traditional outlet and the lower prices in the discount outlet will be missed.

The studies referred to in the previous subsection could be viewed as having some relevance to the possible size of outlet substitution bias. An additional study is Reinsdorf (1993), who compared the prices of incoming and outgoing samples and he obtained an upward bias of 0.25 percentage points per year in the US for food and gasoline. Crawford's (1993) estimate for the maximum amount of outlet substitution bias in Canada was about 0.08 per cent per year. Cunningham's estimates for the UK lie in the 0.08 to 0.25 per cent per year range. Finally, White's (1999) estimates for Canada were in the 0.2 to 0.7 per cent per year range. The commodities that White studied were: audio equipment, other household equipment (ie, small household appliances), and nonprescribed medicines. The discount stores in White's sample had average prices about 20 per cent below their traditional counterparts but White also found that the discount outlets tended to do better over time; ie, their prices increased less rapidly over time than their traditional rivals. Thus, not only did the discounters have an initial absolute price advantage, but this price advantage *widened* over time. It is important that statistical agencies adjust their outlet sampling frames to keep pace with the emergence of new outlets.

7.4.4 Quality Adjustment Bias

Quality adjustment bias or *linking bias* is the bias that can occur when the statistical agency replaces an older model or variety of a commodity by a newer one. For instance, suppose that a new model of a video camera appears on the market. Assume that the statistical agency collects a price quote for the new camera. This first period price quote for the new camera is ignored in the computation of the relevant CPI component index for that first period. When a second period quote for the new camera is collected, the new camera price ratio for the past two periods is averaged together with the price ratios for older model cameras. Thus any absolute drop in the quality adjusted price of the new camera compared to the older model cameras in the sample is *ignored* and this leads to a bias in the index. This source of bias was recognised by Griliches (1979, p.97) and Gordon (1981, pp.130–133; 1993) and is entirely analogous to outlet substitution bias in its mechanics.

One method for controlling for this type of bias is to undertake a *hedonic regression study*. This technique was pioneered by Court (1939) and Griliches (1971). Basically the technique works as follows. The researcher defines a set of relevant model characteristics, say x , y , z are the three relevant characteristics that define a video camera or camcorder. For example, x might be the zoom factor (a number between 6 and 100), y might be a dummy variable ($y = 0$ if the camera has a black and white viewfinder, $y = 1$ if it has a colour viewfinder) and z might be another dummy variable ($z = 0$ if the camera has no built in viewing screen and $z =$

1 if it has one). Now information on the prices of camcorders at period t and their characteristics are collected; ie, let $p(t, x^j, y^j, z^j)$ be the price of model j at time t . Then a regression something like the following one is run:

$$(1) \quad \log p(t, x^j, y^j, z^j) = \alpha^t + \beta x^j + \gamma y^j + \delta z^j + \text{error}; \quad t = 1, \dots, T; \quad j = 1, 2, \dots, J$$

where J is the number of models in the sample and T is the number of periods in the sample. Note that we have taken the logarithm of the price. This is done so that the sequence of exponentiated time dummies, $\exp[\alpha^1], \dots, \exp[\alpha^T]$, can be interpreted as a sequence of quality adjusted average prices for camcorders for periods $1, \dots, T$. Running the regression in this form ensures that the quality adjustment coefficients β, γ, δ are invariant to the amount of general inflation in each period. This is how the hedonic regression technique works in a nutshell. Nicholson describes the procedure in words as follows:

“Most commodities, including the very simplest, have numerous aspects which satisfy different needs and tastes. Durability, appearance, size, comfort, efficiency, convenience, conditions of sale, various technical characteristics – these and other features can affect the prices of different grades and qualities. If we can distinguish the various characteristics and if we know the prices of the different qualities available at a particular date, it should be possible by fitting an appropriate form of regression equation to find out how much of the price is associated with each characteristic, and the variations in price which are associated with variations in any measurable characteristic. ... We could then see how much of any apparent change in price was explained by a difference in quality and how much was a genuine change in price.”
Nicholson (1967, p.515).

Obviously, there are some problems with the procedure, including the following ones:

- Is (1) the ‘right’ functional form for the hedonic regression?
- Are all of the relevant characteristics included?
- How do we avoid multicollinearity and ‘wrong sign’ problems?
- Are the characteristic coefficients β, γ, δ stable over time? How do we deal with new characteristics?
- Should each model be weighted by its sales in the period? More generally, what is the appropriate stochastic specification for the model (1)?
- Is the hedonic method *reproducible*; ie, if two different econometricians were given the same data set, would they come up with the same results?

In spite of the above difficulties (expanded upon by Hoffmann (1998, pp.57–69)), the hedonic method of making quality adjustments is still the best tool that we have at present.

It should be mentioned that hedonic studies do not have to involve regression analysis. Nordhaus (1997) undertook a study that looked at the various methods *light*, or more accurately, *lumens*, were delivered to households by since the days of the invention of fire. Thus, burning wood for illumination was replaced by candles, which in turn were replaced by gas lamps and kerosene lamps, which in turn were replaced by electricity and primitive light bulbs, etc. Nordhaus found some remarkable drops in the price of lumens, drops that were not picked up by the price indexes of the time. Returning to the hedonic model described above, it can be seen that the different delivery mechanisms for light could be regarded as ‘models’. The main characteristic that each ‘model’ has in common is the amount of lumens that it delivers.⁷

A host of hedonic regressions have been run in the last 10 years. A few representative estimates of the amount of upward bias found in the corresponding CPI component in percentage points per year are:

- 24.4%; personal computers in Japan (actually, they are not present in the Japanese CPI); Shiratsuka (1995a)
- 0.5%; automobiles in Japan; Shiratsuka (1995b)
- 5.6%; camcorders in Japan; Shiratsuka (1998)
- 3.0%; television sets in the US; Moulton, Lafleur and Moses (1997)
- 1.0% to 2.5%; washing machines in Germany; Hoffman (1998)
- 0 to 1.5%; refrigerators in Germany; Hoffmann (1998)
- –0.8% to 0.4%; freezers in Germany; Hoffman (1998) (thus in this case, the CPI component may have a downward bias instead of an upward one)
- 5.0% to 23%; portable CD players; preliminary BLS research
- 5.0% to 10%; television sets in Canada; preliminary Statistics Canada research.

There are some rather large bias numbers listed above. As was the case with scanner data studies, the above numbers may not be representative. However, the above numbers are cause for concern about the accuracy of the typical CPI.

It is not appropriate to ‘blame’ statistical agencies for not undertaking more quality adjustment for their price statistics. The problem is that hedonic studies are expensive to undertake and governments and the general public have not been sufficiently aware of these measurement problems to allocate additional funds to statistical agencies to address these problems.

⁷ Nicholson (1967; 525-526) had an analysis analogous to that of Nordhaus for *heat* rather than *light*. However, Nicholson did not provide any empirical estimates for the bias in the price of heat.

7.4.5 New Goods Bias

Hill and Diewert describe this source of bias as follows:

“In general, it may be concluded that in the real world, price indices which are inevitably restricted to commodities found in both situations will fail to capture the improvement of welfare associated with an enlargement of the set of consumption possibilities. The benefits brought by the introduction of new goods are not generally taken into account in price indices in the period in which the goods first make their appearance.” Hill (1988, p.138)

“During the past three decades, the number of commodities that consumers can purchase has increased enormously; supermarkets have steadily increased the number of products that they offer each year; large specialty warehouse stores have sprung up that offer tremendous numbers of related commodities for sale; video rental markets have sprung up; cablevision offers increased channels; etc. However, traditional index number theory makes no allowance for this large expansion in consumers' choice sets.” Diewert (1995b, p.116).

It is difficult to quantify precisely how much of an increase in choice sets has occurred in recent years but Diewert offers the following observations:

“Some general evidence comes from two sources. The first is the A.C. Nielsen scanner data base. William Hawkes has informed me that the number of U.S. Universal Product Codes has grown from 950,000 in January 1990 to 1,650,000 in September 1995. Some of this increase in products is simply a market penetration phenomenon: more and more manufacturers are coding their commodities. However, a substantial fraction of the above increase in codes has to represent a genuine increase in consumers' choice sets. A second general source of evidence on the magnitude of the new products problem comes from the records of the BLS itself: each month, approximately 3 percent of the price quotes of the previous month simply disappear. A substantial fraction of these missing quotes is probably due to temporary inventory shortages and other factors, but surely a substantial fraction must be due to the replacement of old goods by newer goods.” Diewert (1996c, p. 33)

Hicks (1940, p.114) suggested a methodology for adapting traditional index number theory that could in theory be used to capture the benefits of an increased choice set. Diewert describes the Hicksian methodology as follows:

“From the viewpoint of the microeconomic approach to index number theory, Hicks (1940) provided a formal solution to this new good problem: if we are in the consumer context, p_1^N [the imputed price of the new good in period 1 which is the period prior to its introduction in the marketplace] should be the price which would just make the consumer's demand for good N in period 1 equal to zero. The practical problem is that this shadow price is not observable: we require a knowledge of the consumer's indifference surfaces to calculate it. Of course, econometric techniques could be used to estimate these shadow prices (see Diewert (1980) for an example of such a technique in the producer context), but most index number practitioners will find it inconvenient to resort to econometrics. In practice, most official indexes ignore the existence of new goods.” Diewert (1987, p.779).

Eventually, when a new commodity becomes important enough, statistical agencies will ‘discover’ it and introduce the commodity into their CPI basket. However, the price of a new commodity will generally be high at its initial introduction to the market and then trend down over time. The late introduction of the new commodity into the CPI basket means that all of this product cycle decline in price has been missed. Diewert (1987, p.779) provided a few back of the envelop calculations to illustrate the possible magnitude of the upward bias induced by a late introduction of a new commodity to the CPI basket.

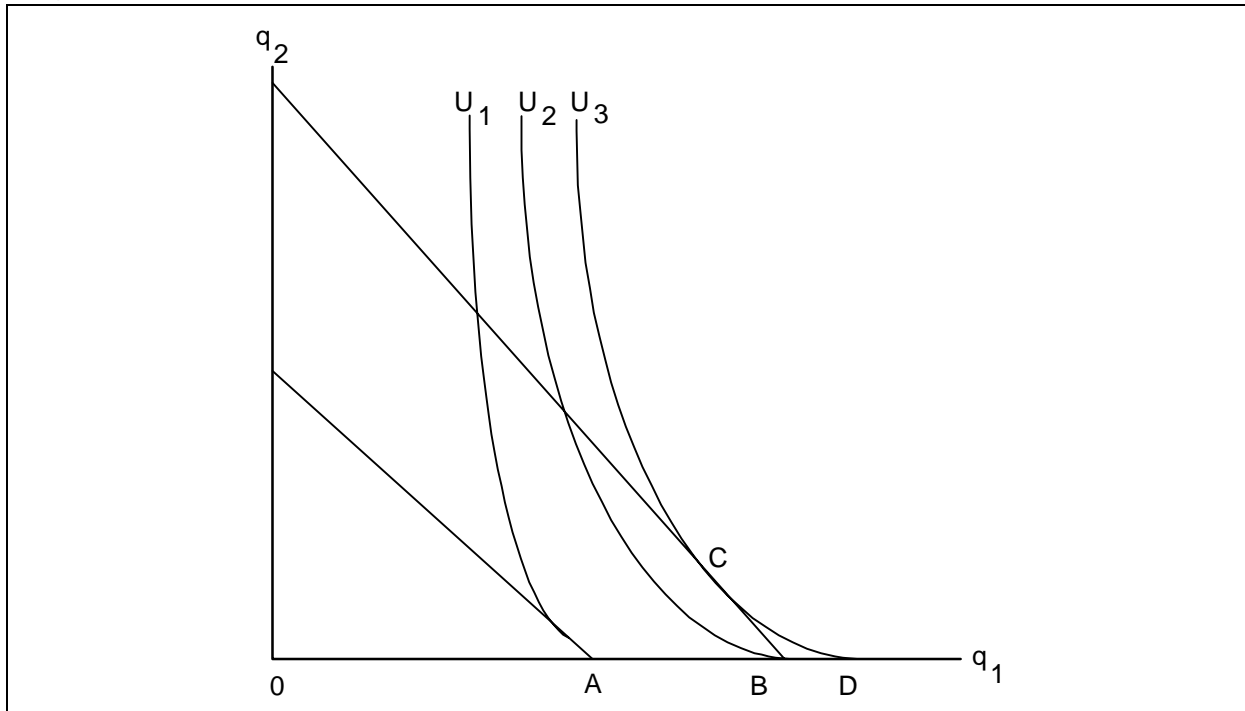
Figure 7.1 provides a diagrammatic exposition of the Hicksian new good methodology as presented by Diewert (1996c, p.32)

The consumer is assumed to have preferences defined over existing goods (the horizontal axis) and a new commodity (the vertical axis) whose quantity consumed is denoted by q_2 . Three representative indifference curves are labelled by u_1 , u_2 , and u_3 . In period 1, before the new product is introduced, the consumer is at point A and consumes q_1^1 units of the “old” good at price p_1^1 . We have drawn in an imaginary budget line which is just tangent to the u_1 indifference curve at the point A. The slope of this budget line is $-p_1^1/p_2^1$ where p_2^1 is the *shadow price* or *reservation price* of the new commodity that would just induce the consumer to purchase 0 units of the new product *if it were available during period 1*. In period 2, the new commodity is available in the marketplace and the consumer faces the budget constraint :

$$(2) \quad p_1^2 q_1 + p_2^2 q_2 = \text{Income in period 2.}$$

The highest utility level, u_3 , which the consumer can achieve in period 2 is attained at the point C. Note that the increase in utility going from period 1 to 2 and measured in terms of the 'old' good is the distance AD.

Figure 7.1 The Hicksian Approach to New Goods



Now consider how typical statistical agency practice will deal with the introduction of the new commodity. In effect, the new commodity will be valued in terms of the 'old' commodity at the period 2 price ratio, p_1^2/p_2^2 , which means that the statistical agency estimate of the utility increase will be the distance AB in terms of the 'old' commodity. Thus the increase in consumer surplus provided by the introduction of the new commodity, the distance BC, will be missed. Put another way, the 'official' Laspeyres price index, $P_L \equiv p_1^2/p_1^1$, will be too high compared to the Paasche price index, P_p , defined as:

$$(3) \quad P_p \equiv [p_1^2 q_1^2 + p_2^2 q_2^2] / [p_1^1 q_1^2 + p_2^1 q_2^2].$$

The 'official' index P_L will also be too high compared to the superlative Fisher ideal index P_F defined as:

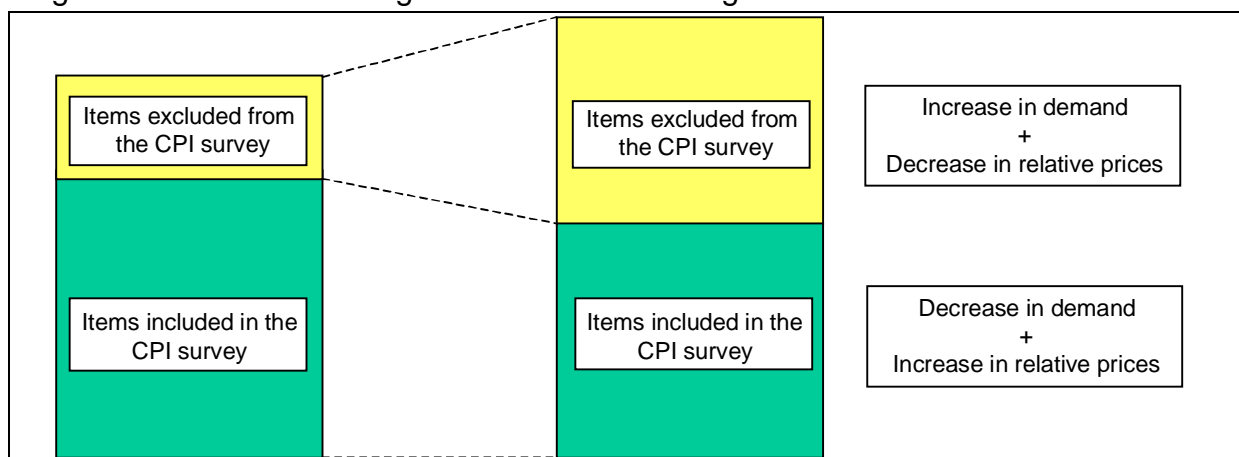
$$(4) \quad P_F \equiv [P_L P_p]^{1/2}.$$

If consumer expenditures were deflated by the Fisher price index defined by (4) above instead of the Laspeyres index P_L , we would obtain a reasonably close approximation to the true utility ratio, OD divided by OA, instead of the underestimated ratio, OB divided by OA. The problem with this suggestion is that the statistical agency *cannot evaluate the Paasche and Fisher indexes without a knowledge of the period 1 imputed price for the new commodity, p_2^1 .*

The estimation of reservation prices is likely to be a somewhat resource intensive exercise which explains why statistical agencies have not yet pursued this option.

There have not been many empirical applications of the Hicksian new goods methodology. Trajtenberg (1990) measured reservation prices for computer assisted tomography (CAT) scanners over the decade 1973–1982. His nominal price index went from 100 to 259 but his quality adjusted price index went from 100 to 7, implying a 55 per cent drop in quality adjusted prices per year on average. Hausman (1997a) used Nielsen scanner data from January 1990 to August 1992 on cereal consumption for 7 major metropolitan areas in the US. He used econometric techniques to estimate consumer preferences over cereals and thus he was able to estimate the Hicksian reservation prices that would cause consumers to demand zero units of a new brand of cereal. His conclusion was that an overall price index for cereals, which excluded the beneficial effects of new brands, would overstate the true cost of living subindex for cereals by about 25 per cent over a 10 year period. Finally, Hausman (1997b) makes some rough estimates of the bias involved in the omission of cellular telephone services in the US CPI. He finds that a substantial bias results from this omission. Hausman's approximate method for inferring the benefits of new products deserves a careful examination since it does not appear to be too resource intensive and thus might be a practical method for statistical agencies to use.

Figure 7.2 Shiratsuka's Argument on CPI Coverage



Shiratsuka (1998) used a diagram (reproduced as figure 7.2) which illustrates the cumulative effects of ignoring all of the little consumer surplus gains of the form BD in figure 7.1. Shiratsuka argues that the effect of a static CPI basket is that the statistical agency is collecting price information on continuing 'old' commodities, which consumers are revealing to be *inferior to the new commodities that they are switching to*. Hence, the agency misses the decline in quality adjusted prices that has induced consumers to shift from the old basket to the new.

The same point was made in words many years ago by Nicholson:

“We might be inclined to assume that the difference in quality is measured by the relative prices during the period when both the old and the new qualities are being bought in substantial quantities by different groups of people covered by the index. But the new quality, when it is first purchased, must ipso facto be preferred at the prevailing prices to the previous quality. The difference in the nominal price will therefore understate the effective increase in real income and consumption in such cases. Over the years there must have been many quality changes of this kind. In order to measure the effective increase in real income resulting from such substitutions, it would be necessary to have much more information than exists at present about elasticities of substitution between different items. But the fact that no attempt is usually made to incorporate this effect must tend to produce a downward bias in index numbers of real income and output.” Nicholson (1967, p.314).

7.4.6 Bias in the New Zealand CPI

Is the New Zealand CPI subject to the above five types of bias? If so, is it possible to provide accurate quantitative estimates for these sources of bias? Our answer to the first question is a “yes” but our answer to the second question is “no”.

Since the New Zealand CPI is based on the standard Laspeyres type fixed basket index number concept, it will be subject to the usual biases that these indexes possess. Even though it is not possible to provide accurate estimates of the amount of bias in each category⁸, we will make a few remarks on the possible size of the biases for New Zealand.

According to Morris (1997, p.25), Statistics New Zealand uses the Dutot formula to aggregate price quotes at the lowest level of aggregation. Hence, *elementary index bias* in the New Zealand CPI should be zero or minimal. However, Morris also indicates that at higher levels of aggregation, the Carli formula is used so there will be some *substitution bias* in the New Zealand CPI. Figure 4.7 in chapter 4 above indicated that there was very little difference between the Fisher ideal output price index and a fixed base Laspeyres price index. Thus substitution bias at the very highest level of aggregation is probably only about 0.05 per cent per year. However, substitution bias at levels between the elementary level and the very highest level of aggregation might add another 0.1 per cent per year of upward bias to the New Zealand CPI.

⁸ As of 1997, no assessment of the magnitude of the various sources of bias had been made for New Zealand; see Morris (1997, p. 27)

It should be noted that substitution bias, both at the elementary level as well as at higher levels of aggregation, is quite controllable using the methodology developed by Shapiro and Wilcox (1997), which is based on the use of the Lloyd-Moulton index number formula.⁹ This index number formula uses the same information that is required to construct the Laspeyres index (namely, base period expenditure shares, base period prices and current period prices) and also requires an estimate of the elasticity of substitution between the commodities being aggregated. This elasticity can be estimated using historical data and then a substitution bias free index can be produced using normal statistical agency techniques.

Turning now to *outlet substitution bias*, relatively little is known about its magnitude in New Zealand. The amount of this bias depends on the degree of retail competition in New Zealand and the propensity of New Zealanders to search for the lowest price. What is required is some scanner data studies that would cast some light on this issue. As we noted in section 7.4.3 above, scanner data studies in a wide variety of countries have uncovered rather large biases. We have no reason to expect the situation in New Zealand to be any different so we would expect that the bias in the CPI might be of the order of 0.25 per cent per year.

Quality adjustment bias in New Zealand is surely similar to the range of biases estimated in other countries; New Zealanders consume video cameras, television sets, home computers, cell phones, new drugs and other rapidly evolving goods and services just like everyone else in the developed world. As we saw in section 7.4.4 above, hedonic studies done on some of these high technology commodities have found large biases associated with these commodities. The following quotation from a Statistics New Zealand statistician indicates that SNZ does undertake quality change studies:

“Where it is possible to do so, quality change is identified and accounted for in the measurement of price change. The methods used to do this are equivalent to those of similar overseas statistical agencies. New methods of evaluating quality are always under consideration.” John Morris (1997, p.50).

It would be desirable for Statistics New Zealand to make public its quality change studies. We are somewhat sceptical that SNZ has the quantity of resources available to undertake much in the way of quality change studies. The problem is that hedonic regression studies and other quality adjustment methods tend to be quite resource intensive. Consider the following examples where it would be useful to do quality change studies:

- internet mail as a substitute for regular mail;
- stock market trading on the internet as opposed to regular brokerage house trading;

⁹ See Diewert (1997)(1998) for discussions of this methodology.

- shopping for books, compact disks, cheap airline fares, computers, etc on the internet; and
- cellular phones as substitutes for regular phones.

In each of the above cases, a 'new' good or service is replacing or augmenting an existing good or service but *it is very difficult to obtain an 'objective' quality adjustment* for the new service. Thus, not only will the quality adjustment process be costly for the statistical agency, but also by undertaking such studies, the agency could be open to criticisms that it is not being 'objective' in its quality adjustments. Hence, the simplest thing to do is to do nothing! However, this means that the official statistics eventually run the risk of becoming irrelevant.

Our guesstimate for the combined size of the *quality adjustment* and *new goods bias* for the New Zealand CPI is in the range of about 0.35 to 0.6 per cent per year.

Combining the above very rough and ready estimates of bias gives a range of upward bias in the New Zealand CPI of about 0.65 to 1.0 percentage points per year.

What are the implications of possible upward bias in the CPI for New Zealand's productivity performance? If the CPI has an upward bias in the 0.65 to 1.0 per cent per year range in recent years, then the growth in household consumption is 0.65 to 1.0 per cent per year greater than is measured in the official statistics. This bias means that market sector TFP is perhaps 0.4 to 0.7 per cent per year higher than we have estimated.

The interesting question is whether this CPI bias has increased over time. The five sources of bias that we noted above have been present for a long time. However, we think it is likely that quality change and new goods bias has increased in recent years for two reasons:

- the pace of new product introductions and quality improvements has probably accelerated in recent years with increased technological change; and
- the reforms that New Zealand has undertaken in the last decade have led to reductions in tariffs and import restrictions and have perhaps dramatically increased New Zealanders' choice sets.

Statistics New Zealand recognises that some of the above sources of bias in its CPI could be reduced if more resources were made available:

“There is more that can be done to limit biases. However, the value of any new measures must be assessed against the extra cost of these additional measures and the impact that any new measures would have on the index. The value to New Zealand of managing CPI bias has to be seen in the context of the opportunity cost from the loss of existing statistics, given that funding is generally unavailable for improving official statistics in New Zealand.” John Morris (1997, p.38).

However, Statistics New Zealand is unlikely to obtain additional funding to improve its measurement of important trends in the economy if it claims that measurement problems are not serious. We believe that measurement problems *are* serious and, hence, it is important for the general public to be aware of these problems so that an informed choice can be made as to whether increased funding should be provided to Statistics New Zealand to address this issue.

We turn now to a brief discussion of the problems involved in measuring the outputs of certain service sector industries.

7.5 Interest and the Measurement of Financial Sector Output

Over the years, there has been tremendous controversy in the System of National Accounts on how to measure properly the outputs of the banking and financial sectors. In a recent paper, Fixler and Zieschang describe the situation as follows:

“Measurement of output for services in general, and for financial services in particular, has been seen as a challenge by economic data providers and users alike. In the context of the national accounts, financial services has traditionally been a controversial area principally because there is a significant component of these services for which payment is made implicitly through the spread between the asset interest earned and liability interest paid by financial institutions. Although it is reasonably clear that the total value of output of financial institutions include the net interest income on financial asset and liability products (such as loans and deposits for banks) plus explicit service charges, the correct allocation of the net interest component across the consuming sectors of the economy—business (intermediate consumers), households, government, and the rest of the world (final consumers)—has not been so well understood.” Fixler and Zieschang (1999, p.1).

Fixler and Zieschang (1991; 1992a,b) have been on the forefront of developments in measuring the output of the financial sector and in their recent paper, Fixler and Zieschang (1999), they present a very clear framework for measuring the output of the financial sector and apply their model to the US financial sector.

The key to an appropriate measure of banking output is the concept of user cost or user benefit (see appendices A and D which discuss the user cost concept applied to durable capital inputs). The user cost (or benefit) of a financial asset or liability is constructed along exactly the same lines. Thus, consider the case of a bank which at the beginning of an accounting period has deposits D and loans L . We construct the net user benefit of a financial asset or liability by looking at the discounted stream of inflows and outflows of funds associated with the financial instrument.

The net benefit to a bank of a deposit can be calculated as follows. A positive item is the inflow of funds D at the beginning of the period but this is offset by the discounted end of the period net outflow of D (conceptually deposits are “returned” to the bank’s customers) plus the interest paid out to depositors at the end of the period, $r_D D$, (where r_D is the interest rate on deposits). However, a positive inflow also occurs at the end of the period; namely any service charges $s_D D$ that the bank is able to charge its depositors (where s_D is the service charge rate on deposits). If we discount the end of the period flows by the discount rate ρ , then the discounted *net benefit* to the bank of rendering deposit services is:

$$(5) \quad D - [(1 + r_D - s_D)D/(1 + \rho)] = [\rho - r_D + s_D]D/(1 + \rho).$$

In a similar fashion, we can work out the net benefit to a bank of a loan. At the beginning of the period, there is an outflow of funds equal to L to the borrower. But this is offset by the discounted end of the period inflow of funds L (when the loan is repaid) plus the interest paid by the borrower to the bank, $r_L L$ (where r_L is the interest rate on loans which is typically much higher than r_D). Another positive inflow at the end of the period is any service charges, $s_L L$, which the bank manages to extract from its borrowers. However, a negative outflow also occurs at the end of the period – namely the provision for loan losses, δL . If we discount the end of the period flows by the discount rate ρ , then the discounted *net benefit* to the bank of rendering loan services is:

$$(6) \quad -L + [(1 + r_L + s_L - \delta)L/(1 + \rho)] = [r_L + s_L - \delta - \rho]L/(1 + \rho).$$

Dropping D and L from the right hand sides of (5) and (6) yields formulae for the user benefits of a deposit or loan from the viewpoint of the level of prices at the beginning of the period. If we multiply these user benefit terms by $(1 + \rho)$, we then obtain the following end of the period net benefit user prices (or the negative of user costs):

$$(7) \quad \text{net benefit of deposits (negative of the user cost of deposits)} = [\rho - r_D + s_D];$$

$$(8) \quad \text{net benefit of loans (negative of the user cost of deposits)} = [r_L + s_L - \delta - \rho].$$

The scalar variable ρ is the Barnett (1978; 1980) *benchmark rate*, or the Hancock (1985) *opportunity cost rate of money*, or the *System of National Accounts 1993's reference rate*. Fixler and Zieschang (1999) have an extensive discussion on how this rate can be determined. The user cost formulae defined by (7) and (8) are the Hancock (1985) user costs for a financial firm; if (7) or (8) are positive, then the corresponding financial assets are outputs of the sector and if they are negative, then the corresponding financial assets are inputs into the sector.¹⁰

¹⁰ These financial firm user costs are related to the user cost of money derived by Donovan (1978) and Barnett (1978; 1980). Diewert (1974c) made an early attempt to derive a user cost of money. Our derivation above has neglected the role of reserve requirements.

Fixler and Zieschang note that the new System of National Accounts does recognise a user cost principle for the output of the financial sector:

“By and large, the input side of financial services business is as straightforward as for any other sector, characterized by purchases of primary factor services from the owners of labor and capital and purchases of produced goods and services from other business sectors. The sole exception to this is the consumption of financial services for own use, or by other establishments in the same sector, which is subject to the same measurement issues as output.”

“Fixler and Zieschang (1991) discussed these issues in some detail, and provided background on the treatment of financial business in the national accounts historically. More recently, a consortium comprising the United Nations, the World Bank, the International Monetary Fund, the Organization for Economic Cooperation and Development, and the European Statistical Agency issued an updated international standard system of national accounts. The System of National Accounts 1993 (SNA93) recommends, as a first option, the calculation of imputed sectoral uses of financial services—termed Financial Intermediation Services Indirectly Measured or FISIM—according to a user cost principle.” Fixler and Zieschang (1999, p.1).

Finally, Fixler and Zieschang provide some evidence that the user cost approach to measuring banking output yields a much higher rate of output growth:

“However, the evidence we have accumulated so far suggests that the existing bank output measures for the U.S. are understating output growth. From 1987 to 1994, growth in real GDP for depository institutions from official data sources was –8.6 percent, while the gross output series in Table 2 of this paper grew by 35.4 percent.” Fixler and Zieschang (1999, p.20).

We have no reason to doubt that the situation in New Zealand would be similar; ie, a user cost approach to measuring banking output would likely lead to a much faster rate of growth of financial sector output.

One final note on the Finance sector in New Zealand. It is likely that the Finance sector is presently the repository of most of the leased structures and capital equipment in New Zealand. It is not clear to us that all of the leasing revenues have been included in the output of this sector. Moreover, it is almost certainly the case that a proper deflation of the leasing revenues has not been done. As we mentioned above in section 7.2.2, the input–output framework will have to be expanded to deal with the intersectoral flows of leased capital.

We turn now to a brief discussion of measurement problems in margin industries.

7.6 The Measurement of Outputs in Margin Industries

Margin type industries essentially purchase a commodity, add some value to it, and sell it. Industries that are of this type include:

- Electricity, gas and water distribution
- Storage (commodities can be thought of as being purchased at one point in time and sold at another)
- Wholesale trade
- Retail trade
- Transportation (commodities can be thought of as being purchased at one location and sold at another)
- Finance (money is purchased at one price and sold as loans at a higher price)
- Real estate (property can be thought of as being purchased by the agent at a low price and sold at a higher price).

For most of these industries¹¹, Statistics New Zealand (1996, pp.27–28) uses what they call single indicator output measures to construct estimates of real output by industry. We explain what is meant by this as follows. Suppose the real output of an industry is y^t in year t and the corresponding measure of real intermediate input is x^t in year t for $t = 0, 1, \dots, T$. With an appropriate choice of units¹², the *real value added* v^t in industry in year t can be defined by the usual double deflation method as:

$$(9) \quad v^t \equiv y^t - x^t \quad \text{for } t = 0, 1, \dots, T.$$

Since Statistics New Zealand is unable to construct proper deflators for the nominal value of intermediate input demand, base period value added is projected forward using either the rate of growth of real gross output or an approximation to this growth rate. Thus, the measure of industry real value added that Statistics New Zealand actually constructs is the following *approximate measure* a^t :

¹¹ The exceptions are in electricity and gas distribution and in parts of the transportation sector where double deflation is used to construct real value added output measures.

¹² Typically we define real value added in the base period v^0 to be equal to the nominal value added in that period. Our treatment of real value added is simplified in this section. Our preferred method for constructing real value added would involve the use of the Fisher ideal index number formula to aggregate y^t and x^t instead of the simple subtraction method defined by (9).

$$(10) \quad a^t \equiv [y^0 - x^0][y^t/y^0] \text{ for } t = 1, \dots, T.$$

Thus, the base period nominal real value added, $y^0 - x^0$, is projected forward using the rate of growth of real gross outputs, y^t/y^0 . The question is: how does the approximate real output measure a^t compare to the theoretically more appropriate measure v^t defined by (9) above?

It seems plausible to us that most of these margin industries would be subject to some degree of technical progress; ie, over time, the industry's partial productivity y^t/x^t should be improving as the industry discovers new value added products and minimises its use of the initial period mix of intermediate inputs as new products and techniques emerge. Thus, we hypothesise that:

$$(11) \quad y^t/x^t > y^0/x^0 \text{ for } t = 1, \dots, T.$$

The inequalities in (11) can be rearranged to yield the following inequalities:

$$(12) \quad -x^0/y^0 < -x^t/y^t \text{ for } t = 1, \dots, T.$$

Now return to the approximate measure of industry output for period t defined by (10). We have:

$$\begin{aligned} (13) \quad a^t &\equiv [y^0 - x^0][y^t/y^0] \\ &= y^t - [x^0/y^0]y^t \\ &< y^t - [x^t/y^t]y^t && \text{using (12)} \\ &= y^t - x^t \\ &\equiv v^t && \text{using definition (9).} \end{aligned}$$

Thus, under our hypotheses, the Statistics New Zealand estimates of real industry output for margin industries will tend to be biased downward. This potential bias¹³ underlines the need to do a proper double deflation method for constructing industry real output measures.

Since the above technique used by Statistics New Zealand to construct measures of real output for margin industries (and other industries as well) is used by other statistical agencies around the world, the above bias will be present in other countries as well. This systematic undervaluation of service sector real output growth combined with the rapid growth in service sector employment can help to explain the world wide productivity slowdown – see Baily and Gordon (1988) and Diewert and Fox (1998; 1999) for more on service sector measurement problems and the productivity slowdown.

¹³ It is possible that the inequalities (11) may not hold if the industry is substituting intermediate inputs with other primary inputs like labour and capital over time. However, normally, we would expect (11) to hold; ie, we would expect that firms and industries are improving their output–intermediate input productivities over time.

7.7 The Measurement of Outputs in Risky Industries

Traditional national income accounting has not tried to apply any of the economic theories of choice under uncertainty to measure the outputs of industries where *risk* is involved in an essential way. Examples of such industries are:

- insurance
- gambling
- investment management
- options trading.

Not much research on the latter two industries has been done but some preliminary research on adapting the theoretical literature on choice under uncertainty has been done on the property insurance and gambling industries (see Diewert (1993b, pp.415–427; 1995d). The main conclusions that have emerged from this preliminary research are:

- The usual net premiums approach to measuring property insurance output does not make sense from the viewpoint of the theoretical economics literature, which suggests that consumers buy *protection services*.
- If insurance companies can reduce their administrative costs, then the protection services approach to insurance output measurement suggests that real output will *increase* while the national accounts approach to output measurement will suggest a *decrease* in output has occurred.
- The theoretical choice under uncertainty approach to the measurement of gambling industry output suggests that a decrease in the degree of unfairness in the gambling activity will *increase* the real output of the industry while traditional national accounts approaches focus only on the net expenditures of consumers on gambling activities.

The Brookings Institution under the leadership of Barry Bosworth and Jack Triplett have organised a research project which will examine various alternative ways of measuring outputs in risky industries. The results of this research endeavour should be available sometime next year.

We conclude this chapter with some observations on the difficulties that statistical agencies face in their measurement activities.

7.8 Measurement Difficulties Facing Statistical Agencies

The first difficulty that statistical agencies face in attempting to measure industry productivity is that *different surveys* are generally used to collect information on the outputs of an industry and on the various input components. The existence of separate surveys leads to the possibility that the input information will not exactly match up with the output information.

A second difficulty is that every statistical agency uses *different surveys* to collect information on prices and values. These separate data collection surveys do not greatly impede the construction of reasonably accurate price and quantity aggregates for the components of final demand for the economy as a whole but they can lead to inaccurate estimates of price and quantity for industries or smaller units such as firms or establishments. In particular, the firm or industry specific price indexes that are applied to the firm's or industry's value components (such as output, intermediate input, labour input, etc) will generally be inaccurate. Hence, in some cases, the resulting firm or industry productivity measures will be virtually useless.

Statistics Canada, under the leadership of Phillip Smith, is instituting a new micro data management plan to manage the data burdens for large firms. Each large firm will have its own Statistics Canada representative who will act as the single point of reference for all survey information that is to be collected from that firm. This will reduce respondent burden but it will also ensure that the survey information is *coherent* so that, for example, price information is matched up with the corresponding value information. It should also be mentioned that the national tax authority in Canada (Revenue Canada) has introduced a single business number for each firm in Canada and Statistics Canada will also use this number. We believe that every statistical agency should monitor the outcome of this experiment, and if it is successful, introduce a similar plan.

Many firms have taken advantage of the low cost of computing and have detailed data on all of their financial transactions (eg, they have the value of each sale and the quantity sold by commodity). This opens up the possibility of the statistical agency replacing or supplementing their surveys on say, prices of outputs, by the electronic submission by firms to the statistical agency of their computerised transaction histories for a certain number of periods. This information would provide the industry/firm counterparts to the scanner data studies that have proved to be so useful in the context of the consumer price index. This information would also lead to true microeconomic price and quantity indexes at the firm level and to accurate firm and industry productivity indexes.

Statistical agencies face some increasingly difficult problems in providing indexes of real output and input, which are the basic ingredients for computing both productivity and real consumption growth rates. As we have seen in section 7.4.5, the growth of knowledge has led to an increase in the dimensionality of the commodity space. It is likely that the commodity space is expanding more rapidly now than ever before. Traditional index number theory assumes that the set of commodities being aggregated is constant and unchanging over time. Thus, strictly speaking, traditional index number theory is not applicable to the current situation: there is a lack of *comparability* of the set of commodities that exist in the current period with the set that existed in the previous period.

We have also observed in section 7.3 that many OECD economies are experiencing an increase in self employment and, hence, there is an increase in the formation of new business units. The entrance of new firms and the exit of old firms again create problems for productivity statistics: the traditional methodology assumes an *unchanging* set of business units. Thus, again there is a lack of comparability: the set of firms that exists in the current period is different from the set of firms that existed in the previous period.

When one examines the range of individual commodities produced by different firms in the same industry, one is struck by the tremendous amount of *heterogeneity* in the composition of these outputs. This heterogeneity makes comparisons of real output and productivity across firms in the same industry somewhat dubious, since their outputs may not be comparable.

Thus, statistical agencies are increasingly facing the problem of a lack of *comparability* when they construct their estimates of business real output, input and productivity. In addition, in the above sections, we saw that statistical agencies faced many difficult conceptual measurement problems, where reasonable people could come up with quite different answers to these measurement problems. These difficulties mean it is becoming increasingly difficult for agencies to construct *reproducible* estimates of real output, input and productivity¹⁴. Unfortunately, we do not see any easy solutions to these measurement problems that statistical agencies face.

¹⁴ The *reproducibility test* for data construction states that every competent statistician would construct the same aggregate given identical disaggregated information sets. The idea of this test dates back to the early accounting literature.

8. THE WAY AHEAD

The two most important areas identified requiring further work are labour data and the services sector. Alternative labour series have an unexpectedly large impact on the productivity results and urgent work is needed to improve the quality and consistency of labour data, particularly at the sectoral level. Of even higher priority, however, is the treatment of the services sector in official statistics. While services have grown rapidly to now dominate most western economies, statistical agencies around the world have lagged in their ability to accurately measure service sector outputs and allocate new forms of inputs such as leased capital. We hope that this report will stimulate public discussion of these measurement (and associated funding) issues. Good economic policy requires good economic statistics.

In this chapter, we conclude by listing some recommendations for future data collection and work that Statistics New Zealand and other agencies should undertake to improve not only productivity measurement for New Zealand, but also to improve economic statistics in general. In section 8.1, we organise our discussion of data improvements along the lines used in section 7.2 above. In section 8.2, we add some additional data classification issues that Statistics New Zealand should consider adopting over the next five or so years. Naturally, dealing with the data deficiencies as we see them will not come without a price – government and the public at large will need to be convinced that it is difficult to evaluate alternative government policies without an adequate base of information about the economy. In section 8.3, we outline some additional priorities for productivity research and, finally, in section 8.4 we note some of SNZ's current plans for the NZSNA.

8.1 Measuring Total Factor Productivity

As was mentioned in section 7.2 above, we require accurate price and quantity information on at least seven classes of outputs and inputs in order to measure the TFP of a firm, industry or group of industries. We discussed the measurement problems involved with these categories at some length in chapter 7, and simply repeat the main priorities here.

Gross outputs

We require accurate information on each industry's output price and, hence, output quantity. Gross output prices should exclude commodity taxes. The quality of this information varies widely at the moment across industries and is at its worst in the service industries. Given the

ever increasing importance of service industries in the economy, a high priority has to be given to improving output measurement in the 'hard to measure' services, particularly the Financial services, Trade, restaurants and hotels and Community services sectors. Identifying output quality improvements is a critical part of this process. In the preceding chapter we listed several possibilities for improving measurement in those industries involving interest and risk.

Intermediate inputs

To obtain accurate industry or sectoral productivity results it is necessary to move to the double deflation procedure to construct industry real value added. This requires information on the value and price of all intermediate inputs used by each industry (measured in producer prices). This greatly increases the amount of information required in terms of detailed input/output accounts. In section 7.6 we illustrated the potentially large biases which can be introduced by some of the simplifying assumptions statistical agencies currently use in constructing estimates of industry real value added. A related problem which needs to be addressed is the way new types of inputs such as leased capital are recorded in the national accounts. These inputs need to be accurately allocated to the industries where they are used rather than to the industry where they are owned.

Labour inputs

In chapter 5 we have highlighted some of the inconsistencies which currently exist in the official database's alternative labour series. The labour data used has a significant impact on measured productivity at both the aggregate and industry levels. Improving the consistency of industry level labour series is a high priority as is improving estimates of the allocation of self employed and proprietors' operating surplus between labour and capital. We also need to assign values to different types of labour input to form more accurate labour aggregates; ie, treating all types of labour input as homogeneous can lead to significant measurement error.

Reproducible capital inputs

Statistics New Zealand is currently preparing a set of official capital stock estimates. This should improve the current situation where there is a wide range of estimates of possible capital stocks for New Zealand as illustrated in chapter 4. The official series should provide a more common basis for forming capital estimates. We also require better information on depreciation and scrapping rates of capital assets and more detailed asset price deflators, at least for the two major asset classes by two digit industry.

Inventory stocks

The current national accounts treatment of inventories is inadequate and is likely to lead to significant biases in measured productivity, particularly in the wholesale and retail trade industries. Apart from the conceptual issues of how inventories should be included in productivity studies, more fundamental measurement difficulties are highlighted by the sometimes opposite signs of real and nominal changes in inventories found across most OECD countries.

Land

Land is an important input to production and should be included in productivity studies. In chapter 3 we have formed estimates of the value of land in New Zealand. While we assume the quantity of land remains constant in aggregate, we do not have sufficient information to pick up changes in the composition of land between rural, commercial and industrial uses as a result of rezoning over time. More detailed information is required to capture the impact of changes in the composition of land use.

Natural resource depletion

In chapter 3 we made a start at estimating the depletion of forestry, oil and gas resources. SNZ should be encouraged to start constructing resource accounts that also include fishing and minerals stocks and the environmental quality of air, water and land stocks.

We believe the order in which Statistics New Zealand should tackle the problems involved in measuring the prices and quantities of each of the above major classes of outputs and inputs is in the order listed.

Additional data problems identified in chapter 7 relate to possible biases in price indexes, particularly the consumer price index. Studies in other countries indicate that various sources of bias can cause substantial overstatement of measured price changes and corresponding underestimation of quantities consumed. New Zealand is unlikely to be immune from these measurement problems and potential biases should be investigated.

Another initiative we advocated in chapter 7 which should be given a high priority is the micro data management plan being trialed by Statistics Canada. This plan aims to limit the data burden imposed on larger firms while at the same time ensuring coherent information is supplied so that, for example, price information is matched up with the corresponding value information.

8.2 Classification Problems

The industrial classification that Statistics New Zealand is presently using is probably at least 50 years old. Since World War II, many new industries have emerged, both in manufacturing and in the service industries. There is an urgent need for Statistics New Zealand to invest in a new industrial classification. One option that Statistics New Zealand should investigate (possibly in conjunction with the Australian Bureau of Statistics) is the possibility of adapting the new North American Industrial Classification that has recently been adopted by Canada, the US and Mexico. This classification is quite up to date, contains much more detail on service industries and better approximates the current structure of western economies. It may be possible to essentially save most of the development costs that went into the implementation of this classification.

New Zealand's commodity classification is also fairly obsolete. In particular, service sector outputs are extremely poorly defined and measured. A great deal of work needs to be done in this area as well. Again, it may be possible to free ride on North American developments in this area.

8.3 Additional Productivity Research Topics

We conclude our review of measurement problems by suggesting four topics that further research could be done on:

- Benchmarking and DEA (data envelopment analysis) projects that would examine particular New Zealand industries or firms and compare their performance with international best practice. This would provide information on productivity levels as well as growth rates while ensuring like is being compared with like. Attention may focus initially on those industries where there has been most reform (to demonstrate the benefits of reform) or where problems are thought to exist (to highlight the need for further reforms).
- Measuring the contribution of government infrastructure services to TFP performance in the market sector. This is a largely unresolved issue that warrants further attention if we are to understand the main drivers behind productivity improvement.
- Measuring exactly how knowledge is created and transmitted to the New Zealand private production sector. Again a better understanding of this is necessary before policies to encourage superior uptake rates and increased productivity can be adequately developed.
- Constructing new output measures for hard to measure service industries. We have demonstrated the major impact measurement problems in industries such as Financial services are having on measured productivity performance. While we have highlighted the

importance of better service sector output data in section 8.1, considerable conceptual work remains to be done in developing output measures for many service industries.

8.4 Current Developments in the NZSNA

Finally, we note that SNZ is currently undertaking a number of developments which will improve the quality of the accounts and the information available for future productivity studies. These include:

- benchmarking the accounts to the detailed 1995–96 inter–industry study;
- rebasing the constant price accounts and introducing chained Laspeyres indexes in their compilation;
- investigating alternative data sources and methods for measuring problem industries;
- producing official capital stock series;
- adopting the Australia New Zealand Industrial Classification;
- adopting SNA93; and
- redevelopment and rebasing of many key price indexes including the business price indexes of inputs and outputs and the capital goods price indexes.

We think that all of the above developments are very worthwhile and should be undertaken. However, as noted at the beginning of the chapter, a great deal of additional work needs to be done to improve the quality of New Zealand's official statistics. This additional work will require additional resources for Statistics New Zealand. We hope that this report will stimulate public discussion of these measurement and funding issues. Good economic policy requires good economic statistics.

APPENDIX A: A SURVEY OF PRODUCTIVITY MEASUREMENT

1. Productivity and efficiency concepts

In this introductory section, we will give verbal definitions of efficiency and productivity and provide an overview of the remainder of the paper.

Efficiency in an engineering sense means that a production process has achieved the maximum amount of output that is physically achievable with current technology given fixed amounts of inputs that can be utilised in the time period under consideration. This concept of efficiency is called *technical efficiency* in the economics literature. Economists also distinguish another type of efficiency which is more stringent than technical efficiency. If a production unit (or firm) faces given (constant) output and input prices, then the observed set of outputs produced and inputs utilised is said to be *allocatively efficient* if this set of outputs and inputs maximised the firm's profits at the given prices. It can be seen that allocative efficiency implies technical efficiency; ie. in order to maximise profits, the combination of outputs and inputs chosen by the firm must lie on the frontier of its production surface. However, technical efficiency does not necessarily imply allocative efficiency; ie. the observed outputs and inputs can be on the firm's production frontier but not be profit maximising. The concepts of technical and allocative efficiency are due to Farrell (1957).

It should be obvious why engineers, economists, businessmen and governments are interested in achieving technical efficiency: if firms or production units are not technically efficient, then resources are being wasted.

However, it is not so obvious why economists are interested in achieving allocative efficiency. If a group of firms are not all achieving allocative efficiency, then it can be shown¹ that resources could be reallocated so that more of at least one output could be produced by the group of firms while producing the same amount of other outputs in total and utilising the same total amounts of all inputs. Hence the lack of allocative efficiency at the level of the individual firm shows up as the technical inefficiency of a group of firms.

The efficiency concepts defined above are *absolute concepts*. On the other hand, *productivity* (or productivity change) is a *relative concept*: in a productivity comparison, the current period outputs and inputs of a firm (which we will call the target firm) are compared against standard

¹ See Diewert (1983) who drew on the earlier work of Allais (1943; 1977) and Debreu (1951; 1954).

outputs and inputs for a firm which is in the same line of business. The *standard* set of outputs and inputs could be: (i) a technically efficient set of outputs and inputs; (ii) an allocatively efficient set of outputs and inputs where the prices are chosen to be the current output and input prices that the target firm is facing; (iii) a set of outputs and inputs that an average firm in the industry produces and utilises; (iv) the set of outputs and inputs produced by the target firm in a previous period or (v) a budgeted set of outputs and inputs.

The comparison of the two situations can be made using *ratios* (this is the usual approach in economics) or using *differences* (this is the usual approach in managerial accounting²). The ratio approach will be used in this paper.

As defined above, productivity change encompasses: (i) increases in technical efficiency (a movement towards the firm's production frontier); (ii) technical change (an outward shift in the firm's production surface) and (iii) increasing returns to scale (a movement along the firm's production surface). These concepts will be explained in more detail in section 2 below. If we are measuring productivity change over a group of firms (or over the divisions of a firm), then a favourable productivity change could also be due to improvements in allocative efficiency across the firms or divisions.

If the standard for comparison is chosen to be the set of outputs and inputs produced by the target firm in the previous period, then productivity change can also be related to changes in profitability; see section 2 below.

We now outline the contents of the remainder of this appendix.

In section 2 below, we consider the problem of measuring productivity change for a production unit or firm that utilises only one input to produce one output. In this highly simplified situation, index number problems are absent and the analysis is very easy to understand. In the remainder of the paper, we try to adapt the one input, one output analysis to the general case of N inputs and M outputs.

Sections 3 and 4 consider the conceptual problems involved in defining measures of productivity change where the firm's production (or cost) function is known.

Since the approaches to productivity measurement outlined in sections 3 and 4 are not really practical in most cases, we consider index number approaches in sections 5 and 6. Section 5 considers the axiomatic approach to index number theory while section 6 considers the economic approach to index number theory. Both of these approaches are practical and in fact

² In the accounting literature, the standard set of outputs and inputs is usually chosen to be a budgeted set; see Kaplan (1982, Ch.9). The comparison of the firm's actual performance with the budgeted performance is generally called variance analysis in the accounting literature.

lead to the same algebraic expression to measure productivity change (although their assumptions are quite different).

The remaining sections consider a variety of related topics.

Section 7 looks at the problem of relating engineering type partial productivity change measures to our suggested overall measures of productivity change.

Section 8 looks at continuous time approaches to productivity measurement and Section 9 looks at the problem of calculating period by period (user) costs for capital inputs. Capital inputs have the property that they last longer than one accounting period and hence their initial purchase cost should be distributed across the useful life of the input. Finally, section 10 concludes.

2. Productivity measurement in the one output, one input case

We consider in this section the problem of measuring the total factor productivity (TFP) of a one output, one input firm. To do this, we require data on the amounts of output produced, y^0 and y^1 , during two time periods, 0 and 1, and on the amounts of input utilised, x^0 and x^1 , during those same two time periods. It should be noted that the period 0 data can be interpreted as a set of standard data. It is also convenient to define the firm's revenues R^t and total costs C^t for period t where $t = 0, 1$. The average selling price of a unit of output in period t is assumed to be p^t and the average cost of a unit of input in period t is w^t for $t = 0, 1$. Thus we have:

$$(1) \quad R^t = p^t y^t \quad \text{for } t = 0, 1 \text{ and}$$

$$(2) \quad C^t = w^t x^t \quad \text{for } t = 0, 1.$$

Our first definition of the *total factor productivity change* of the firm going from period 0 to period 1 (or more briefly, of the *productivity* of the firm) is:

$$(3) \quad TFP(1) \equiv [y^1 / y^0] / [x^1 / x^0].$$

Note that y^1 / y^0 is the firm's output growth rate going from period 0 to period 1 while x^1 / x^0 is the corresponding input growth rate going from period 0 to period 1. If $TFP(1) > 1$, then the output growth rate was greater than the input growth rate and we say that the firm has experienced a productivity improvement going from period 0 to period 1. If $TFP(1) < 1$, then we say that the firm has experienced a productivity decline.

The output growth rate, y^1 / y^0 can also be interpreted as a quantity index of outputs. In section 4 below, we will define quantity indexes for multiple output firms. However, if there is only one output, it can be verified that the output quantity indexes defined there all reduce to

the output growth rate, y^1 / y^0 defined here. Similarly, the input growth rate, x^1 / x^0 , can be interpreted as a quantity index of inputs. Hence, our first definition of productivity change or productivity, $TFP(1)$ defined by (3), can be interpreted as an output quantity index divided by an input quantity index.

An alternative method for measuring productivity in a one output, one input firm is the change in technical coefficients method. Define the input-output coefficient of the firm in period t as:

$$(4) \quad a^t \equiv y^t / x^t, \quad t = 0, 1.$$

Thus, a^t is the total amount of output y^t produced by the firm in period t divided by the total amount of input utilised by the firm in period t , x^t . It can be interpreted as a coefficient which summarises the engineering and economic characteristics of the firm's technology in period t : a^t describes the rate at which inputs are transformed into outputs during period t .

Our second definition of total factor productivity can be expressed in terms of the output-input coefficients, a^0 and a^1 as follows:

$$(5) \quad TFP(2) \equiv a^1 / a^0$$

Thus, if a^1 is greater than a^0 , so that the firm is producing more output per unit input in period 1 compared to period 0, then $TFP(2) > 1$ and the firm has experienced an increase in productivity going from period 0 to period 1.

It should be noted that the two productivity concepts that we have defined thus far, $TFP(1)$ and $TFP(2)$, are both relative concepts. This is a general feature of economic definitions of productivity: the performance of the firm in a current period 1 is always compared to its performance in a base period 0. In contrast, an engineering concept of productivity or efficiency is usually an absolute one, concerned with obtaining the maximum amount of output in period one, y^1 , given an available amount of input in period one, x^1 , consistent with the laws of physics.³

³ Thus, the engineers Norman and Bahiri (1972, p.27) define productivity as the quotient obtained by dividing output by one of the factors of production. Since our simple model has only one factor of production, this engineering definition of productivity reduces to $a^1 = y^1 / x^1$. However, even engineers recognise that this definition of productivity is unsatisfactory, since it is not invariant to changes in the units of measurement. Thus, Norman and Bahiri (1972, p.28) later define productivity as a relative concept as the following quotation indicates:

“Consequently, we define and measure relative productivity levels in comparison with a level achieved in the past or in comparison with another establishment in the same industry, or in comparison with the national average achieved by another nation.”

Thus, a^1 is compared to a^0 where $a^0 = y^0 / x^0$ is a reference input-output coefficient. Note that a^1 / a^0 is invariant to changes in the units of measurement. It should be mentioned that sometimes economists (such as Jorgenson and Griliches (1967, p.252)) define productivity as total output divided by total input, $y^1 / x^1 = a^1$,

Using (3), (4), and (5), it is easy to show that $TFP(2)$ coincides with an earlier $TFP(1)$ concept in this simple one output, one input model of production; ie. we have:

$$(6) \quad TFP(2) \equiv a^1 / a^0 = [y^1 / x^1] / [y^0 / x^0] = [y^1 / y^0] / [x^1 / x^0] \equiv TFP(1)$$

We turn now to a third possible method for defining productivity:

$$(7) \quad TFP(3) \equiv [(R^1 / R^0) / (p^1 / p^0)] / [(C^1 / C^0) / (w^1 / w^0)]$$

Thus, $TFP(3)$ is equal to the firm's revenue ratio R^1 / R^0 deflated by the output price index p^1 / p^0 divided by the cost ratio between the two periods C^1 / C^0 deflated by the input price index w^1 / w^0

Using (1), we have

$$(8) \quad (R^1 / R^0) / (p^1 / p^0) = (p^1 y^1 / p^0 y^0) / (p^1 / p^0) = y^1 / y^0$$

and using (2), we have

$$(9) \quad (C^1 / C^0) / (w^1 / w^0) = (w^1 x^1 / w^0 x^0) / (w^1 / w^0) = x^1 / x^0$$

Thus, in this simple one input, one output model, (8) says that the deflated revenue ratio is equal to the output growth rate and (9) says that the deflated cost ratio is equal to the input growth rate. Hence, (7) equals (3) and we have, using (6):

$$(10) \quad TFP(1) = TFP(2) = TFP(3).$$

There is a fourth way for measuring productivity change that is a generalisation of a method originally suggested by Jorgenson and Griliches (1967). In order to explain this fourth method, we need to introduce the concept of the firm's period t margin, m^t ie. define

$$(11) \quad 1 + m^t \equiv R^t / C^t, \quad t = 0, 1.$$

Thus, $1 + m^t$ is the ratio of the firm's period t revenues R^t to its period t costs C^t . If m^t is zero, then the firm's revenues equal its costs in period t and the economic profit of the firm is zero. If m^t is positive, then the bigger m^t is, the bigger are the firm's profits.

We can now define our fourth way for measuring productivity change in a one output, one input firm:

$$(12) \quad TFP(4) \equiv [(1 + m^1) / (1 + m^0)] [w^1 / w^0] / [p^1 / p^0].$$

Thus, $TFP(4)$ is equal to the margin growth rate $(1 + m^1) / (1 + m^0)$ times the rate of increase in input prices w^1 / w^0 divided by the rate of increase in output prices.

and then define productivity change as the rate of change of a^1 . However, it is only their productivity change concept that is regarded as being meaningful.

If we use equations (11) to eliminate $(1 + m^1) / (1 + m^0)$ in (12), we find that

$$(13) \quad TFP(4) = TFP(3)$$

and thus, by (10), $TFP(1) = TFP(2) = TFP(3) = TFP(4)$. Thus, in a one output, one input firm, we have four conceptually distinct methods for measuring productivity change that turn out to be equivalent. (Unfortunately, this equivalence does not generally extend to the multiple output, multiple input case.)

Definition (12) of productivity can be used to show the importance of achieving a productivity gain: a productivity improvement is the source for increases in margins or increases in input prices or decreases in output prices. Equation (12) also indicates the relationship between total factor productivity and increased profitability. Rearranging (12), we have

$$(14) \quad [(1 + m^1) / (1 + m^0)] = [TFP(4)] [p^1 / p^0] / [w^0 / w^0].$$

Thus, the rate of growth in margins is equal to TFP times the output price growth rate divided by the input price growth rate.

If there are constant returns to scale in production or margins m^t are zero for whatever reason in periods 0 and 1, then $TFP(4)$ reduces to $[w^0 / w^0] / [p^1 / p^0]$ which is the input price index divided by the output price index, a formula due to Jorgenson and Griliches (1967, p.252).

We conclude this section with a rather lengthy discussion of the problem of distinguishing TFP from the concept of technical change or technical progress, TP . In order to distinguish TFP from TP , it is necessary to introduce the concept of the firm's period t production function f^t ; ie. in period t , $y = f^t(x)$ denotes the maximum amount of output y that can be produced by x units of the input. We assume that in periods 0 and 1, the observed amounts of output, y^0 and y^1 , are produced by the observed amounts of input, x^0 and x^1 , according to the following production function relationships:

$$(15) \quad y^0 = f^0(x^0);$$

$$(16) \quad y^1 = f^1(x^1).$$

Note that we are now explicitly assuming that production is technically efficient during the two periods under consideration.

We define technical progress TP as a measure of the shift in the production function going from period 0 to period 1. There are an infinite number of possible shift measures but it turns out that four measures of technical progress (involving the observed data y^0, y^1, x^0 or x^1 in some way) are the most useful. First, define:

$$(17) \quad y^{0*} \equiv f^1(x^0) \text{ and } y^{1*} \equiv f^0(x^1).$$

Thus, y^{0*} is the output that *could* be produced by the period 0 input x^0 if the period 1 production function f^1 were available and y^{1*} is the output which *could* be produced by the period 1 input x^1 but using the period 0 technology which is summarised by the period 0 production function f^0 . Note that in order to define these hypothetical outputs y^{0*} and y^{1*} , a knowledge of the period 0 and 1 production functions f^0 and f^1 is required. This knowledge is not easy to acquire but it could be obtained by engineering studies or by econometric (statistical) techniques.

With y^{0*} and y^{1*} defined, we can define the following two output based indexes of *technical progress* $TP(1)$ and $TP(2)$:⁴

$$(18) \quad TP(1) \equiv y^{0*} / y^0 = f^1(x^0) / f^0(x^0);$$

$$(19) \quad TP(2) \equiv y^1 / y^{1*} = f^1(x^1) / f^0(x^1).$$

Thus, $TP(1)$ is one plus the percentage increase in output due to technical and managerial improvements (going from period 0 to period 1) evaluated at the period 0 input level x^0 and $TP(2)$ is one plus the percentage increase in output due to the new technology evaluated at the period 1 input level x^1 .

It is also possible to define input based measures of technical progress $TP(3)$ and $TP(4)$. First, define x^{0*} and x^{1*} as follows:

$$(20) \quad y^0 = f^1(x^{0*}) \text{ and } y^1 = f^0(x^{1*})$$

Thus, x^{0*} is the input required to produce the period 0 output y^0 but by using the period 1 technology, and so x^{0*} will generally be less than x^0 (which is the amount of input required to produce the period 0 output using the period 0 technology). Similarly, x^{1*} is the amount of input required to produce the period 1 output y^1 but by using the period 0 technology, and x^{1*} will generally be larger than x^1 (because the period 0 technology will generally be less efficient than the period 1 technology). Now define the following two input based measures of technical progress, $TP(3)$ and $TP(4)$:⁵

$$(21) \quad TP(3) \equiv x^0 / x^{0*};$$

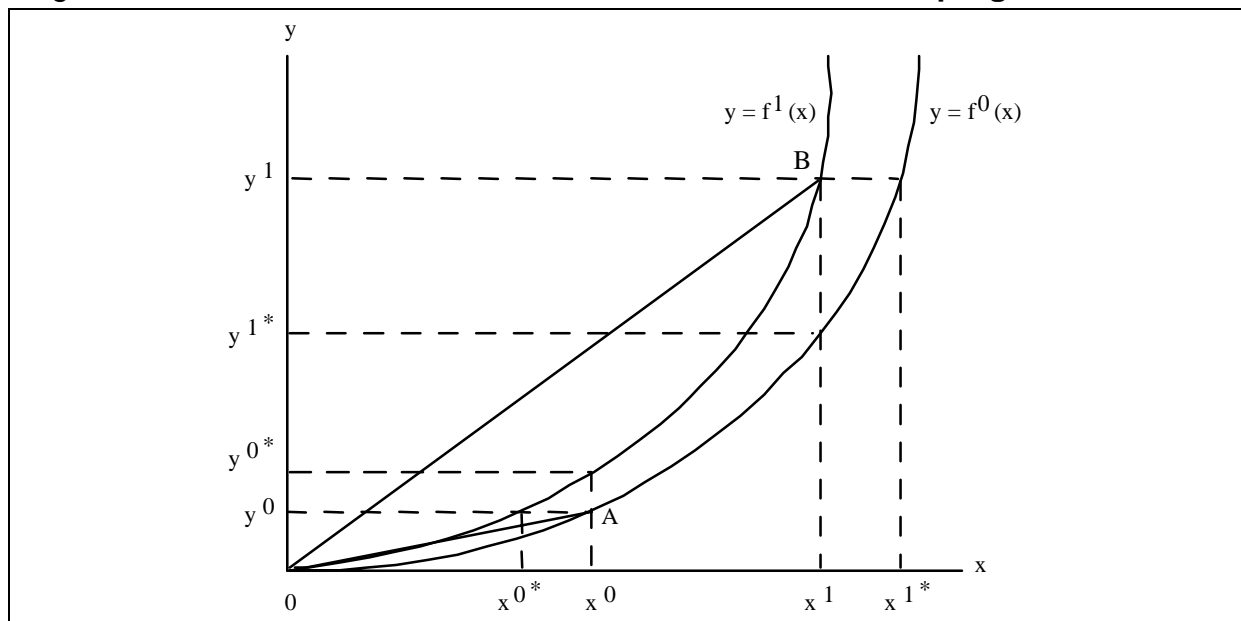
$$(22) \quad TP(4) \equiv x^{1*} / x^1.$$

⁴ $TP(1)$ and $TP(2)$ are the one input, one output special cases of Caves, Christensen, and Diewert's (1982, p.1402) output based 'productivity' indexes. However, note that in the present appendix, we are defining productivity differently.

⁵ $TP(3)$ and $TP(4)$ are the one input, one output special cases of Caves, Christensen, and Diewert's (1982, p.1407) input based 'productivity' indexes. However, in the present appendix, we regard these 'productivity' indexes as measures of the shift in the production functions and hence as measures of technical progress.

The above four measures of *TP* can be illustrated with the aid of Figure A1. The diagram shows that each of the *TP* measures can be different.

Figure A1: Production function based measures of technical progress



The lower curved line is the graph of the period 0 production function; ie. it is the set of points (x, y) such that $x \geq 0$ and $y = f^0(x)$. The higher curved line is the graph of the period 1 production function; ie. it is the set of points (x, y) such that $x \geq 0$ and $y = f^1(x)$. The observed data points are A, which has coordinates (x^0, y^0) and B, which has coordinates (x^1, y^1) . Note that the absolute amounts of production function shift in the direction of the y axis are $y^{0*} - y^0$ (at point A) and $y^1 - y^{1*}$ (at point B). The absolute amounts of production function shift in the direction of the x axis are $x^0 - x^{0*}$ (at point A) and $x^{1*} - x^1$ (at point B). We have chosen to measure *TP* in terms of the relative shifts, y^{0*} / y^0 , y^1 / y^{1*} , x^0 / x^{0*} and x^{1*} / x^1 rather than the absolute shifts, $y^{0*} - y^0$, $y^1 - y^{1*}$, $x^0 - x^{0*}$ and $x^{1*} - x^1$ in order to obtain measures of shift that are invariant to changes in the units of measurement. Note that $TFP = TFP(2) = [y^1 / x^1] / [y^0 / x^0]$ is equal to the slope of the straight line OB divided by the slope of the straight line OA.

It turns out that there is a relationship between each of our technical progress measures, *TP*(1), *TP*(2), *TP*(3), *TP*(4), and total factor productivity, *TFP*. We have:

$$(23) \quad TFP = TP(i) RS(i), \quad i = 1,2,3,4$$

where the four returns to scale measures *RS*(*i*) are defined as follows:

$$(24) \quad RS(1) \equiv [y^1 / x^1] / [y^{0*} / x^{0*}];$$

$$(25) \quad RS(2) \equiv [y^{1*} / x^1] / [y^0 / x^0];$$

$$(26) \quad RS(3) \equiv [y^1 / x^1] / [y^0 / x^{0*}];$$

$$(27) \quad RS(4) \equiv [y^1 / x^{1*}] / [y^0 / x^0].$$

The returns to scale measures $RS(1)$ and $RS(3)$ pertain to the period 1 production function f^1 while the measures $RS(2)$ and $RS(4)$ pertain to the period 0 production function f^0 . To interpret each of these returns to scale measures geometrically, see Figure A1. Each of these returns to scale measures is the ratio of two input-output coefficients, say $[y^j / x^j]$ divided by $[y^k / x^k]$, where (y^j / x^j) and (x^k / y^k) are two points on the same production function and $(x^j > x^k)$. Thus, if $RS(i) = [y^j / x^j] / [y^k / x^k]$ is greater than 1, then $y^j / x^j > y^k / x^k$ and we say that the production function exhibits *increasing returns to scale* between the two points. If $RS(i) = 1$, then the production function exhibits *constant returns to scale* between the two points and finally if $RS(i) < 1$ then the production function exhibits *decreasing returns to scale* between the two points.

The total factor productivity decompositions given by equations (23) tell us that TFP is equal to the product of a technical progress term $TP(i)$ (this corresponds to a *shift* in the production function going from period 0 to period 1) and a returns to scale term $RS(i)$ (this corresponds to a *movement along* one of the production functions). The reader can use Figure A1 and definitions (18)–(22) and definitions (24)–(27) to verify that each of the four decompositions of TFP given by (23) corresponds to a different combination of shifts and movements along a production function that take us from point A to point B.

For firms in a regulated industry, returns to scale will generally be greater than one, since increasing returns to scale in production is often the reason for regulation in the first place. Thus, TFP will exceed TP for growing firms in a regulated industry (provided that there are increasing returns to scale for that firm).

We note that the technical progress and returns to scale measures defined above cannot in general be calculated without a knowledge of the production functions that describe the technology for the two periods under consideration. However, in a one input, one output firm, the TFP measures defined above can be calculated unambiguously provided that we know inputs used and outputs produced during the two periods.

In section 3 below, we shall generalise the above production function based definitions of productivity and technical progress to cover the case of many outputs and many inputs.

3. Productivity measurement and production functions

In this section and in subsequent sections, we assume that the firm produces M outputs and utilises N inputs in periods 0 and 1. We assume that the technology and managerial efficiency

of the firm in period t can be summarised by its period t production function and we also assume that production is technically efficient in each period; ie. we have for $t = 0, 1$:

$$(28) \quad y_1 = f^t(y_2, y_3, \dots, y_M, x_1, x_2, \dots, x_N)$$

where y_1 is the maximum amount of output 1 that the firm can produce in period t , given that it produces y_2 units of output 2, y_3 units of output 3, ..., y_M units of output M and utilises x_1 units of input 1, x_2 units of input 2, ..., x_N units of input N during period t .

In this section, we will assume that the period 0 and period 1 production functions f^0 and f^1 are known.⁶ Our purpose in this section is to use the production functions f^0 and f^1 in order to define multiple input, multiple output counterparts to the total factor productivity concepts that we defined in the previous section where we had only one output and one input.

We need to introduce some notation. We assume that y_1^t is the amount of output 1 produced in period t , $\tilde{y}^t \equiv [y_2^t, y_3^t, \dots, y_M^t]$ is the vector of other (than output 1) outputs produced in period t and $x^t \equiv [x_1^t, x_2^t, \dots, x_N^t]$ is the vector of inputs utilised in period t , for $t = 0, 1$. The production function in period 0 is f^0 and in period 1 is f^1 . We assume that:

$$(29) \quad y_1^0 = f^0(\tilde{y}^0, x^0) = f^0(y_2^0, \dots, y_M^0, x_1^0, \dots, x_N^0) \text{ and } y_1^1 = f^1(\tilde{y}^1, x^1).$$

The *output index* α^0 is defined as the number which satisfies the following equation:

$$(30) \quad y_1^1 / \alpha^0 = f^0(\tilde{y}^1 / \alpha^0, x^0) = f^0(y_2^1 / \alpha^0, \dots, y_M^1 / \alpha^0, x_1^0, \dots, x_N^0).$$

If $M = 1$ so that there is only one output, equation (30) becomes $y_1^1 / \alpha^0 = f^0(x^0) = y_1^0$ and thus $\alpha^0 = y_1^1 / y_1^0$, the (single) output growth rate. In the many output case, α^0 is a number which deflates the period 1 vector of outputs produced by the firm, $y^1 \equiv [y_1, y_2, \dots, y_M]$ into $y^1 / \alpha^0 \equiv [y_1^1 / \alpha^0, y_2^1 / \alpha^0, \dots, y_M^1 / \alpha^0]$ and this deflated output vector can be produced with the period 0 vector of inputs x^0 using the period 0 technology.

Another *output index* α^1 is defined as the number which satisfies the following equation:

$$(31) \quad \alpha^1 y_1^0 = f^1(\alpha^1 \tilde{y}^0, x^1) \equiv f^1(\alpha^1 y_2^0, \alpha^1 y_3^0, \dots, \alpha^1 y_M^0, x_1^1, x_2^1, \dots, x_N^1).$$

If there is only one output so that $M = 1$, then equation (31) becomes $\alpha^1 y_1^0 = f^1(x^1) = y_1^1$ and thus, $\alpha^1 = y_1^1 / y_1^0$, the (single) output growth rate. In the many output case, α^1 is the number which inflates the period 0 vector of outputs y^0 into $\alpha^1 y^0$ and this inflated output vector can be produced with the period 1 vector of inputs x^1 using the period 1 technology. Thus, in some sense, the vector $\alpha^1 y^0$ is equivalent to the vector y^1 .

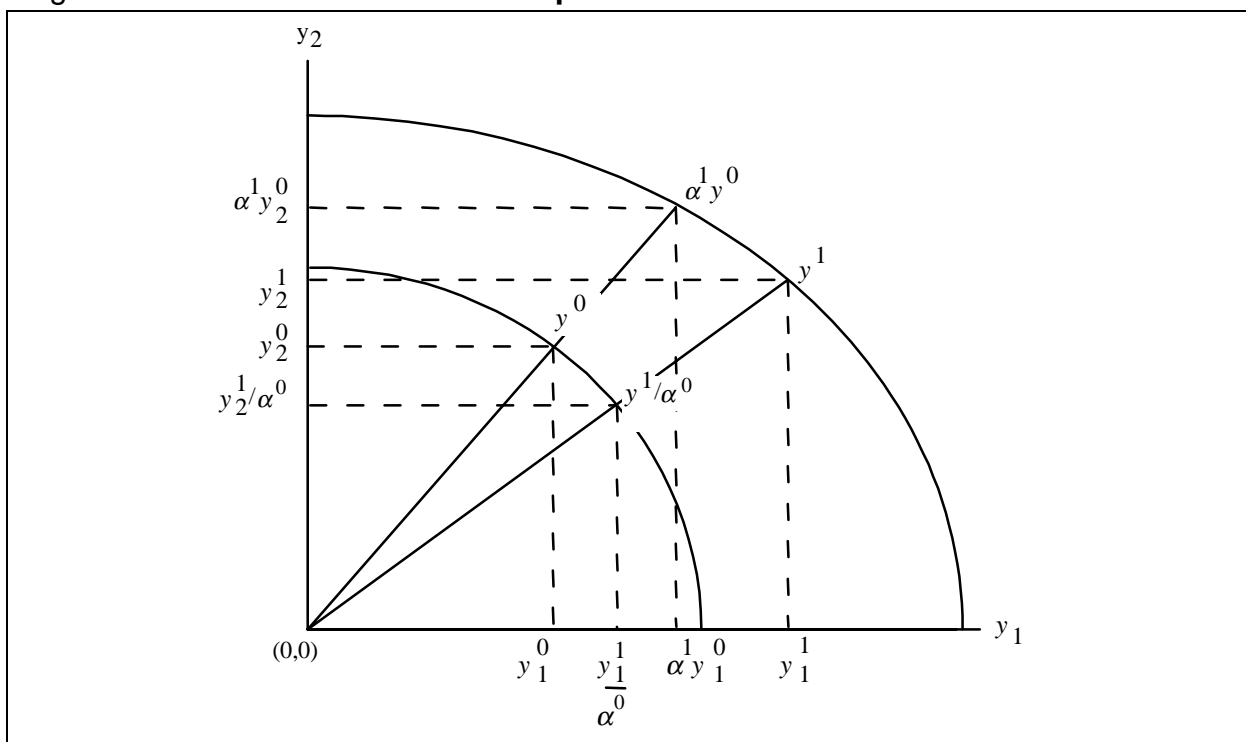
⁶ Econometric methods for estimating production functions are reviewed in Jorgenson (1986), Diewert (1992a), and Berndt (1991).

In the many output case, both α^0 and α^1 can be interpreted as aggregate rates of growth of output going from period 0 to period 1 and in the one output case both α^0 and α^1 equal the single output growth rate y^1 / y^0 that occurred in section 2.

The output indexes α^0 and α^1 correspond to the two Malmquist output indexes defined in Caves, Christensen, and Diewert (1982, p.1400). Similar indexes were developed in the consumer context by Malmquist (1953) and in the producer context by Moorsteen (1961) and Hicks (1961; 1981, pp.192 and 256).

If there are two outputs, then the two output indexes can be illustrated in a diagram; see Figure A2. The lower curved line in Figure A3 represents the set of outputs that can be produced with period 0 technology and inputs (the set $\{(y_1, y_2,) : y_1 = f^0(y_2, x^0)\}$) and the higher curved line represents the set of outputs that can be produced with period 1 inputs and technology (the set $\{(y_1, y_2,) : y_1 = f^1(y_2, x^1)\}$). The period 1 output possibilities set will generally be higher than the period 0 output possibilities set for two reasons: (i) technical progress and (ii) input growth.⁷ In Figure A3, the point $\alpha^1 y^0$ is the straight line projection of the period 0 output vector $y^0 = [y_1^0, y_2^0]$ onto the period 1 output possibilities set and $y^1 / \alpha^0 = [y_1^1 / \alpha^0, y_2^1 / \alpha^0]$ is the straight line contraction of the period 1 output vector $y^1 = [y_1^1, y_2^1]$ onto the period 0 output possibilities set.

Figure A2: Alternative economic output indexes illustrated



⁷ However, if there were technical regress (so that production becomes less efficient in period 1 compared to period 0) or if the utilisation of inputs declined going from period 0 to period 1, then the period 1 output production possibilities set could lie below the period 0 output set.

Since there is no particular reason to prefer the output index α^0 over α^1 , it is useful to measure aggregate output growth going from period 0 to 1 by taking a symmetric average of α^0 and α^1 . Thus, we define the aggregate output growth rate α as the geometric mean of α^0 and α^1 :

$$(32) \quad \alpha \equiv [\alpha^0 \alpha^1]^{1/2}$$

We turn now to the problem of constructing input growth indexes when there are N inputs.

Define the input index β^0 as the number which satisfies the following equation:

$$(33) \quad y_1^0 = f^0(\tilde{y}^0, x^1 / \beta^0) \equiv f^0(y_2^0, \dots, y_M^0, x_1^1 / \beta^0, \dots, x_N^1 / \beta^0).$$

If there is only one input so that $N = 1$, then using (29), we have $y_1^0 = f^0(\tilde{y}^0, x_1^0)$ and from (33), we have $y_1^0 = f^0(\tilde{y}^0, x_1^1 / \beta^0)$. Thus, $x_1^0 = x_1^1 / \beta^0$ or $\beta^0 = x_1^1 / x_1^0$, the (single) input growth rate. In the many input case, it can be seen that x^1 / β^0 is a deflated period 1 input vector that is “equivalent” to the period 0 input vector x^0 using the period 0 technology, since we have $f^0(\tilde{y}^0, x^1 / \beta^0) = f^0(\tilde{y}^0, x^0)$. Thus, β^0 is the number which proportionally deflates the period 1 input vector x^1 into a vector which is “equivalent” to the period 0 input vector x^0 . Hence, β^0 can be interpreted as an aggregate input growth rate.

Define the input index β^1 as the solution to the following equation:

$$(34) \quad y_1^1 = f^1(\tilde{y}^1, \beta^1 x^0) \equiv f^1(y_2^1, \dots, y_M^1, \beta^1 x_1^0, \dots, \beta^1 x_N^0).$$

If $N = 1$ so that there is only one input, then (29) and (34) imply that $f^1(\tilde{y}^1, x_1^1) = f^1(\tilde{y}^1, \beta^1 x_1^0)$ or $x_1^1 = \beta^1 x_1^0$ or $\beta^1 = x_1^1 / x_1^0$, the (single) input growth rate. In the general many input case, it can be seen that $\beta^1 x^0$ is an inflated period 0 input vector that is “equivalent” to the period 1 input vector x^1 using the period 1 technology, since we have $f^1(\tilde{y}^1, \beta^1 x^0) = f^1(\tilde{y}^1, x^1)$. Thus, β^1 is the number which proportionally inflates the period 0 input vector into a vector which is “equivalent” to the period 1 input vector and thus β^1 can be interpreted as an aggregate input growth rate.

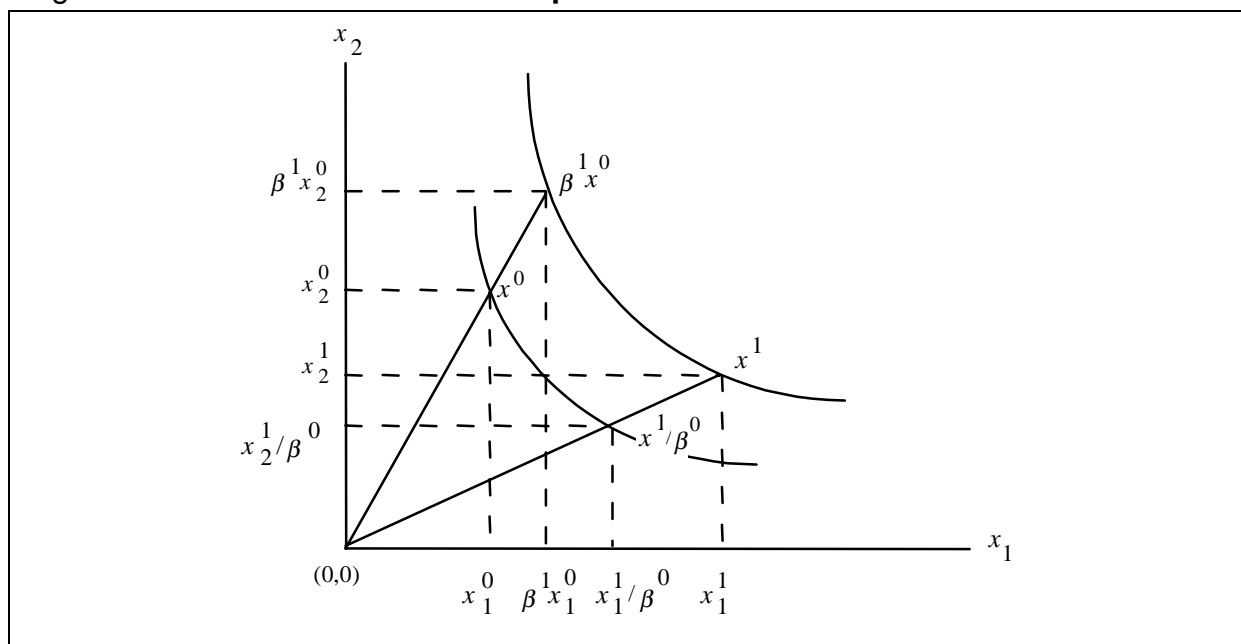
In the general many input, many output case, β^0 and β^1 are the two Malmquist input indexes defined in Caves, Christensen, and Diewert (1982, p.1396).

Figure A3 illustrates the two input indexes when there are only two inputs. The lower curved line in Figure A3 represents the set of inputs that are needed to produce the vector of period 0 outputs y^0 using period 0 technology (the set $\{(x_1, x_2) : y_1^0 = f^0(\tilde{y}^0, x_1, x_2)\}$) and the higher curved line represents the set of inputs that are needed to produce the period 1 vector of outputs y^1 using period 1 technology (the set $\{(x_1, x_2) : y_1^1 = f^1(\tilde{y}^1, x_1, x_2)\}$).⁸ The point

⁸ If technical progress were sufficiently positive or if output growth between the two periods were sufficiently negative, then the period 1 input requirements set could lie *below* the period 0 input requirements set instead of above.

$\beta^1 x^0 = [\beta^1 x_1^0, \beta^1 x_2^0]$ is the straight line projection of the period 0 input vector $x^0 = [x_1^0, x_2^0]$ onto the period 1 input requirements set and $x^1 / \beta^0 = [x_1^1 / \beta^0, x_2^1 / \beta^0]$ is the straight line contraction of the period 1 input vector $x^1 = [x_1^1, x_2^1]$ onto the period 0 input requirements set.

Figure A3: **Alternative economic input indexes illustrated**



As was the case with output indexes, there is no reason to prefer β^0 to β^1 . Thus, we define aggregate input growth β as the geometric average of β^0 and β^1

$$(35) \quad \beta \equiv [\beta^0 \beta^1]^{1/2}.$$

Once output growth has been defined by (32) and input growth by (35), we can define total factor productivity in the many output, many input case by

$$(36) \quad TFP(1) \equiv \alpha / \beta.$$

In the case of only one output and one input, $TFP(1)$ defined by (36) reduces to $TFP(1)$ defined earlier by (3).

We now turn our attention to the measurement of productivity under the assumption that the firm is engaging in cost minimising behaviour during periods 0 and 1.

4. Productivity measurement and cost functions

The use of cost functions to estimate productivity change involves an extra assumption over the production function techniques described in the previous section: the assumption of competitive cost minimising behaviour on the part of the firm. However, the use of cost

functions has a major advantage over production functions in that statistical estimation of the unknown parameters that characterise technology is much more accurate using cost function techniques.

Recall the period t production function f^t that appeared in the previous section. This production function is used to define the *period t cost function* $c^t(y_1, y_2, \dots, y_M, w_1, w_2, \dots, w_N)$, which is defined as the minimum cost of producing the quantity y_m of output m for $m = 1, 2, \dots, M$, given that the firm has available the period t technology which can be summarised by the production function constraint $y_1 = f^t(y_2, \dots, y_M, x_1, w_2, \dots, x_N)$ and given that the firm faces the input price w_n for input n for $n = 1, 2, \dots, N$.

The problems involved in choosing a functional form for the cost function and the associated statistical estimation problems are discussed by Berndt (1991), Diewert (1982; 1992a), Fuss and McFadden (1978) and Jorgenson (1986). We note that these statistical problems are rather formidable.

In this section, we shall assume that the period 0 and 1 cost functions c^0 and c^1 are known and we shall discuss various output, input and productivity indexes that are defined directly in terms of these two cost functions.

In order to save space, it is convenient to use vector notation. Thus, for $t = 0, 1$, define the period t observed output vector of the firm by $y^t \equiv [y_1^t, \dots, y_M^t]$, the period t observed input vector of the firm by $x^t \equiv [x_1^t, \dots, x_N^t]$ and the period t observed input price vector by $w^t \equiv [w_1^t, \dots, w_M^t]$. The inner product of the vectors w^t and x^t is defined as:

$$(37) \quad w^t \cdot x^t \equiv \sum_{n=1}^N w_n^t x_n^t.$$

In this section, we assume cost minimising behaviour on the part of the firm for periods 0 and 1; ie. we assume that the observed period t cost $w^t \cdot x^t$ equals the period t cost function c^t evaluated at the period t output vector y^t and at the period t input price vector w^t :

$$(38) \quad w^t \cdot x^t \equiv c^t(y^t, w^t), \quad t = 0, 1.$$

Before we define some new output indexes, it is first necessary to assume that the period t cost function $c^t(y, w)$ is differentiable with respect to the components of the vector y at the point (y^t, w^t) for $t = 0, 1$. With these differentiability assumptions, we can define the *ith marginal cost* for period t , mc_i^t as follows:

$$(39) \quad mc_i^t \equiv \partial c^t(y^t, w^t) / \partial y_i, \quad i = 1, 2, \dots, N; \quad t = 0, 1.$$

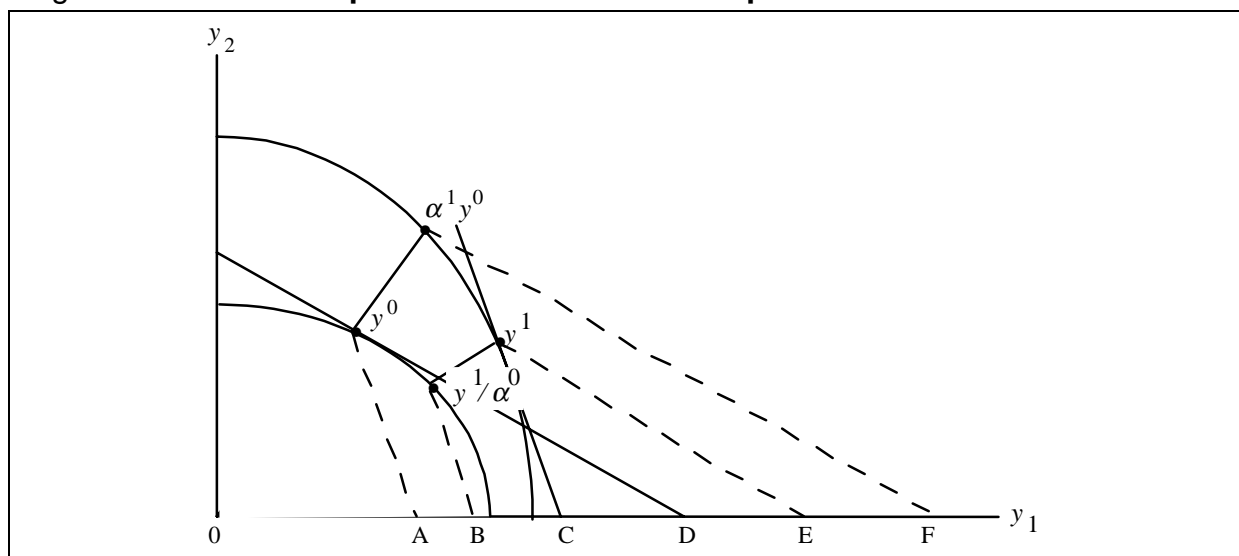
Define the period t marginal cost vector as $mc^t \equiv [mc_1^t, mc_2^t, mc_N^t]$ for $t = 0, 1$. The two marginal cost vectors mc^0 and mc^1 can be used as weighting vectors in order to define the *output indexes* γ^0 and γ^1 as follows:

$$(40) \quad \gamma^0 \equiv mc^0 \cdot y^1 / mc^0 \cdot y^0, \quad \gamma^1 \equiv mc^1 \cdot y^1 / mc^1 \cdot y^0.$$

It can be seen that γ^0 is a Laspeyres type output index which uses the period 0 vector of marginal costs mc^0 as weights and γ^1 is a Paasche type output index which uses the period 1 vector of marginal costs mc^1 as weights for the output quantities.

If there is price taking profit maximising behaviour in each period $t = 0, 1$, then γ^1 will solve maximise $y\{p^t \cdot y - c^t(y, w^t)\}$ for $t = 0, 1$ where $p^t \equiv [p_1^t, \dots, p_M^t]$ is the period t vector of output prices that the firm faces. The first order necessary conditions for the period t profit maximisation problem are $p^t = mc^t$, for $t = 0, 1$. Thus, under the hypothesis of profit maximising behaviour, $\gamma^0 = p^0 \cdot y^1 / p^0 \cdot y^0$ (the Laspeyres output index) and $\gamma^1 = p^1 \cdot y^1 / p^1 \cdot y^0$ (the Paasche output index). However, we do not necessarily want to assume price taking profit maximising behaviour in this Appendix since it is not consistent with an increasing returns to scale technology and moreover, firms may behave monopolistically.

Figure A4: Alternative price based economic output indexes



In the case of two outputs, the difference between the new output indexes γ^t and our old Malmquist output indexes α^t defined in the previous section can be illustrated in Figure A4. The lower curved line in Figure A4 is the period 0 output possibilities set, $\{(y_1, y_2): y_1 = f^0(y_2, x^0)\}$ and the higher curved line is the period 1 output possibilities set, $\{(y_1, y_2): y_1 = f^1(y_2, x^1)\}$. The straight line ending in D is tangent to the period 0 output possibilities set at the period 0 output vector $y^0 \equiv [y_1^0, y_2^0]$ and the straight line ending in C is tangent to the period 1 output possibilities set at the period 1 observed output vector $y^1 \equiv [y_1^1, y_2^1]$. It can be shown that the tangent line through y^0 has slope equal to

$-mc_1^0 / mc_2^0$ and the tangent line through y^1 has slope equal to $-mc_1^1 / mc_2^1$ where the mc_i^t are the period t marginal costs. The straight line ending in E passes through y^1 and the straight line ending in F passes through $\alpha^1 y^0$ and both of these lines are parallel to the line ending in D . The straight line ending in A passes through y^0 and the straight line ending in B passes through y^1 / α^0 and both of these lines are parallel to the line ending in C . The output index $\gamma^0 = OE / OD < OF / OD = \alpha^1$ and $\gamma^1 = OE / OD < OF / OD = \alpha^0$. Note that although the four output indexes are quite different in magnitude, the geometric average of γ^0 and γ^1 is reasonably close to the geometric average of α^0 and α^1 .

Since we have no reason to prefer γ^0 over γ^1 we define an aggregate marginal cost weighted output growth rate γ as the geometric mean of γ^0 and γ^1 :

$$(41) \quad \gamma \equiv [\gamma^0 \gamma^1]^{1/2}.$$

If there is only one output, it can be readily verified that $\gamma^0 = \gamma^1 = \gamma = y_1^1 / y_1^0$, the growth rate for the single output.

The cost functions c^0 and c^1 can also be used to define directly two indexes of input growth δ^0 and δ^1 as follows:⁹

$$(42) \quad \delta^0 \equiv c^1(y^1, w^0) / c^0(y^0, w^0); \quad \delta^1 \equiv c^1(y^1, w^1) / c^0(y^0, w^1).$$

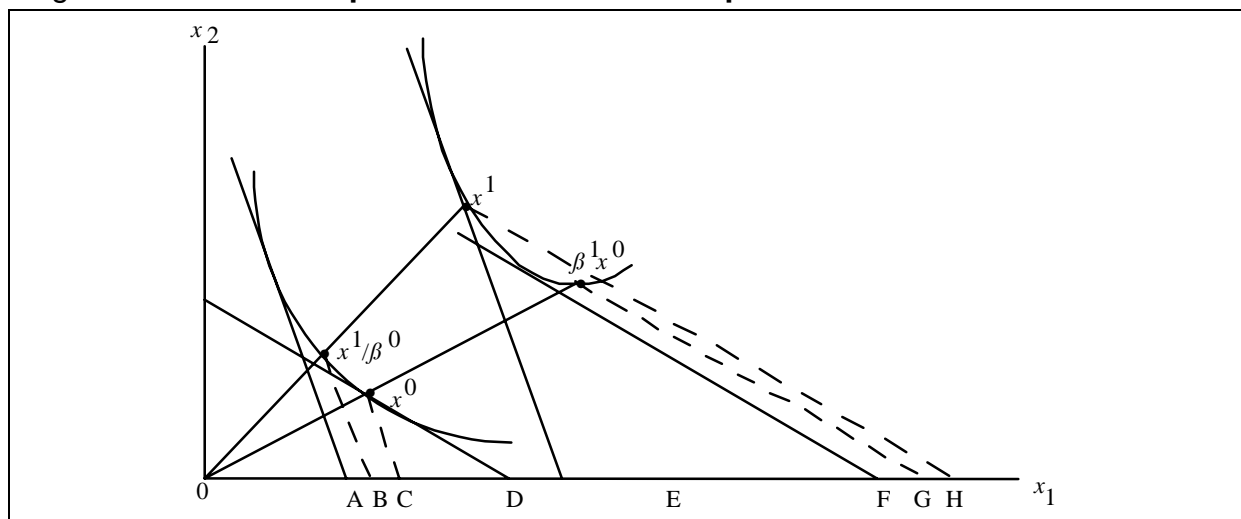
To interpret δ^0 , note that $c^0(y^0, w^0) = w^0 \cdot x^0$ is period 0 observed cost, while $c^1(y^1, w^0)$ is the minimum cost of producing the period 1 output vector y^1 using the period 1 technology but facing the period 0 input prices w^0 . Since input prices are held constant in the two costs, their ratio $c^1(y^1, w^0) / c^0(y^0, w^0) = \delta^0$ is an indicator of overall input growth during the two periods. Similarly $c^1(y^1, w^1) = w^1 \cdot x^1$ is the period 1 observed cost while $c^0(y^0, w^1)$ is the minimum cost of producing the period 0 output vector y^0 using the period 0 technology but facing the period 1 input prices w^1 . Since input prices are held constant in these two costs, their ratio $c^1(y^1, w^1) / c^0(y^0, w^1) = \delta^1$ is a measure of overall input growth during the two periods.

If there are only two inputs, then δ^0 and δ^1 can be compared with the Malmquist input indexes β^0 and β^1 defined in section 2 above. The lower curved line in Figure A5 is the set of input combinations (x_1, x_2) that can produce the period 0 output vector y^0 using the period 0 technology, $\{(x^1, x^2) : y_1^0 = f^0(y_2^0, \dots, y_M^0, x_1, x_2)\}$ and the upper curved line is the set of input combinations that can produce the period 1 output vector $y^1 \equiv [y_1^1, y_2^1, \dots, y_M^1]$ using the period 1 production function $f^1, \{(x_1, x_2) : y_1^1 = f^1(y_2^1, \dots, y_M^1, x_1, x_2)\}$. The straight line ending at the point E in

⁹ If there is only one output and if $c^0 = c^1$, the indexes δ^0 and δ^1 reduce to two quantity indexes which were originally proposed by Allen (1949, p.199) in the consumer context.

Figure A6 is tangent to the input possibilities curve for period 1 at the observed period 1 input vector $x^1 \equiv [x_1^1, x_2^1]$. This tangent line to x^1 has slope equal to $-w_1^1 / w_2^1$ and the lines ending in A, B, and C have this same slope. The line ending at the point C passes through the period 0 observed input vector $x^0 \equiv [x_1^0, x_2^0]$ the line ending at B passes through $x^1 / \beta^0 \equiv [x_1^1 / \beta^0, x_2^1 / \beta^0]$ and the line at A is tangent to the period 0 input possibilities set. The straight line ending at the point D in Figure A5 is tangent to the period 0 input possibilities set at the point $x^0 \equiv [x_1^0, x_2^0]$, the period 0 observed input vector. The slope of this tangent line¹⁰ is $-w_1^0 / w_2^0$ and the lines ending in F, G, and H have the same slope. The line ending at H have the same slope. The line ending at H passes through x^1 , the line ending at G passes through $\beta^1 x^0 \equiv [\beta^1 x_1^0, \beta^1 x_2^0]$, and the line ending at F is tangent to the period 1 input possibilities curve. It can be shown that $\delta^0 = OF / OD < OG / OD = \beta^1$ and that $\delta^1 = OE / OA > OE / OB = \beta^0$.

Figure A5: Alternative price based economic input indexes



Since we have no reason to prefer δ^0 to δ^1 as a measure of input growth, we prefer to use their geometric average δ as a single overall index of input growth:

$$(43) \quad \delta \equiv [\delta^0 \delta^1]^{1/2}.$$

In the case where $N = 1$ so that there is only one input, it can be shown that $\delta^0 = \delta^1 = \delta = x_1^1 / x_1^0$, the single input growth rate.

Finally, Laspeyres and Paasche indexes of input growth, ϵ^0 and ϵ^1 , respectively, can be defined as follows:

¹⁰ This tangency relation follows using Shephard's (1953, p.11) Lemma: $x_1^0 = \partial c^0(y^0, w_1^0, w_2^0) / \partial w_1$ and $x_2^0 = \partial c^0(y^0, w_1^0, w_2^0) / \partial w_2$. Similarly, the fact that the tangent line ending at E has slope equal to w_1^1 / w_2^1 follows from $x_1^1 = \partial c^1(y^1, w_1^1, w_2^1) / \partial w_1$ and $x_2^1 = \partial c^1(y^1, w_1^1, w_2^1) / \partial w_2$.

$$(44) \quad \varepsilon^0 \equiv w^0 \cdot x^1 / w^0 \cdot x^0;$$

$$(45) \quad \varepsilon^1 \equiv w^1 \cdot x^1 / w^1 \cdot x^0.$$

For the two input case (see Figure A6), $\varepsilon^0 = OH / OD > OF / OD = \delta^0$ and $\varepsilon^1 = OE / OC < OE / OA = \delta^1$.

To interpret ε^0 and ε^1 in terms of costs, note that ε^0 compares the cost of the period 1 input vector x^1 to the cost of the period 0 input vector x^0 using the period 0 input price vector w^0 as a common set of price weights while ε^1 compares the cost of x^1 to the cost of x^0 using the period 1 input price vector w^1 as the common set of price weights.

Since there is no reason to prefer ε^0 over ε^1 we take the geometric average ε of ε^0 and ε^1 as a preferred single measure of input growth:

$$(46) \quad \varepsilon \equiv [\varepsilon^0 \varepsilon^1]^{1/2}.$$

The input index ε is a Fisher (1922) ideal input quantity index.

So far we have developed three distinct indexes of output growth using the cost function (γ^0, γ^1 and γ defined by (40) and (41)) and six distinct indexes of input growth ε^0 and ε defined by (42)–(46). All three of these output indexes reduce to the single output growth rate used in section 2 if there is only one output and all six of these input indexes reduce to the single input growth rate used in section 2 if there is only one input.

In the general M output, N input case, many indexes of total factor productivity can be defined: simply take any of the aggregate output growth rates and divide by an aggregate input growth rate. Each such alternative *TFP* is a valid productivity measure. A few of the more interesting alternative measures of *TFP* that are based on the cost function in some way are defined below by (47)–(50):

$$(47) \quad TFP(5) \equiv \gamma / \delta^0;$$

$$(48) \quad TFP(6) \equiv \gamma / \delta^1;$$

$$(49) \quad TFP(6) \equiv \gamma / \delta;$$

$$(50) \quad TFP(8) \equiv \gamma / \varepsilon.$$

The productivity measures developed in this section and the previous section all make use of either the production function concept or the cost function concept and hence these measures can be regarded as *economics based* definitions of productivity. The results of these two sections demonstrate that there are a number of alternative economics based productivity measures and the selection of any one of these measure as *the* measure of total factor productivity is bound to be somewhat arbitrary (except in the one input, one output case,

where all of our economics based productivity measures collapse down to the TFP measure defined in section 2).

We now turn to some approaches to the measurement of productivity that do not rely on the assumption that the cost or production function has been statistically estimated.

5. The axiomatic or test approach to productivity measurement

Recall our first definition of productivity change in the one output, one input case (3), $TFP(1) \equiv [y^1 / y^0] / [x^1 / x^0]$, which was the output ratio divided by the input ratio between periods 0 and 1. In the multiple output, multiple input case, the output ratio is replaced by an output quantity index Q and the input ratio is replaced by an input quantity index Q^* .

An output quantity index is defined to be a function of the output price and quantities for the two periods under consideration. As usual, in order to save space, we denote the entire collection of period t output prices by the symbol p^t and the entire collection of output quantities by the symbol y^t ie. we have $p^t \equiv (p_1^t, p_2^t, \dots, p_M^t)$ and $y^t \equiv (y_1^t, y_2^t, \dots, y_M^t)$ for $t = 0, 1$.

Similarly, we denote the period t collection of input prices by w^t and the period t collection of input quantities by x^t for periods $t = 0, 1$; ie. we have

$$(51) \quad w^t \equiv (w_1^t, w_2^t, \dots, w_N^t) \text{ and } x^t \equiv (x_1^t, x_2^t, \dots, x_N^t) \text{ for } t = 0, 1.$$

Thus, an *output quantity index* between period 0 and 1, $Q(p^0, p^1, y^0, y^1)$, is simply a function of $4M$ variables, the output prices and quantities pertaining to the two periods under consideration. Similarly, an *input quantity index* between periods 0 and 1, $Q^*(w^0, w^1, x^0, x^1)$ is simply a function of $4N$ variables, the input prices and quantities pertaining to the two periods under consideration.

Two of the most frequently used functional forms for quantity indexes are the Laspeyres (1871) and Paasche (1874) quantity indexes. The Laspeyres output quantity index between periods 0 and 1 is defined as:

$$(52) \quad Q_L(p^0, p^1, y^0, y^1) \equiv \sum_{i=1}^M p_i^0 y_i^1 / \sum_{j=1}^M p_j^0 y_j^0 = p^0 \cdot y^1 / p^0 \cdot y^0.$$

The Paasche output quantity index between periods 0 and 1 is defined as:

$$(53) \quad Q_P(p^0, p^1, y^0, y^1) \equiv \sum_{i=1}^M p_i^1 y_i^1 / \sum_{j=1}^M p_j^1 y_j^0 = p^1 \cdot y^1 / p^1 \cdot y^0.$$

Note that the period 0 prices, $p^0 \equiv (p_1^0, p_2^0, \dots, p_M^0)$ are used as weights for the quantities in the Laspeyres formula (52) while the period 1 prices, $p^1 \equiv (p_1^1, p_2^1, \dots, p_M^1)$ are used as weights in the Paasche formula (53).

The Laspeyres and Paasche input quantity indexes between periods 0 and 1, $Q_L^*(w^0, w^1, x^0, x^1)$ and $Q_P^*(w^0, w^1, x^0, x^1)$ respectively, are defined analogously to (52) and (53) except that input prices and quantities replace output prices and quantities; ie. we have:

$$(54) \quad Q_L^*(w^0, w^1, x^0, x^1) \equiv \sum_{i=1}^N w_i^0 x_i^1 / \sum_{j=1}^N w_j^0 x_j^0 = w^0 \cdot x^1 / w^0 \cdot x^0 ;$$

$$(55) \quad Q_P^*(w^0, w^1, x^0, x^1) \equiv \sum_{i=1}^N w_i^1 x_i^1 / \sum_{j=1}^N w_j^1 x_j^0 = w^1 \cdot x^1 / w^1 \cdot x^0 .$$

In what follows, we shall concentrate on the problems involved in choosing a functional form for the output index Q ; an analogous discussion applies to the choice of a functional form for the input index Q^* .

Another commonly used functional form for a quantity index is the Fisher (1922, p.234) ideal quantity index Q_F which is equal to the square root of the product of the Laspeyres and Paasche quantity index defined by (52) and (53); ie.

$$(56) \quad Q_F(p^0, p^1, y^0, y^1) \equiv [Q_L(p^0, p^1, y^0, y^1) Q_P(p^0, p^1, y^0, y^1)]^{1/2} .$$

Yet another commonly used functional form for a quantity index is the Törnqvist (1936) quantity index Q_T . The natural logarithm of Q_T is defined to be the right-hand side of formula (57) below:

$$(57) \quad \ln Q_T(p^0, p^1, y^0, y^1) = (1/2) \sum_{m=1}^M [(p_m^0 y_m^0 / p^0 \cdot y^0) + (p_m^1 y_m^1 / p^1 \cdot y^1)] \ln(y_m^1 / y_m^0) .$$

The quantity index Q_T is also known as the *translog quantity index* (eg. see Jorgenson and Nishimizu (1978) who introduced this terminology) because Diewert (1976, p.120) related Q_T to a translog production function. The index is also known as the Divisia index since Jorgenson and Griliches (1967; 1972) used Q_T to provide a discrete time approximation to the continuous time Divisia index (which is considered in section 8 below).

The four quantity indexes Q_L, Q_P, Q_F , and Q_T defined by (52), (53), (56), and (57) respectively, all have a common property: if the number of outputs M equals one, then each of these quantity indexes reduces to the output ratio, y_1^1 / y_1^0 . Thus, it can be seen that the use of quantity indexes for outputs and inputs generalises our one output, one input measure of productivity change, $TFP(1)$ defined by (3), discussed in section 2 above. More formally, let us define the direct quantity index measure of productivity change $TFP(9)$ in the general multiple output, multiple input case as follows:

$$(58) \quad TFP(9) \equiv Q(p^0, p^1, y^0, y^1) / Q^*(w^0, w^1, x^0, x^1)$$

where Q is the output quantity index and Q^* is the input quantity index. If the number of outputs equals one and the number of inputs equals one, if Q equals Q_L, Q_P, Q_F , or Q_T and if Q^* equals Q_L^*, Q_P^*, Q_F^* , or Q_T^* , then

$$(59) \quad TFP(9) = TFP(1)$$

where $TFP(1)$ was defined by (3) and $TFP(9)$ is defined by (58). Thus, the approach to productivity measurement outlined in this section reduces to the approach outlined in section 2 if there is only one input and only one output.

In the general multiple output, multiple input case, we still have to address a problem: which functional forms for the output index Q and the input index Q^* should we choose? We shall return to this functional form problem shortly.

We turn now to an index number measure of productivity that generalises the deflated revenues divided by deflated costs productivity measure $TFP(3)$ that was defined earlier by (7).

Denote period t revenue by R^t and period t cost by C^t . We have

$$(60) \quad R^t \equiv \sum_{m=1}^M p_m^t y_m^t \equiv p^t \cdot y^t; C^t \equiv \sum_{n=1}^N w_n^t x_n^t \equiv w^t \cdot x^t \text{ for } t = 0, 1.$$

The multiple output analogue to the output price ratio which occurred in formula (7) above is the *output price index* $P(p^0, p^1, y^0, y^1)$, which is a function of $4M$ variables, the output prices and quantities that pertain to the two periods under consideration. The multiple input analogue to the input price ratio which occurred in (7) above is the *input price index* $P^*(w^0, w^1, x^0, x^1)$ which is a function of $4N$ variables, the input prices and quantities that pertain to the two periods under consideration.

Using the output price index P as a deflator for the revenue ratio R^1 / R^0 between periods 0 and 1 and using the input price ratio P^* as a deflator for the cost ratio C^1 / C^0 between the two periods leads to the following definition of the firm's productivity change going from period 0 to 1:

$$(61) \quad TFP(10) \equiv [(R^1 / R^0) / P(p^0, p^1, y^0, y^1)] / [(C^1 / C^0) / P^*(w^0, w^1, x^0, x^1)].$$

Note that (61) is a generalisation to multiple inputs and outputs of our earlier productivity change measure $TFP(3)$ defined by (7).

There remains the problem of choosing a functional form for the output price index P and the input price index P^* . The same four index number formulae that were used for quantity indexes, (52), (53), (56), and (57) are also used for price indexes, except that the role of prices and quantities are interchanged. Thus, define the Laspeyres price index P_L , the Paasche price

index P_P the Fisher price index P_F and the translog price index P_T by (62), (63), (64), and (65), respectively:

$$(62) \quad P_L(p^0, p^1, y^0, y^1) \equiv Q_L(y^0, y^1, p^0, p^1);$$

$$(63) \quad P_P(p^0, p^1, y^0, y^1) \equiv Q_P(y^0, y^1, p^0, p^1);$$

$$(64) \quad P_F(p^0, p^1, y^0, y^1) \equiv Q_F(y^0, y^1, p^0, p^1);$$

$$(65) \quad P_T(p^0, p^1, y^0, y^1) \equiv Q_T(y^0, y^1, p^0, p^1).$$

Thus, the price indexes are equal to the corresponding quantity indexes with the role of prices and quantities interchanged in the quantity indexes. The input price indexes $P_L^*(w^0, w^1, x^0, x^1)$, $P_P^*(w^0, w^1, x^0, x^1)$, $P_F^*(w^0, w^1, x^0, x^1)$ and $P_T^*(w^0, w^1, x^0, x^1)$ may be defined in an analogous manner.

If $M = 1$, so that there is only one output, then it can be verified that the output price indexes defined by (62)–(65) all collapse down to the output price ratio, p_1^1 / p_1^0 . Similarly, if $N = 1$, so that there is only one input, then P_L^* , P_P^* , P_F^* and P_T^* all collapse down to the input price ratio, w_1^1 / w_1^0 . Thus, the use of the Laspeyres, Paasche, Fisher or translog price indexes in (61) leads to the following equality in the $M = 1, N = 1$ case:

$$(66) \quad TFP(10) = TFP(3)$$

where $TFP(3)$ was defined by (7) and $TFP(10)$ is defined by (61). Thus, our new definition of productivity change defined by (61) is a generalisation to many outputs and inputs of our earlier one output, one input measure of productivity change defined by (7).

Returning to the general case of many outputs and many inputs, it can be seen that different choices of the output price index P and the input price index P^* will generate different productivity change measures $TFP(10)$ defined by (61). The situation is similar to the problem we encountered with the $TFP(9)$ definition of productivity change given by (58), where different choices of the output quantity index Q and the input quantity index Q^* led to different measures $TFP(9)$.

However, the degree of arbitrariness in the formulae (58) and (61) is not quite as large as it might seem at first glance. It turns out that the two families of productivity measures are related, because the deflated revenue ratio which occurs in the numerator of the right-hand side of (61) $(R^1 / R^0) / P(p^0, p^1, y^0, y^1)$ can be interpreted as an implicit quantity index of outputs, and the denominator in (61), $(C^1 / C^0) / P^*(w^0, w^1, x^0, x^1)$, can be interpreted as an implicit quantity index of inputs.

To see the above point more clearly, let us determine what $(R^1 / R^0) / P(p^0, p^1, y^0, y^1)$ equals when we let P equal the four specific price indexes defined by (62)–(65). We find that

$$(67) \quad [R^1 / R^0] / P_L(p^0, p^1, y^0, y^1) = Q_P(p^0, p^1, y^0, y^1);$$

$$(68) \quad [R^1 / R^0] / P_P(p^0, p^1, y^0, y^1) = Q_L(p^0, p^1, y^0, y^1);$$

$$(69) \quad [R^1 / R^0] / P_F(p^0, p^1, y^0, y^1) = Q_F(p^0, p^1, y^0, y^1);$$

$$(70) \quad [R^1 / R^0] / P_T(p^0, p^1, y^0, y^1) = \tilde{Q}_T(p^0, p^1, y^0, y^1).$$

where Q_P is the Paasche quantity index defined by (53), Q_L is the Laspeyres quantity index defined by (52), and Q_F is the Fisher quantity index defined by (56). Since the left-hand side of (70) does not simplify into a quantity index that we have already defined, we simply define the implicit translog quantity index Q_T as the left-hand side of (70).

Formula (67) shows that a Laspeyres price index corresponds to a Paasche quantity index, (68) shows that a Laspeyres price index corresponds to a Paasche quantity index, and (69) shows that deflating the revenue ratio by a Fisher price index leads to a Fisher quantity index. However, deflation of the revenue ratio by the translog price index did not lead to the translog quantity index but rather it led to a new quantity index Q_T .

The five quantity indexes Q_L , Q_P , Q_F , Q_T , and \tilde{Q}_T defined by (52), (53), (56), (57), and (70) are the five functional forms for quantity indexes that are used most frequently in applied economics.

We turn now to the problem of choosing a functional form for the quantity index using the test approach.

Recall that $P(p^0, p^1, y^0, y^1)$ denoted an output price index and $Q(p^0, p^1, y^0, y^1)$ denoted an output quantity index. The *test or axiomatic approach* to the determination of the functional form for P and Q works as follows: researchers suggest various mathematical properties that P or Q should satisfy based on a priori reasoning — these properties are called "tests" or "axioms" — and then mathematical reasoning is applied to determine: (i) whether the *a priori* tests are mutually consistent and (ii) whether the *a priori* tests uniquely determine the functional form for P or Q . The main contributors to the test or axiomatic approach were Walsh (1901; 1922), Irving Fisher (1911; 1922), Eichhorn (1976), Eichhorn and Voeller (1976) and Funke and Voeller (1978; 1979).

One fundamental test that the price and quantity index should jointly satisfy is the following property:

$$(71) \quad P(p^0, p^1, y^0, y^1) Q(p^0, p^1, y^0, y^1) = R^1 / R^0$$

ie. the product of the output price and quantity indexes between periods 0 and 1 should equal the revenue or value ratio between the two periods, $R^1 / R^0 = \sum_{i=1}^M p_i^1 y_i^1 / \sum_{j=1}^N p_j^0 y_j^0$.

This test was called the *product test* by Frisch (1930, p.399), but it was first formulated by Irving Fisher (1911, p.388).

If we accept the validity of the product test (and virtually all researchers do accept its validity), then P and Q cannot be determined independently. For example, if the functional form for the price index P is given, then (71) determines the functional form for the quantity index Q ; ie. we have

$$(72) \quad Q(p^0, p^1, y^0, y^1) = [R^1 / R^0] / P(p^0, p^1, y^0, y^1).$$

Thus, in what follows, we focus in on the determination of the functional form for the price index P . Once P has been determined, Q will be determined by (72).

We list a few examples of tests that have been proposed for price indexes.

The *Identity* or *Constant Prices Test*, originally proposed by Laspeyres (1871, p.308) and also by Walsh (1901, p.308), and Eichhorn and Voeller (1976, p.24) is

$$(73) \quad P(p, p, y^0, y^1) = 1;$$

ie. if $p^0 = p \equiv (p_1, \dots, p_M) = p^1$ so that all prices are equal in the two periods, then the price index should be one no matter what the quantities are in period 0 and 1, y^0 and y^1 respectively.

The *Constant Basket Test* or the *Constant Quantities Test*, proposed by many researchers including Walsh (1901, p.540) is

$$(74) \quad P(p^0, p^1, y, y) = \sum_{i=1}^N p_i^1 y_i / \sum_{j=1}^N p_j^0 y_j = p^1 \cdot y / p^0 \cdot y;$$

ie. if quantities are constant over the two periods 0 and 1 so that $y^0 = y^1 = y \equiv (y_1, \dots, y_M)$ then the level of prices in period 1 compared to period 0 is the value of the constant basket of quantities evaluated at the period t prices, $\sum_{i=1}^N p_i^1 y_i$, divided by the value of the basket evaluated at the period 0 prices, $\sum_{j=1}^N p_j^0 y_j$.

The *Proportionality in Period t Prices Test*, proposed by Walsh (1901, p.385) and Eichhorn and Voeller (1976, p.24), is

$$(75) \quad P(p^0, \lambda p^1, y^0, y^1) = \lambda P(p^0, p^1, y^0, y^1) \text{ for } \lambda > 0.$$

ie, if each price in period 1 is multiplied by the positive constant λ , then the level of prices in period 1 relative to the level of prices in period 0 increases by the same positive constant λ .

Our final example of a price index test is the *Time Reversal Test*, which was first informally proposed by Pierson (1896, p.128) and more formally by Walsh (1901, p.368; 1921, p.541), and Fisher (1922, p.64):

$$(76) \quad P(p^1, p^0, y^1, y^0) = 1 / P(p^0, p^1, y^0, y^1);$$

ie. if the prices and quantities for periods 0 and 1 are interchanged, then the resulting price index is the reciprocal of the original price index.

The four tests (73)–(76) will suffice to give the reader the flavour of the test approach to index number theory. For a much more extensive list of twenty or so tests, see Diewert (1992b).

There are five leading functional forms for the output price index P that are most frequently used in empirical work: (1) the Laspeyres price index P_L defined by (62) above, (ii) the Paasche price index P_P defined by (63), (iii) the Fisher price index P_F defined by (64), (iv) the translog price index P_T defined by (64), and (v) the implicit translog price index \tilde{P}_T defined by:

$$(77) \quad \begin{aligned} \tilde{P}_T(p^0, p^1, y^0, y^1) &\equiv [\sum_{i=1}^N p_i^1 y_i^1 / \sum_{j=1}^N p_j^0 y_j^0] / Q_T(p^0, p^1, y^0, y^1) \\ &= [p^0 \cdot y^1 / p^0 \cdot y^0] / Q_T(p^0, p^1, y^0, y^1) \end{aligned}$$

where the translog quantity index Q_T is defined by (57). Do these five functional forms for P satisfy the four test (73) to (76)?

The answer is yes in the case of the Fisher ideal price index P_F and no for the other four price indexes: P_L fails (76), P_P fails (76), P_T fails (74), and \tilde{P}_T fails (73).

When more extensive lists of tests are compiled, the Fisher ideal price index P_F continues to satisfy more tests than other leading candidates; see Diewert (1976, p.131; 1992b). In fact, the Fisher price index satisfies all 20 tests utilised by Diewert (1992b). Moreover, satisfactory axiomatic characterisations of P_F have been obtained recently; see Funke and Voeller (1978; p.180; 1979) and Diewert (1992b). Thus, from the viewpoint of the test approach to index number theory, the Fisher price index P_F defined by (64) and the corresponding Fisher quantity index Q_F defined by (56) seem to be the best choice. It should also be noted that P_F and Q_F satisfy the Product Test (71). Hence, if the Fisher indexes are used in the productivity measures defined by (58) and (61), then both of these productivity measures will coincide; ie. if we use Fisher price and quantity indexes for P and Q and P^* and Q^* wherever they occur in (58) and (61), we obtain the following equality:

$$(78) \quad TFP_F(9) = TFP_F(10)$$

where we have added a subscript F to the two productivity measures to indicate that Fisher indexes are being used. *Thus, an added benefit of using Fisher price and quantity indexes is that two conceptually distinct (but equally attractive) productivity change measures become identical.*

We may summarise the results of this section as follows: from the viewpoint of the test or axiomatic approach to measurement, the Fisher quantity index Q_F defined by (56) and the Fisher price index P_F defined by (64) appear to be the "best" and hence the direct Fisher productivity measure $TFP_F(9)$ defined by (58) (with $Q = Q_F$ and $Q^* = Q_F^*$) or the indirect Fisher productivity measure $TFP_F(9) = TFP_F(10)$ defined by (78) (with $P = P_F$ and $P^* = P_F^*$) which used deflated revenues as the output measure and deflated costs as the input measure are also the "best" productivity measures from the test point of view. Moreover, the direct and indirect Fisher productivity measures coincide; ie. we have (78).

Although Q_F and P_F emerge as being "best" from an *a priori* theoretical point of view, it should be noted that from an empirical view, the Fisher quantity index Q_F can be replaced by the direct translog quantity index Q_T defined by (57) or by the indirect translog quantity index \tilde{Q}_T defined by (70), and the Fisher price index P_F can be replaced by the direct translog price index P_T defined by (65) or by the indirect translog price index \tilde{P}_T defined by (77), since Q_F , Q_T , and \tilde{Q}_T will be numerically very close and P_F , P_T , and \tilde{P}_T will be numerically very close.¹¹

The test approach to index number theory can be summarised as follows: it attempts to decompose a value ratio like $p^1 \cdot y^1 / p^0 \cdot y^0$ into the product of a price index $P(p^0, p^1, y^0, y^1)$ and a quantity index $Q(p^0, p^1, y^0, y^1)$. The price index function P is supposed to represent a generalisation of the single good price ratio p_1^1 / p_1^0 to the case of M goods and when $M = 1$, then $P(p_1^0, p_1^1, y_1^0, y_1^1)$ should equal the single price ratio p_1^1 / p_1^0 . Similarly, the quantity index function Q is a generalisation of the single good output ratio y_1^1 / y_1^0 to the case of M goods and when $M = 1$, then $Q(p_1^0, p_1^1, y_1^0, y_1^1)$ should equal the single good quantity ratio y_1^1 / y_1^0 .

We turn now to an approach which links the theoretical output indexes based on a knowledge of the producer's production functions developed in section 4 above to the test approach index formulae developed in this section.

¹¹ See Diewert (1978, p.894) for some empirical evidence on this point. Diewert (1978, p.888) also proves that Q_F , Q_T , and \tilde{Q}_T approximate each other to the second order around an equal price and quantity point and that P_F , P_T , and \tilde{P}_T also approximate each other to the second order.

6. Exact index number approaches

Recall the output index $\alpha = [\alpha^0 \alpha^1]^{1/2}$ defined by (32) above where α^0 and α^1 were theoretical output indexes defined in terms of the period 0 and 1 production functions f^0 and f^1 (see (30) and (31) for the definitions of α^0 and α^1). Recall also the input indexes β^0 , β^1 and β defined in terms of f^0 and f^1 (see (33)–(35) above).

Caves, Christensen, and Diewert (1982, pp.1395–1401) showed that under certain hypotheses, the following equalities were valid:

$$(79) \quad \alpha = Q_T(p^0, p^1, y^0, y^1) \text{ and}$$

$$(80) \quad \beta = Q_T^*(w^0, w^1, x^0, x^1)$$

where $Q_T(p^0, p^1, y^0, y^1)$ is the Törnqvist (1936) or translog output quantity index defined by (57) above and $Q_T^*(w^0, w^1, x^0, x^1)$ is the translog input quantity index. The notation used here is the same as was used in sections 4 and 5: $y^t \equiv [y_1^t, \dots, y_M^t]$ and $x^t \equiv [x_1^t, \dots, x_N^t]$ are the output and input quantity vectors respectively for the firm in period t while $p^t \equiv [p_1^t, \dots, p_M^t]$ and $w^t \equiv [w_1^t, \dots, w_M^t]$ are the output and input price vectors for the firm in period $t = 0, 1$. Thus, (79) and (80) establish connections between the production function based quantity indexes defined in section 3 above and the axiomatic quantity indexes defined in section 5 above.

Assuming that (79) and (80) hold, we can calculate the total factor productivity measure $TFP(1)$ defined by (36) by taking the ratio of (79) to (80); ie. we have

$$(81) \quad \alpha / \beta = Q_T(p^0, p^1, y^0, y^1) / Q_T^*(w^0, w^1, x^0, x^1) \equiv TFP(1).$$

The practical importance of (81) is that the right-hand side of (81), $TFP(1)$, can be calculated from a knowledge of observable input and output prices and quantities for periods 0 and 1: it is *not* necessary to know explicitly the production functions f^0 and f^1 which characterise the technology in periods 0 and 1.

There remains the problem of describing exactly which assumptions are required to derive (79) and (80). The required assumptions are, roughly speaking: (i) price taking revenue maximising behaviour on the part of the producer; (ii) price taking cost minimising behaviour and (iii) a translog technology.

It should be emphasised that the results presented in this section do not rely on the assumption of constant returns to scale in production: returns to scale can be arbitrary.

Recall that in section 5 above, we found that the "best" productivity index from the axiomatic point of view was the Fisher productivity index defined as

$$(82) \quad TFP_F(9) \equiv Q_F(p^0, p^1, y^0, y^1) / Q_F^*(w^0, w^1, x^0, x^1)$$

where the Fisher quantity index Q_F was defined by (56). As was mentioned in section 5, the right-hand side of (82) will be numerically very close¹² to the right-hand side of (81) for normal time series data on prices and quantities; ie. $TFP(9)$ will closely approximate $TFP(11)$. This approximate equality is somewhat comforting since it implies that two very different approaches to productivity measurement (the axiomatic approach and the economic approach) will give more or less the same results in empirical applications.

Actually, the Fisher productivity index defined by (82) can be given a strong economic interpretation in its own right; see Diewert (1992b, pp.240–243). The assumptions required to give (82) an economic justification are again competitive revenue maximising and cost minimising behaviour and the underlying technology has to be described by a certain class of functional forms.¹³

The assumption of revenue maximising behaviour that was used to derive the equality (79) can be dropped, provided that we know the firm's marginal costs in the two periods under consideration. However, typically we will not know these marginal costs.

To summarise: the results in this section and the previous section justify the use of the Fisher productivity change measure (82) in the multiple output, multiple input case and the results in this section also justify the use of the translog productivity change measure (81). Both of these formulae are practical in the sense that they can be evaluated provided that we have data on the firm's outputs, inputs and prices for the two periods under consideration.

We turn now to the problem of relating total factor productivity measures like (82) to partial productivity measures.

7. Partial efficiency measures and total factor productivity

Recall that in the case of one output and one input, our second definition of productivity change was $TFP(2) \equiv \alpha^1 / \alpha^0 = [y^1 / x^1] / [y^0 / x^0]$ where y^t / x^t was the firm's

¹² See Diewert (1978, p.894).

¹³ The firm's output distance function for period t must have the following functional form: $d^t(y, x) = \sigma^t [y^T A y (x^T C x)^{-1} + \alpha^t \cdot y \beta^t \cdot x^{-1} y^T B^t x^{-1}]^{1/2}$ for $t = 0, 1$ where the parameter matrices A and C are symmetric and independent of time t but the parameter vectors α^t and β^t can depend on time as can the parameter matrix B^t . The vector x^{-1} is defined as the vector whose components are the reciprocals of the components of the vector x . The parameter matrices and vectors satisfy additional restrictions which are listed in Diewert (1992b, p.241).

period t output-input coefficient. In the general case of M outputs and N inputs, there are MN period t output input coefficients of the form y_m^t / x_n^t where $m=1, \dots, M$ and $n = 1, \dots, N$.

Engineers and managers often use the rate of change in a selected subset of the firm's output-input coefficients as an indicator of efficiency change. Thus we define the output m , input n *partial efficiency measure* as

$$(83) \quad PE(m, n) \equiv [y_m^1 / x_n^1] / [y_m^0 / x_n^0], \quad m = 1, \dots, M; n = 1, \dots, N.$$

Note that if $M = 1$ and $N = 1$, then $PE(1, 1)$ reduces to our old one input, one output total factor productivity measure $TFP(2)$ defined by (5) above.

The building blocks in the partial efficiency measures defined by (83) are the firm's output-input coefficients y_m^t / x_n^t . It turns out that these building blocks can also be used to construct a measure of total factor productivity. The key to this construction is definition (61) which defined TFP in terms of revenues R^t , costs C^t , the output price index $P(p^0, p^1, y^0, y^1)$ (which we set equal to α to conserve space) and the input price index $P^*(w^0, w^1, x^0, x^1)$ (which we set equal to β). With the above definitions of α and β , we can rewrite (61) as follows:

$$(84) \quad TFP(10) = \{[R^1 / \alpha] / [C^1 / \beta]\} / [R^0 / C^0].$$

Note that R^1 / α is period 1 revenue divided by the output price index α and hence R^1 / α can be interpreted as period 1 revenue restated in terms of period 0 prices. Similarly, R^1 / β is period 1 cost divided by the input price index β and thus C^1 / β can be interpreted as period 1 cost restated in terms of period 0 prices. Thus $TFP(10)$ can be interpreted as a rate of growth in the firm's revenue cost ratio at "constant" period 0 prices.

Rewrite R^t / C^t as follows:

$$(85) \quad \begin{aligned} R^t / C^t &= \sum_{m=1}^M p_m^t y_m^t / \sum_{n=1}^N w_n^t x_n^t \\ &= \sum_{m=1}^M [1 / \sum_{n=1}^N w_n^t x_n^t / p_m^t y_m^t] \\ &= \sum_{m=1}^M \{ \sum_{n=1}^N [p_m^t / w_n^t]^{-1} [y_m^t / x_n^t]^{-1} \}^{-1}, \quad t = 0, 1. \end{aligned}$$

Equation (85) shows that the period t revenue cost ratio R^t / C^t is a relative price weighted harmonic sum of the period t output-input coefficients $[y_m^t / x_n^t]$. Note that R^t / C^t will increase if any output-input coefficient y_m^t / x_n^t increases. This is a natural property: improvements in (partial) efficiency, must translate into an improved revenue cost ratio, holding prices fixed.

Substitution of (85) into (84) yields:

$$(86) \quad TFP(10) = \frac{\sum_{m=1}^M \{ \sum_{n=1}^N [(p_m^1 / \alpha) / (w_n^1 / \beta)]^{-1} [y_m^1 / x_n^1]^{-1} \}^{-1}}{\sum_{m=1}^M \{ \sum_{n=1}^N [p_m^0 / w_n^0]^{-1} [y_m^0 / x_n^0]^{-1} \}^{-1}}$$

Equation (86) shows that a partial productivity improvement (an increase in y_m^1 / x_n^1 compared to y_m^0 / x_n^0) will increase TFP as well, provided that the period 1 inflation adjusted price ratio $(p_m^1 / \alpha) / (w_n^1 / \beta)$ has not decreased so far below the corresponding period 0 output-input price ratio p_m^0 / w_n^0 so as to nullify the partial productivity improvement.

All methods for measuring productivity change require accurate information on prices and quantities. A major problem is that it is very difficult to determine accurately the prices for durable inputs. We shall discuss this problem in section 9 below. However, we now turn to a discussion of continuous time approaches to productivity measurement.

8. Continuous time approaches to productivity measurement

As in the previous sections of this appendix, it is assumed that the firm produces M outputs and utilises N inputs. The price and quantity of output m at time t are denoted by $p_m(t)$ and $y_m(t)$ for $m = 1, 2, \dots, M$ and the price and quantity of input n at time t is denoted by $w_n(t)$ and $x_n(t)$ respectively for $n = 1, 2, \dots, N$. In the discrete time approaches to productivity measurement that we have considered up to now, the price and quantity data were defined only for $t = 0$ and $t = 1$. In Divisia's (1926; 40) approach to the measurement of aggregate input and output, $p_m(t)$, $y_m(t)$, $w_n(t)$, and $x_n(t)$ are defined for all t between 0 and 1; ie. the data are now regarded as depending continuously on time t for $0 \leq t \leq 1$. Moreover, we also assumed that these price and quantity functions were differentiable with respect to time for $0 \leq t \leq 1$.

Define revenue at time t , $R(t)$ and cost a time t , $C(t)$, as follows:

$$(87) \quad R(t) \equiv \sum_{m=1}^M p_m(t) y_m(t);$$

$$(88) \quad C(t) \equiv \sum_{n=1}^N w_n(t) x_n(t).$$

Now differentiate both sides of (87) with respect to time, divide both sides of the resulting equation by $R(t)$ and obtain the following equation:

$$(89) \quad R'(t) / R(t) = [\sum_{m=1}^M p_m'(t) y_m(t) + \sum_{m=1}^M p_m(t) y_m'(t)] / R(t) \\ = [\sum_{m=1}^M [p_m'(t) / p_m(t)] [p_m(t) y_m(t) / R(t)] \\ + \sum_{m=1}^M [y_m'(t) / y_m(t)] [p_m(t) y_m(t) / R(t)]$$

$$(90) \quad = \sum_{m=1}^M [p_m'(t) / p_m(t)] s_m^R(t) + \sum_{m=1}^M [y_m'(t) / y_m(t)] s_m^R(t)$$

where a prime denotes the time derivative of a function and $s_m^R(t) \equiv p_m(t) y_m(t) / R(t)$ is the output m revenue share at time t for $m = 1, 2, \dots, M$. The left-hand side of (90) is $R'(t) / R(t)$, the (percentage) rate of change in revenue at time t . The first set of terms on the right-hand side of (90) is a revenue share weighted sum of rates of growth in output prices and Divisia (1926, p.40) simply *defined* these terms to be the percentage rate of change of an aggregate output price at time t , $P(t)$; ie. $P'(t) / P(t)$ was defined as follows:

$$(91) \quad P'(t) / P(t) \equiv \sum_{m=1}^M [p_m'(t) / p_m(t)] s_m^R(t).$$

The second set of terms on the right-hand side of (90) is a revenue share weighted sum of rates of growth in output quantities and Divisia defined these terms to be the percentage rate of change of an aggregate quantity at time t , $Y(t)$; ie.

$$(92) \quad P'(t) / P(t) \equiv \sum_{m=1}^M [p_m'(t) / p_m(t)] s_m^R(t)$$

Then substitute (91) and (92) into (90) yields:

$$(93) \quad R'(t) / R(t) = P'(t) / P(t) + Y'(t) / Y(t).$$

In words, (93) says that revenue growth at time t is equal to aggregate output price growth plus aggregate output quantity growth at time t .

Equation (93) is the Divisia index counterpart to the product test equation (71) which occurred in the axiomatic approach to index number theory.

A decomposition similar to (93) can be derived for the rate of growth in cost at time t , $C'(t) / C(t)$. Differentiate both sides of (88) with respect to t , divide both sides of the resulting equation by $C(t)$ and obtain:

$$(94) \quad C'(t) / C(t) = [\sum_{n=1}^N w_n'(t) x_n(t) + \sum_{n=1}^N w_n(t) x_n'(t)] / C(t) \\ = [\sum_{n=1}^N s_n^C(t) [w_n'(t) / w_n(t)] + \sum_{n=1}^N s_n^C(t) [x_n'(t) / x_n(t)]]$$

where $w_n'(t)$ is the rate of change of the n th input price at time t , $x_n'(t)$ is the rate of change of the n th input quantity at time t and $s_n^C(t) \equiv w_n(t) x_n(t) / C(t)$ is the input n share of total cost at time t . Let $W(t)$ and $X(t)$ denote the Divisia aggregate input price and quantity, respectively, at time t . Their proportional rates of change are defined by the two cost share weighted sums of the individual rates of growth of the individual input prices and quantities, respectively; ie. we have:

$$(95) \quad W'(t) / W(t) \equiv \sum_{n=1}^N s_n^C(t) [w_n'(t) / w_n(t)];$$

$$(96) \quad X'(t) / X(t) \equiv \sum_{n=1}^N s_n^C(t) [x_n'(t) / x_n(t)].$$

Substituting (95) and (96) into (94) yields the following input counterpart to (93):

$$(97) \quad C'(t) / C(t) = W'(t) / W(t) + X'(t) / X(t).$$

In words, (98) says that the rate of growth in cost is equal to aggregate input price growth plus aggregate input quantity growth at time t .

Jorgenson and Griliches (1967, p.252) define the *Divisia total factor productivity index* at time t , $TFP(t)$, as the rate of growth of the Divisia output index at time t minus the rate of growth of the Divisia input index at time t ; ie. $TFP(t)$ is defined as:

$$(98) \quad TFP(t) \equiv [Y'(t) / Y(t)] - [X'(t) / X(t)],$$

where $Y'(t) / Y(t)$ is defined by (92) and $X'(t) / X(t)$ is defined by (96). Thus, Divisia total factor productivity at time t equals the Divisia aggregate output growth rate minus the Divisia aggregate input growth rate.

Note that the Divisia productivity measure is defined as a difference in rates of growth whereas our previous productivity definitions were based on taking a ratio of growth rates. For example, in the case of one input and one output, our first definition of productivity, (3) above, was $[y^1 / y^0] / [x^1 / x^0] \equiv [1 + G] / [1 + g]$ where $G \equiv (y^1 / y^0) - 1$ is the output growth rate and $g \equiv (x^1 / x^0) - 1$ is defined to be the input growth rate. Now let us calculate the Divisia productivity defined by (98) when $t = 0$ and $M = 1$ and $N = 1$. In this one output, one input case, $Y(t) = y_1(t) = y(t)$ and $X(t) = x_1(t) = x(t)$. We need to approximate the derivatives $Y'(0)$ and $X'(0)$ by finite differences:

$$(99) \quad Y'(0) = y'(0) \cong y(1) - y(0) = y^1 - y^0;$$

$$(100) \quad X'(0) = x'(0) \cong x(1) - x(0) = x^1 - x^0.$$

Using the approximations (99) and (100), (98) evaluated at $t = 0$ in the case of only one output and one input becomes:

$$\begin{aligned} (101) \quad TFP(0) &= [y'(0) / y(0)] - [x'(0) / x(0)] \\ &= [(y^1 / y^0) / y^0] - [(x^1 / x^0) / x^0] \\ &= (y^1 - y^0) / y^0 - (x^1 - x^0) / x^0 \\ &= G - g. \end{aligned}$$

Thus, in the one input, one output case, Divisia productivity is approximately equal to the difference in the output and input growth rates, $G - g$, and approximately equal to $-1 + [1 + G] / [1 + g]$ where $[1 + G] / [1 + g] = [y^1 / y^0] / [x^1 / x^0]$ was the definition of productivity that we used in section 2.

Returning to the general Divisia productivity measure $TFP(t)$ defined by (98), Jorgenson and Griliches (1967, p.252) develop an interesting alternative formula for $TFP(t)$, under the

additional assumption that costs equal revenue at each point in time, ie. under the assumption that

$$(102) \quad R(t) = C(t), \quad 0 \leq t \leq 1.$$

If (102) is true, then we also have $R'(t) / R(t) = C'(t) / C(t)$ and hence the right-hand side of (93) can be equated to the right-hand side of (97). Rearranging the resulting equation yields:

$$(103) \quad W'(t) / W(t) - [P'(t) / P(t)] = [Y'(t) / Y(t)] - [X'(t) / X(t)] \\ \equiv TFP(t).$$

Thus, under assumption (102), Divisia productivity also equals the Divisia input price growth rate minus the Divisia output price growth rate.

Since data on firm inputs and output are not available as continuous functions of time, it is necessary to discuss how we can approximate $TFP(t)$ defined by (98) using discrete data. Before we do this, we want to discuss whether the Divisia productivity concept can be related to measures of technical progress; ie. to shifts in the producer's production or cost function.

Up to this point, our discussion of the Divisia input, output and productivity indexes has made no mention of economics; ie. there was no mention of production functions or cost minimising behaviour. In the remainder of this appendix, we shall assume cost minimising behaviour on the part of the firm.

The Divisia productivity index defined by (98) was related to measures of production function shift by Solow (1957) in the case of one output and two inputs and by Jorgenson and Griliches (1967) in the many input and output case. Since these authors assumed either constant returns to scale (or that $R(t) = C(t)$), their analysis cannot be applied directly to regulated industries that have increasing returns to scale. However, Denny, Fuss and Waverman (1981, pp.196–199) relate the Divisia TFP measure defined by (98) to shifts in the cost function without assuming constant returns to scale. We shall now present their analysis, using slightly different notation.

The approach of Denny, Fuss and Waverman requires the assumption that the firm continuously minimises costs at each moment of time t between 0 and 1. For $0 \leq t \leq 1$ denote the firm's total cost function by $c(y, w, t)$ where $y \equiv [y_1, \dots, y_m]$ denotes the vector of outputs to be produced and $w \equiv [w_1, \dots, w_N]$ denotes the vector of input prices that the firm faces. The t variable in $c(y, w, t)$ indicates that the cost function is continuously changing due to technical progress or improvements in managerial techniques as t travels between 0 and 1. Under the assumption of cost minimising behaviour on the part of the firm for $0 \leq t \leq 1$ cost at time t , is equal to:

$$(104) \quad C(t) \equiv \sum_{n=1}^N w_n(t) x_n(t) = c[y(t), w(t), t]$$

where $y(t) \equiv [y_1(t), \dots, y_M(t)]$ is the vector of outputs produced at time t and $w(t) \equiv [w_1(t), \dots, w_N(t)]$ is the vector of input prices faced at time t .¹⁴

Define the continuous time technical progress measure at time t by:

$$(105) \quad TP(t) \equiv -[\partial c[y(t), w(t), t] / \partial t] / c[y(t), w(t), t],$$

where $\partial c[y, w, t] / \partial t$ is the rate of change of the cost function with respect to the time variable evaluated at time t . It can be seen that $TP(t)$ is minus the (percentage) rate of increase in cost at time t . If there is technical progress at time t , then $TP(t)$ will be positive since cost reductions will be occurring.

Since we are assuming cost minimising behaviour at each instant of time t , Shephard's (1953, p.11) Lemma implies that the partial derivative of the cost function with respect to the n th input price will equal the cost minimising input demand for input n at time t , $x_n(t)$; ie. we have:

$$(106) \quad x_n(t) = \partial c[y(t), w(t), t] / \partial w_n, \quad n = 1, 2, \dots, N.$$

Differentiate both sides of (104) with respect to t and divide both sides of the resulting equation by $C(t)$. Using (105) and (106), we obtain the following equation:

$$(107) \quad \begin{aligned} C'(t) / C(t) &\equiv \sum_{m=1}^M [\partial c[y(t), w(t), t] / \partial y_m] [y'_m(t) / C(t)] \\ &\quad + \sum_{n=1}^N x_n(t) [w'_n(t) / C(t)] - TP(t) \\ &= \sum_{m=1}^M \varepsilon_m(t) [y'_m(t) / y_m(t)] + \sum_{n=1}^N s_n^C(t) [w'_n(t) / w_n(t)] - TP(t) \end{aligned}$$

where $\varepsilon_m(t) \equiv [\partial c[y(t), w(t), t] / \partial y_m] / [c[y(t), w(t), t] / y_m(t)]$ is the elasticity of cost with respect to the m th output at time t for $m = 1, 2, \dots, M$ and $s_n^C(t) \equiv w_n(t) x_n(t) / C(t)$ is the n th input cost share at time t .

Recall that the Divisia output aggregate $Y(t)$ was defined by (92). We now follow Denny, Fuss, and Waverman (1981, p.196) and define another continuous time output aggregate $Q(t)$ by:

$$(108) \quad Q'(t) / Q(t) \equiv \sum_{m=1}^M \varepsilon_m(t) [y'_m(t) / y_m(t)] / \sum_{i=1}^M \varepsilon_i(t).$$

Recall that the Divisia output aggregate growth rate $Y'(t) / Y(t) \equiv \sum_{m=1}^M s_m^R(t) [y'_m(t) / y_m(t)]$ weighted the individual output growth rates $y'_m(t) / y_m(t)$ by the revenue shares $s_m^R(t)$ for $m = 1, \dots, M$ whereas in (108), $y'_m(t) / y_m(t)$ is weighted by the m th cost elasticity share, $\varepsilon_m(t) / \sum_{i=1}^M \varepsilon_i(t)$.

¹⁴ To reconcile the notation used here to the notation used in section 4, note that $c^0(y^0, w^0) = c[y(0), w(0), 0]$ and $c^1(y^1, w^1) = c[y(1), w(1), 1]$ so that $y(t) \equiv y^t$ and $w(t) \equiv w^t$ for $t = 0, 1$.

It can be shown that $\sum_{i=1}^M \varepsilon_i(t)$ is the percentage increase in cost due to a one percent increase in the scale of each output;¹⁵ ie. it is the reciprocal of the following measure $RS(t)$ of (local) *returns to scale*:

$$(109) \quad RS(t) \equiv [\sum_{i=1}^M \varepsilon_i(t)]^{-1}.$$

Now equate the right-hand side of (97) to the right-hand side of (109). Using (95), (108), and (109), we obtain the following equation:

$$(110) \quad X'(t) / X(t) = [RS(t)]^{-1} [Q'(t) / Q(t)] - TP(t) \text{ or}$$

$$(111) \quad TP(t) = [RS(t)]^{-1} [Q'(t) / Q(t)] - X'(t) / X(t).$$

Equation (111) says that the technical progress $TP(t)$ is equal to the marginal cost weighted index of output growth $Q'(t) / Q(t)$ divided by the local returns to scale measure $RS(t)$ minus the Divisia index of input growth $X'(t) / X(t)$.

It is also possible to relate the Divisia productivity measure $TFP(t)$ defined by (98) to the technical progress measure $TP(t)$ defined by (105). Use equation (98) to solve for $X'(t) / X(t) = [Y'(t) / Y(t)] - TFP(t)$ and use equation (111) to solve for $X'(t) / X(t)$. Equating these two expressions for $X'(t) / X(t)$ yields the following equation after a bit of rearrangement:

$$(112) \quad TFP(t) = [Y'(t) / Y(t)] - [RS(t)]^{-1} [Q'(t) / Q(t)] + TP(t)$$

$$(113) \quad = TP(t) + [1 - [RS(t)]^{-1}] [Q'(t) / Q(t)] \\ + [Y'(t) / Y(t)] - [Q'(t) / Q(t)].$$

Equation (113) is due to Denny, Fuss, and Waverman (1981, p.197). This equation says that the Divisia productivity index equals the technical progress measure $TP(t)$ plus the marginal cost weighted output growth index $Q'(t) / Q(t)$ times $1 - [RS(t)]^{-1}$ (this term will be positive if and only if the local returns to scale measure $RS(t)$ is greater than 1) plus the difference between the Divisia output growth index $Y'(t) / Y(t)$ and the marginal cost weighted output growth index $Q'(t) / Q(t)$.

¹⁵ The elasticity of cost with respect to a scale variable k is defined as $1 / c[y(t), w(t), t]$ times the following derivative evaluated at $k = 1$:

$$\begin{aligned} \partial c[ky(t), w(t), t] / \partial k &= \sum_{m=1}^M y_m(t) \partial c(y(t), w(t), t) / \partial y_m \\ &= c[y(t), w(t), t] \sum_{m=1}^M \varepsilon_m(t) \end{aligned}$$

where the last equality follows from the definition of $\varepsilon_m(t)$ below (107). Therefore, the elasticity of cost with respect to scale equals

$$[1 / c(y(t), w(t), t)] [c(y(t), w(t), t)] \sum_{m=1}^M \varepsilon_m(t) = \sum_{m=1}^M \varepsilon_m(t)$$

Denny, Fuss, and Waverman (1981, p.197) interpret $Y'(t) / Y(t) - Q'(t) / Q(t)$ as an effect on Divisia $TFP(t)$ which occurs only if there is nonmarginal cost pricing of a nonproportional variety. Their argument can be explained as follows. Suppose that at time t , the m th marginal cost is proportional to the period t selling price $p_m(t)$ for $m = 1, 2, \dots, M$. Let the common factor of proportionality be $\lambda(t)$. Then we have:

$$(114) \quad \partial c[y(t), w(t), t] / \partial y_m = \lambda(t) p_m(t) \quad m = 1, 2, \dots, M.$$

Using (114), the definition of $\varepsilon_m(t)$ below (107) and the definition of $s_m^R(t)$ below (90), we find that

$$(115) \quad \varepsilon_m(t) = s_m^R(t) \lambda(t) R(t) / C(t) \quad m = 1, 2, \dots, M.$$

Substituting (115) into (108) and using (92) yields

$$(116) \quad Y'(t) / Y(t) = Q'(t) / Q(t).$$

Hence, if marginal costs are proportional to output prices¹⁶ (ie. (114) holds), then the term $Y'(t) / Y(t) - Q'(t) / Q(t)$ vanishes from (113). Note also that if $M = 1$, then (115) and (116) will automatically hold.

In general, if (116) holds, then (113) can be rewritten as follows:

$$(117) \quad TFP(t) = TP(t) + [1 - (1 / RS(t))] [Y'(t) / Y(t)].$$

Equation (117) is analogous to equation (23), where we decomposed TFP , in the one output, one input case into the product of a technical progress term and a returns to scale term. In both of these equations, if output growth is positive and returns to scale are greater than one, then productivity will exceed technical progress. Of course, the TFP decomposition given by (117) cannot be evaluated empirically unless econometric estimates for the cost function are available.

This completes our discussion of the Denny, Fuss, and Waverman (1981) approach to productivity measurement using a continuous time optimisation approach. We conclude this section with some comments on the problems associated both with their approach and the earlier Divisia approach which did not rely on the assumption of cost minimising behaviour.

In order to make operational any continuous time approach to productivity measurement, it is necessary to replace derivatives such as $y'_m(t)$ by finite differences such as

¹⁶ It can be shown that if the firm (i) maximises revenues holding constant its utilisation of inputs and (ii) minimises costs holding constant its production of outputs, then marginal costs will in fact be proportional to output prices; ie, we obtain $p^t / p^t \cdot y^t = mc^t / mc^t \cdot y^t$. Hence prices in period t , p^t are proportional to marginal costs in period t , mc^t . It should be noted that assumptions (i) and (ii) above are weaker than the assumption of overall profit maximising behaviour.

$y_m(t + 1) - y_m(t)$ or $y_m(t) - y_m(t - 1)$. A related problem is: at which t between 0 and 1 should we evaluate the derivatives $y'_m(t)$? It turns out that the apparent precision of the Divisia approach to output and input measurement vanishes when we consider these discrete data approximation problems: Diewert (1980, pp.444–446) shows that there are a wide variety of discrete time approximations to the continuous time Divisia indexes.

The Divisia approach can also be criticised on metaphysical grounds: producers do not continuously optimise at each instant of time and price and more importantly, quantity data are not available on a continuous time basis.

To conclude, we note that the continuous time approach to productivity measurement due to Divisia (1926) and Jorgenson and Griliches (1967) that resulted in the productivity change measure defined by (92), (96) and (98) can be justified without the assumption of optimising behaviour on the part of the producer. Thus this approach is a continuous time counterpart to the discrete time axiomatic approach described in section 5. On the other hand, the continuous time approach to productivity measurement due to Denny, Fuss and Waverman (1981) that resulted in the productivity change measures defined by (113) and (119) relied on the assumption of optimising behaviour. Thus this latter approach is a continuous time counterpart to the economic approaches to productivity measurement discussed in section 4.

9. The construction of prices or user costs for durable inputs

It is relatively easy to price inputs whose services are completely used up in the course of a year. However, the task of pricing the services of a durable input is much more complex. The main problem is the following one. When a durable input is purchased in one accounting period, the entire cost cannot be charged against that period's income, since the durable input will be able to yield a flow of productive services in one or more subsequent periods. The question is: what fraction of the purchase cost should be charged to the current period and what fraction should be charged to future periods?

The related problem of interest payments must also be addressed. Before a firm can deliver goods, investors somewhere must defer their consumption and loan funds so that the firm's durable equipment can be purchased on the international market. Once the firm is in operation, usually the principle of the loan cannot be repaid immediately and thus investors must continue to postpone their consumption. As a reward for deferring their consumption, investors must be paid interest. Another question is: how should interest payments be charged to the various capital inputs that the firm utilises during the accounting period?¹⁷

¹⁷ The analysis presented in this section is largely taken from Diewert (1992a).

The above questions are not easy ones to answer. Accountants and economists have been struggling with them for hundreds of years and a universally accepted consensus on the answers has not yet been achieved.

Our method for answering these questions proceeds as follows: We take an ex post accounting point of view. Suppose at the beginning of the accounting period, the plant manager buys one unit of a capital item at price P . In order to pay for the capital item, the manager floats a one period bond that pays the interest rate r . At the end of the accounting period, we pretend that the manager retires the bond and sells the (depreciated) capital stock item at the market price for the depreciated items, S where S stands for the second hand market price. (Of course, the manager will usually start next period by "buying" from himself the used capital stock item at the price S and the first period analysis can be repeated for the second period, except that S replaces P , there will be a new end of period second hand price S^* and so on.) This is all the information we require to form the one period user cost u for the capital stock component. The user cost consists of the objective cost of buying and selling the good which is $P - S$ and the financial cost of issuing and redeeming a bond which has face value P ; ie. we have

$$(118) \quad u = [P - S] + [-P + (1 + r)P] \\ = P - S + rP.$$

Note that in formula (118), cost items have a positive sign while revenue items have a negative sign. Note also that u could be negative; ie. if $S > (1 + r)P$ so that the asset appreciates over the period at a rate higher than the one period interest rate r , then the ex post cost u is negative. In this case, the normally positive cost of using the asset, u , becomes negative and thus, becomes a source of explicit revenue (if the asset is sold) or implicit revenue (if the asset is kept).

The formula for the user cost (118) looks rather unfamiliar so some further discussion is required. The price S for the used capital good may be rewritten as follows:

$$(119) \quad S = (1 - \delta)(1 + \rho)P$$

where S is the end of the period price for one unit of the capital stock component, P is the beginning of the period price, δ is a one period depreciation rate and ρ is the one period inflation rate for a unit of the capital stock that has the same quality and physical characteristics as the capital stock component had at the beginning of the period. In order to describe this inflation rate ρ more accurately, we need to introduce some additional notation. Let $P^t = P$ be the dollar beginning of period t price for the capital stock component and let P^{t+1} be the dollar end of the period t price for the same capital stock component; ie. if the component was new at the beginning of period t , then P^{t+1} is the price of a new item at the end of the period;

if the component was one year old and of a certain quality at the beginning of the period, then P^{t+1} is the price of a one year old component of the same quality at the end of the period. We can now define the pure inflation rate ρ by the following equation:

$$(120) \quad 1 + \rho = P^{t+1} / P^t$$

Thus $1 + \rho$ is a measure of pure price change of a capital good of constant quality over the accounting period under consideration. In principle, this measure of inflation can be calculated from market data if second hand markets for the capital stock item exist or if expert appraisals for the used capital goods exist. If the capital stock component under consideration is an inventory component, then $1 + \rho$ can readily be calculated.

Given that we can form an estimate for $1 + \rho$ and given that information on P and S exists, then the depreciation rate δ may be estimated by the following equation:

$$(121) \quad (1 + \delta) = S / P(1 + \rho).$$

Thus, $1 + \delta$ is the end of the period price of a used capital stock item divided by the end of the period price of a capital stock item which is identical in physical characteristics to the beginning of the period capital stock component. It can be seen that $(1 + \delta)$ is a measure of the relative market value of a capital stock component before and after a period's use, but evaluated at end of period prices. Thus δ is a measure of the physical deterioration or depreciation of the capital stock component. (It should be noted that δ should not reflect any obsolescence of the capital good that might have taken place over the accounting period: obsolescence over the period will tend to make P^{t+1} / P^t less than one, and hence ρ defined by (120) will be negative.)

Substituting (119) into (118) yields the following formula for the user cost of the capital stock component:

$$\begin{aligned} (122) \quad u &= [1 + r] P - (1 - \delta) (1 + \rho)P \\ &= rP + \delta(1 + \rho)P - \rho P \\ &= \text{interest cost} + \text{depreciation cost} - \text{capital gains} \end{aligned}$$

Formula (122) is much more familiar. In fact, if $\rho = 0$, so that there is no inflation in the price of the capital good, then (122) reduces to

$$(123) \quad u = (r + \delta)P$$

Formula (123) was essentially derived by Walras (1854, p.269) over 100 years ago. Actually his formula for the user cost of capital was:

$$(124) \quad u = (r + \delta + \mu)P$$

where μ is the property insurance premium rate. Other contributors to the user cost literature include Jorgenson (1963) who derived more complex formulae with income tax complications in continuous time and Diewert (1980, pp.470–480) who worked in discrete time but took an ex ante point of view instead of our present ex post accounting point of view.

Let us follow the example of Walras and add another term to the user cost formulae (118) and (122). The additional cost term is τP where τ is the combined ad valorem property tax rate that may be applicable plus the property insurance premium rate (if the relevant capital stock component is insured). With this additional term, formula (122) may be rearranged into the following instructive formula:

$$(125) \quad u = (r - \rho + \tau) P + \delta(1 + \rho)P$$

Note that r is a nominal interest rate for the period and ρ is an ex post inflation rate for the asset over the period and so $r - \rho$ may be interpreted as a real interest rate. Note also that the "physical" depreciation rate δ is multiplied by $1 + \rho$ in order to obtain the overall "financial" depreciation rate $\delta(1 + \rho)$, ie, depreciation is indexed for inflation.

Usually, accountants assume that the inflation rate ρ equals zero. Under these conditions, (125) reduces to the Walrasian user cost, $u = (r + \delta + \tau)P$. Moreover, accountants do not actually attempt to measure the depreciation rate δ using market data for second hand goods or appraised values for the plant's depreciated capital equipment; ie. they do not use (121) to determine δ . Rather, they pick an *a priori* pattern of depreciation rates which may or may not reflect the actual pattern of deterioration.

Unfortunately, the user cost formula (125) is not the end of the story: we have neglected the corporate income tax in deriving (118) and (125). We shall now explain how business income taxes may be introduced into the user cost. In order to simplify the exposition, let us assume that there is only one durable input and that the amount purchased by the firm in the period under consideration is K . Denote the revenue of the firm by R and the variable costs by VC . We suppose that the business income tax rate is t where $0 < t < 1$ and that for tax purposes, the firm is allowed to deduct costs equal to u^*K associated with the use of the durable. For example, the tax authorities may allow the depreciation deduction dPK where d is a tax determined depreciation rate between 0 and 1. The tax authorities may also allow an interest deduction equal to $rfPK$ where f is the firm's debt equity ratio. In this case,

$$(126) \quad u^* = (d + rf)P.$$

In general, it is assumed that the firm maximises after tax profits. If so, the firm will choose inputs and outputs so as to maximise

$$(127) \quad R - VC - uK - t[R - VC - u^*K]$$

$$= (1 - t)[R - VC - uK] - t(u - u^*)K$$

Equation (127) shows that if the tax authorities manage to set the tax cost u^* equal to the economic user cost u defined by (125), then the appropriate price for K which should be used in index number computations is the user cost u defined by (125). However, in general u will not equal u^* and so it will be necessary to adjust u for the tax distortion. If we divide (127) through by the positive number $1-t$, it can be seen that the firm will want to maximise the resulting expression which can be rewritten as follows:

$$(128) \quad R - VC - [u + (1 - t)^{-1} t[u - u^*]]K$$

Thus, the appropriate tax adjusted user cost is

$$(128) \quad u + (1 - t)^{-1} t[u - u^*]$$

where u is defined by (125) and u^* might be defined by (126).

The point of this derivation is to illustrate how uncertain our empirical estimates of these tax adjusted user costs are going to be. Looking at formulae (125) and (126), it can be seen that there will be uncertainty about which interest rate r should be used, it may be difficult or impossible to measure the ex post appreciation rate ρ defined by (120), it may be difficult to determine the current price P of a new capital good, it will certainly be difficult to measure the economic depreciation rate δ defined by (121) and finally it may be difficult to determine precisely which tax deductions can be associated with the use of a particular durable input. For further discussion on these points, see Diewert (1980, pp.474–483).

A final related source of uncertainty concerns the use of ex post appreciation rates ρ . Many economists would not recommend the use of ex post appreciation rates due to their volatility. Other economists recommend the use of ex ante or expected appreciation rates since economic decisions regarding the purchase or continued use of a durable input must often be made in advance of the knowledge about next period's prices. The use of ex ante or forecasted prices creates an additional layer of uncertainty since opinions differ on how to forecast future prices. Harper, Berndt and Wood (1986) show that alternative methods of forecasting future prices can lead to very different user costs. This variability in user costs will generate variability in the input quantity indexes used in productivity measurement formulae and hence the productivity adjustments may be rather unreliable.

10. Conclusion

Before we review the various approaches to productivity measurement, it is necessary to mention some limitations of our analysis.

In most of our analysis thus far, we have made a number of implicit assumptions that may not be warranted including: (i) the firm's list of inputs used and outputs produced remains constant in the two periods under consideration; (ii) data on the quantities of inputs purchased and outputs sold (and their corresponding average prices) are available for each of the two periods; (iii) user costs or rental prices for capital inputs (ie. durable inputs whose initial cost must be spread over the useful life of the good) can be calculated in an unambiguous way, and (iv) the differences between ex ante expected prices and ex post realised prices are negligible. We briefly discuss each of these four problematic assumptions below.

The first problem is the problem of *quality change* or the *new good problem*. Over time, new products and services are constantly being created and utilised by firms. How can the various definitions of productivity be modified to deal with the problem that M (the number of outputs produced by the firm) and N (the number of inputs used) may not be constant over time? If there is complete information on prices and quantities, then this problem can be addressed in a reasonably satisfactory manner; see chapter 7 above.

This leads us to the second problem area concerning the availability of complete price and quantity data for both periods. A typical large firm produces hundreds of outputs for which there are specific prices and utilises thousands of materials and services inputs. The firm will generally have data on its selling prices and the quantities sold in each accounting period, since this information is required in order to bill customers. Similarly, detailed information on hours worked and rates of pay will generally be available for labour inputs (although hours worked for white collar labour will generally have to be estimated). However, there can be problems in obtaining information on purchases of capital inputs (which are inputs which last longer than the accounting period). Although information on major capital purchases will generally be available, price and quantity information on smaller purchases may be unavailable or available only on a sampling basis. Finally, there usually will be a problem in obtaining detailed price and quantity information on purchases of materials and business services due to the large number of these purchases. Of course, value information on these purchases will always be available from accounting information: the problem is that traditional accounting does not decompose value changes into the product of price and quantity changes. Hence, in order to calculate productivity, it will be necessary for many firms to modify their accounting procedures so that at least selected materials and business services purchases can be decomposed into price and quantity components. Alternatively, national statistical agencies could provide the relevant price indexes for materials deflation.

The third problem area concerns the measurement of capital inputs and their corresponding user costs. When an input which lasts longer than an accounting period is purchased, this purchase price should be spread over the lifetime of that durable input. Accounting

depreciation allowances attempt to do this but the traditional accounting treatment of depreciation in an inflationary environment is not satisfactory. There are also accounting problems associated with calculating the interest charges that should be attributed to the durable good; ie. should imputed equity interest costs also be included? In addition to these accounting problems, there are some real economic problems associated with the measurement of capital inputs. For example, should the quantity of capital services yielded by a machine during an accounting period remain constant over the lifetime of the machine or should the quantity be reduced each period by a deterioration factor to reflect the decline in efficiency of the machine? The first view leads to a gross capital services concept and the second view leads to a net capital services concept. These two views of capital can lead to quite different measures of capital services input and, hence, quite different measures of productivity. For discussions on the measurement problems associated with capital, see Jorgenson (1963), Jorgenson and Griliches (1967, pp.254–260), (1972), Diewert (1980, pp.470–486) (1992a) and the references in these papers.¹⁸

The fourth and final problem area that we have neglected is concerned with the difference between an ex ante price and an ex post price. This difference is only a problem for those approaches to productivity measurement that rely on the assumption of cost minimising behaviour. Since many capital inputs cannot be adjusted instantaneously (ie. be bought or sold instantaneously), a cost minimising producer will have to form a priori expectations about the purchase and disposal prices of a non adjustable capital input. As well, in order to form period by period user costs for this capital input, the producer will be forced to make assumptions about future interest rates, depreciation rates and tax rates. These expectations lead to a priori or ex ante user costs for these slowly adjusting capital inputs. However, as outside observers, all we will be able to observe are the after the fact or ex post prices, interest rates, depreciation rates, and tax rates; ie. we will only be able to calculate ex post user costs. If expectations about these future prices and rates are not realised, then the ex ante user costs — which are the prices which *should* appear in our cost functions or in the exact index number formulae — may differ significantly from the ex post user costs calculated on the basis of accounting data. Thus, the approaches to productivity measurement that rely on optimising behaviour on the part of the firm can break down due to the unavailability of data on expectations. This breakdown is likely to be particularly severe in an inflationary environment.

With the above limitations in mind, we can now evaluate the six main approaches to the measurement of total factor productivity that we discussed in sections 4 to 7 above for their suitability for empirical purposes.

¹⁸ The gross and net capital stock approaches are discussed more fully in appendix D. However, in that appendix, we neglect the complications due to the existence of capital taxes.

The production function and cost function approaches outlined in sections 4 and 5 are not suitable for most empirical purposes due to the difficulties involved in estimating the firm's production or cost functions in an unambiguous way.

The Divisia approach outlined in section 8 above is not suitable for empirical purposes for two reasons: (i) data on the firm's prices and quantities are not continuously available and (ii) if we attempt to approximate the continuous time Divisia productivity index defined by (98) above using discrete time data, there is no unique way of accomplishing this approximation.

The initial exact index number approach outlined in section 6 above is also often not suitable since this approach relied on revenue maximising behaviour on the part of the firm and this assumption is unlikely to be fulfilled in the regulated firm context or in the context of non price taking firms. Exact index number techniques could be used if accurate information on marginal costs were available in each period. However, the estimation of marginal costs will usually involve estimating cost functions and as we noted above, this cannot be done in an unambiguous way.

This leaves by default the axiomatic or test approach to productivity measurement which was outlined in section 5 above. Indeed, this does seem to be the most promising approach for most purposes, since it leads to a unique productivity measure, the Fisher productivity measure $TFP(9)$ defined by (56) and (82) above. Moreover, the test approach does not depend on any assumptions about optimising behaviour on the part of producers (assumptions which may or may not be satisfied). Of course, since the translog input and output indexes closely approximate the corresponding Fisher indexes, the translog productivity index could be used in place of the Fisher productivity index. Finally, the test approach is consistent with the use of ex post accounting data, whereas approaches that rely on cost minimising behaviour should use ex ante or anticipated data on prices, and these data are not observable in general.

APPENDIX B: DIEWERT–LAWRENCE DATABASE

The construction of reliable total factor productivity (TFP) estimates requires comprehensive information on the full range of outputs produced by the market sector of the economy as well as on all inputs used in the production process. Furthermore, to be consistent with the underlying economic theory of productivity measurement, output and input quantities need to be valued at the prices actually faced by the production sector. As a result taxes and subsidies which drive a wedge between producers' and consumers' prices need to be allowed for. To enable these effects to be adequately taken into account and to provide as much information as is currently possible on the full range of New Zealand's outputs and inputs, an important part of this project has been updating, expanding and further improving the detailed database originally developed for Diewert and Lawrence (1994, 1998a).

The TFP database we have constructed for this project contains value, price and quantity information on a total of 62 output and input categories. These are made up of 18 consumer commodities, one government consumption commodity, 7 market sector investment commodities, one commodity representing government purchases of investment goods, 11 export commodities, one commodity representing government subsidies, 10 import commodities, 3 labour types, one commodity representing government fuel taxes paid by the production sector, two resource inputs and 7 capital stocks. Data on these variables covers the 27 year period from 1971–72 to 1996–98. In constructing the database we have worked closely with Statistics New Zealand (SNZ) and Valuation New Zealand (VNZ) as well as drawing heavily on data from the Organisation for Economic Cooperation and Development (OECD) and the International Monetary Fund (IMF). A detailed listing of all 62 commodities is presented in Table B1.

An important distinction that arises in all productivity studies is the difference between stocks and flows. Most outputs from the production sector and some of the inputs to it are produced and consumed in the one period. This makes their measurement relatively easy. However, many of the inputs used in the production process are durable assets and last several periods (or decades in some cases). Measuring the amount of these durable items consumed in any one period becomes problematic and requires measurement of the flow of services provided by the asset over its lifetime. Measurement of the stock, or total value of the asset held is also not straight forward due to the presence of inflation and alternative assumptions about depreciation rates. While some time series do exist for housing flows in particular, they have been constructed using national accounting rather than economic conventions. Consequently,

in this study considerable time has been spent constructing the major stocks and flows in a consistent manner using economic conventions.

Table B1: Full Listing of Variables Contained in the TFP Database

<i>Broad category</i>	<i>Individual components</i>
Consumer commodities	Food and non-alcoholic beverages Alcohol Clothing and footwear Fuel and power Furniture, etc Textiles, etc Other goods Health services Motor vehicles Vehicle operation Public transport Recreation Hotels and restaurants Tobacco Personal services Post and telephone Other services Non-resident expenditure
Government consumption	Government consumption of intermediates
Investment goods	Residential dwellings Non-residential and other construction Transport equipment Electrical machinery Plant and other Machinery Agricultural inventory outputs Non-agricultural inventory outputs
Government investment	Government purchases of investment goods
Exports	Butter Cheese Meat Wool Other pastoral and dairy products Fish and fish preparations Forestry products Aluminium

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Table B1: Full Listing of Variables Contained in the TFP Database (cont'd)

<i>Broad category</i>	<i>Individual components</i>
Exports (cont'd)	Transport equipment Other merchandise exports Services exports
Subsidies	Subsidies
Imports	Food and beverages Petroleum and petroleum products Non-fuel crude materials Textiles, yarns, fabrics and related products Iron and steel Non-electrical machinery Electrical machinery Transport equipment Other merchandise imports Services imports
Labour	Managers, professional and technical Clerical, sales and services Production and labourers
Fuel tax	Fuel taxes
Resources	Oil and gas Forestry
Capital	Non-residential and other construction Transport equipment Electrical machinery Plant and other machinery Livestock inventory inputs Non-agricultural inventory inputs Business and agricultural land

Data for New Zealand tends to be presented using a wide variety of conventions regarding the starting and end points of the year covered. Until recently most Department of Statistics data was presented for the year ending in March. However, other New Zealand agencies used different conventions and some Department of Statistics series also used different coverage. Recently there has been a move to present New Zealand data more consistently on a June year basis. Some OECD data are presented on a calendar year basis. Wherever possible, data used in this study have been converted to a March year basis and the convention adopted is that reference to a particular year refers to the year ending in March of that year. In the more recent years data are still directly available for many variables on a March year basis. For

those series where only June year data is now available we form March year estimates by pro-rating the values from adjoining June years.

In the remainder of this appendix we outline the sources for each of the variables in the TFP database, list some of the data used in constructing the variables and, finally, list the values and prices of all 62 variables.

Consumption Commodities

SNZ (1994a) contains a disaggregated breakdown of household consumption expenditure with a total of 19 consumption categories for selected years from 1982–83 onwards. To form a detailed series of the price and quantity of consumption commodities, Diewert and Lawrence (1998a) contracted SNZ to construct a consistent time series for the 19 consumption categories for the period 1971–72 to 1994–95 in both current and constant prices. In the original SNZ specification alcohol consumption is split between Beverages and Hotels and restaurants. We asked SNZ to form separate estimates of alcohol consumption and provide information that enabled us to derive the residual values of Beverages and Hotels and restaurants consumption. In the current project, SNZ provided an update of these series to 1998.

Having value, price and quantity estimates for the Alcohol consumed in hotels and restaurants and the total Hotels and restaurants consumption categories it was then necessary to recover consistent estimates of the price and quantity of the residual category, Hotels and restaurants excluding alcohol. This was done by assuming that the overall price index was a chain Laspeyres index of the two components. This permits the residual or second component price index to be recovered as follows:

$$(1) \quad P_2^t = \left(V_T^{t-1} P_T^t / (P_T^{t-1} X_2^{t-1}) \right) - \left((P_1^t X_1^{t-1}) / X_2^{t-1} \right)$$

where P_T , X_T and V_T are the price, quantity and value of the overall aggregate category, respectively, and 1 and 2 refer to the two components. By setting the period $t-1$ price of alcohol and the residual equal to one, the period t price of the residual can be recovered using equation (1) above. The period t residual quantity, X_2^t , is then obtained by dividing the residual value by its price for that period. This permits (1) to be used to recover the residual price for period $t+1$ and so on.

The consumption data supplied by SNZ are listed in tables B2a to B2c in current prices and in tables B to B3c in constant 1991–92 prices.

One problem identified in the SNZ consumption data was the treatment of motor vehicle purchases. The official series have underestimated the large increase in the number of

consumer motor vehicles that has occurred since restrictions on the importation of second-hand motor vehicles were relaxed in the late 1980s. SNZ is currently reviewing its methodology and revising its estimates from 1994 onwards. We revised this series from 1989 onwards using data on changes in motor vehicle registrations to index forward the constant price series to more accurately reflect the actual stock of consumer vehicles. We retain the SNZ implicit price index for motor vehicles to derive a revised current price series.

We require information on the expenditure by foreign visitors in New Zealand as we need to account for all New Zealand production of goods and services. Consequently, we also requested SNZ to supply current and constant price series for Nonresident expenditure in New Zealand.

Constructing this portion of the database proved to be a challenging task for SNZ given the difficulty of retrieving detailed information for the early years. However, we now have a reasonably consistent time series using official estimates for the 18 consumption commodities we use in the database.

The data presented in tables B2 and B3 are all in consumer prices, ie at the prices which consumers face. The series used in our TFP model are valued at producer prices, ie at the prices producers face. These series are reported later in the appendix after we have described the allocation of consumer taxes.

Government Consumption of Intermediates

The market sector of the economy supplies intermediate inputs used by the government sector. Consequently, in forming a series for government purchases from the market sector we need to exclude government wages payments from total government consumption. SNZ supplied Diewert and Lawrence (1998a) with a time series of the value of government expenditure on intermediates (goods and services produced by the private production sector) for the period 1972 to 1994. We also have estimates of government labour costs from our detailed labour data. In the current project, Treasury supplied detailed SNZ tables which provide current and constant price series for central government expenditure on intermediates and labour and total local government consumption expenditure from 1983 onwards. Local government intermediate purchases were updated using the proportional changes in the total local government series. The price of government consumption of intermediates was taken to be the SNZ price index for central government intermediates from 1983 onwards spliced onto

an earlier series obtained from the OECD *National Accounts* for the period 1972 to 1983. The relevant series are presented in Table B4¹.

Investment Goods

The quality of information available on producer investment expenditure has improved considerably in recent years and Treasury has made available SNZ data on detailed gross fixed capital expenditure for the period from 1982 onwards.

In addition to the Non-residential and other construction component, we have disaggregated the Plant and equipment component into investment in Transport equipment, Electrical machinery and Plant and other machinery due to the rapid structural change which has occurred as greater and greater use has been made of computers and other electrical equipment. The disaggregated value series were formed from a combination of SNZ data on transport equipment investment and imports of electrical machinery. Price indexes were sourced from import price indexes for the relevant categories up to 1991 and SNZ capital expenditure group indexes that were available from 1992 onwards. In the case of transport equipment we used the import price index for the period 1972 to 1981, the price index for Commercial vehicles under 3,500 kilograms for the period 1982 to 1991 and the transport equipment group index for 1992 to 1998.

Estimates of government nonmarket capital expenditure were only available from the December 1986 issue of the SNZ *Monthly Abstract of Statistics* covering the period 1976 to 1985. This was used to estimate the proportion of government capital expenditure by asset type being used for nonmarket purposes which was then deducted to form estimates of total market sector capital expenditure by asset type. Tables B5 and B6 present the disaggregated market sector gross fixed capital formation values and price indexes, respectively.

Government Investment

Because government investment is generally purchased from the private sector, government investment needs to be counted as an output supplied by the market sector to government. Consequently, the government components of the above four investment components were aggregated to form a government investment variable using a chained Fisher index and assuming the government faces the same price for each component as the market sector. The values of government investment are presented in Table B7. This variable was not included in the earlier Diewert and Lawrence (1998a) database.

¹ A similar argument can be made for purchases of intermediate inputs by the owner occupied housing sector but these are excluded due to their small size and the unreliability of data in this area.

Exports and Imports

Disaggregated series for merchandise exports and imports were built up using value series and price and quantity indexes published in SNZ (1994b) *Trade Statistics*. This provided good detail on rural, forestry and aluminium exports but no information on manufactured exports which have become significant for New Zealand. To obtain more information on manufactured exports SNZ provided us with information on exports of Machinery and transport equipment from the INFOS database. Data on services exports and imports values were supplied specially by Statistics New Zealand for the period 1972 to 1982 on a consistent System of National Accounts basis. Treasury supplied SNZ data for 1983 onwards which contained current and constant price series for the Transport, Travel, Insurance and Other services components. Aggregate services prices were formed using chained Fisher indexes of these 4 components from 1983 onwards. These were spliced with the consumer price index for transport prior to 1983. Services exports and imports were not included in the earlier Diewert and Lawrence (1998a) database.

This permitted us to form a total of 11 export and 10 import commodities. Export values and price indexes are presented in tables B8 and B9, respectively, while import values and price indexes appear in tables B10 and B11, respectively.

Subsidies

Due to the difficulty of obtaining information on the interindustry flows of intermediate goods and services, we do not distinguish separate industries in our study. Thus we view the private production sector of the economy as an aggregate technology that transforms primary inputs and imports into the components of final demand. If all individual producers in the economy face the same prices for their inputs and outputs, then the economy's aggregate technology set or aggregate production can be rigorously justified under the assumption of competitive profit maximising behaviour.

However, the existence of subsidies on the outputs of various industries means that all producers do not face the same price for the same commodity. For example, the price received by a subsidised producer in industry i is $(1+s_i)P_i$ where P_i is the selling price and s_i the subsidy rate for one unit of output in industry i , while the price paid for a unit of output by a user is only P_i . Thus, summing the value of subsidised outputs produced less the expenditures of other producers on subsidised commodities yields $\sum_i s_i P_i Q_i$, total subsidies paid, where Q_i is the quantity produced of the i th subsidised commodity. In our empirical work, we add an aggregate subsidised commodity to our list of outputs whose value in period t is $\sum_i s_i^t P_i^t Q_i^t$. We treat the $s_i^t P_i^t$ as the individual prices in the aggregate and the Q_i^t as the

corresponding quantities. As usual, a Fisher ideal chain index is used to construct the aggregate “subsidy” price and quantity series.

This output variable representing government subsidies to producers was formed from a time series of estimates of subsidies to 6 industry groups: Agriculture; Forestry and logging; Food, beverages and tobacco; Chemicals, petroleum, rubber and plastics; Trade, restaurants and hotels; and, Transport and storage. Information on subsidies to these six groups was obtained from the SNZ publication *New Zealand National Accounts 1980–81 to 1986–87*. This was used to disaggregate the OECD subsidies series across the six groups for the whole time period. The proportions applying in 1987 were used to disaggregate total subsidies for the years 1988 to 1998. For this period, this led to 13 per cent of subsidies being allocated to Agriculture; 4 per cent to Forestry and logging; 2 per cent to Food, beverages and tobacco; 3 per cent to Chemicals, petroleum, rubber and plastics; 4 per cent to Trade, restaurants and hotels; and, 74 per cent to Transport and storage. The ‘price’ of the subsidies commodity was taken to be the subsidy rate for each industry group (the ratio of its subsidies to the corresponding value of industry output) multiplied by that industry group’s output price.

A significant form of subsidy during the 1970s and 1980s was import licensing, which initially operated on the principle that if a product could be made in New Zealand, with a few exceptions, licences would not be granted. This had a particular impact on manufacturing, conferring some high effective rates of assistance, with an estimated average of 39 per cent in 1982 across manufacturing according to Syntec Economic Services (1988). Other industry assistance instruments included guarantees and debt write offs for agriculture and the major projects. The distortions caused to producer prices by various forms of industry assistance are likely to have been significant but it has not been feasible to allow for this in the current study.

The values of subsidies for the six industry groups along with the aggregate subsidy value, price and quantity are presented in Table B12.

Labour

SNZ supplied us with information on the employment levels of 3 broad occupational groups for the 6 Census years 1971, 1976, 1981, 1986, 1991 and 1996. They also supplied us with detailed information on the number of hours worked by each of these occupational groups in 1991 along with information on the distribution of hours worked for the total workforce in the other Census years. We have combined this information with the OECD’s employment level data published in the *Economic Outlook* series to form our estimates of labour inputs. The

OECD labour series is one of the few that is available on a relatively consistent basis for the entire time period.

First, the OECD series for total employment and general government employment were converted to March years. The OECD general government employment series corresponded closely with SNZ data on the government nontrading sector available in later years. Proportions of the workforce in the 3 broad occupational groups — Managers, professional and technical; Clerical, sales and services; and, Production and labourers — were interpolated (and extrapolated in the case of year after 1996) to form a time-series for the 26 years and applied to the total employment series to derive 3 occupational employment series. From the 1981 Census report we were able to obtain the composition of general government employment by each of these occupations. This was used to form series of general government employment by occupation which were subtracted from total occupational employment to form estimates of market sector employment in each of the occupations. This was then combined with data on the distribution of hours worked by occupation in 1991 and the change in average hours worked over time to form estimates of the full-time equivalent employment in each occupation.

Wage rate indexes for the 3 occupations were formed by indexing and splicing together series for the closest occupational classifications from a number of SNZ sources. For instance, the SNZ *Wages and Labour Statistics* publication has price indexes for six occupational groups for the years 1972 to 1977, and for 1977 to 1979 on a slightly different classification basis. Econdata presents indexes for seven occupational groups for 1979 to 1993 and with yet another change in classification for 1993 to 1998. Data on numbers by occupation for 1985 to 1990 were used to index the disaggregated occupational wage indexes into aggregates corresponding to our three categories.

It then remained to 'benchmark' the indexes against wage levels in one year so that an average full-time annual wage rate for each of the occupations could be formed for each year. This was done by using SNZ estimates of ordinary time earnings for industries representative of each of the occupations. The Business and financial services industry was used to benchmark the Managers, professional and technical occupational group; the Retail and wholesale trade industry the Clerical, sales and services occupation; and, the Manufacturing industry the Production and labourers occupation.

Selected aspects of the labour database are presented in tables B13 to B21. Table B13 presents the SNZ data on occupations by numbers for the six Census years. Table B14 presents SNZ data on the distribution of hours worked for the six Census years while Table B15 presents the SNZ data on hours by occupation for 1991. Tables B16 to B18 present our estimated total economy occupations by numbers, estimated general government occupations

by numbers and market sector occupations by full-time equivalents, respectively. In table B18a we present average hours worked per employed person by occupation and estimated ordinary time earnings by occupation appear in Table B19. The market sector wages bills by occupation appear in table B20. Finally, in table B21 we present the Household Labour Force Survey (HLFS) data used in the sensitivity analysis reported in chapter 3.

Fuel Taxes

Since government taxes on fuel and vehicle use form a significant component of producers' costs, we have formed a separate input variable to capture them. Fuel taxes present us with a problem that is similar to the existence of subsidies, ie fuel taxes cause different producers to face different prices for the same commodity. A producer or importer of motor fuel (a refiner, say) receives only the price P for a unit of fuel while a producer who uses fuel as an input will pay the after-tax price of $(1+t)P$, where t is the fuel tax rate. Summing over all producers and users of fuel in the production sector, indexing fuel revenues with a positive sign and fuel costs with a negative sign, will lead to a period t net fuel revenue of $-t^t P^t Q^t$ associated with the use of fuel within the production sector, or a net cost of $t^t P^t Q^t$, where Q^t is the quantity of fuel used by the private production sector in period t . In our empirical work, we add an aggregate fuel tax commodity to our list of inputs whose value in period t is $t^t P^t Q^t$. We treat $t^t P^t$ as the period t price of this fuel tax input and Q^t as the corresponding period t quantity.

Total gasoline taxes, motor vehicle fees and road user charges were split between the production sector and consumers on the basis of the estimated relative sizes of the capital stock series for transportation equipment and the stock of consumer motor vehicles. The value of fuel used was formed by combining data on energy consumption and price data on fuel costs. This permitted the producer tax rate, t^t , to be estimated. Table B22 presents the key series used in constructing the variable.

Resource Inputs

In an effort to account for as many inputs used by the production sector as possible and thus minimise the impact of 'free lunches' for producers resulting from incomplete cost measurement, we have included the use of forestry, oil and gas resources in the current database. These are treated as current inputs to the production sector with quantity set equal to the quantity of the resource used each year and value set equal to an estimate of the resource rents each year.

The quantity of forestry resources consumed each year was set equal to the volume of round wood production from New Zealand forests obtained from the SNZ *Yearbooks*. The quantity of domestic oil and gas resources consumed annually was taken to be the petajoule content of domestic oil and gas production. This series was obtained from the Ministry of Commerce.

The value of resource rents for the two sectors were obtained by subtracting labour compensation, depreciation and the opportunity cost of capital from value added. In each case these series had to be compiled from a number of sources. For forestry a number of SNZ and United Nations sources were used while for oil and gas SNZ sources relating to the Mining and quarrying industry were used, combined with regression techniques.

Table B23 presents the quantities of resource consumption and the estimated value of resource rents for forestry, and oil and gas.

Allocation of Taxation Data

We have devoted considerable time to producing detailed taxation estimates to match the degree of detail we now have in our outputs and inputs. Indeed, the extra output and input detail necessitates more taxation detail as TFP is calculated using producer prices.

The range of taxes explicitly incorporated in the database includes:

- individual income taxes
- fringe benefit taxes
- payroll taxes
- corporate taxes
- withholding taxes
- goods and services tax
- sales tax
- motor vehicle sales tax
- petroleum excises and taxes
- tobacco excises
- alcohol excises
- customs duties
- motor vehicle fees
- road user fees
- stamp, cheque and credit duties
- gaming duties
- energy resources levy, and
- property taxes.

In forming labour and capital taxes we use data supplied by Treasury on source deductions for 1972–92 combined with data for 1993–98 from SNZ *Yearbooks*. The problem is then allocating the difference between total individual taxes and source deductions between labour and capital. Treasury provided Diewert and Lawrence (1994) with data for 1991 showing that 60.18 per cent of residual individual income tax could be attributed to labour. We again form a labour tax series as the sum of source deductions, payroll tax and 60.18 per cent of residual individual income taxes². We form a capital tax series as the sum of corporate taxes, withholding taxes and 39.82 per cent of residual individual income taxes. Fringe benefits tax is included in individual income taxes. Table B24 presents the information used on direct taxation.

Allocating goods and services taxes, sales taxes and excise duties across our 18 consumer goods was greatly assisted by a detailed table we earlier commissioned from SNZ on the allocation of these taxes in 1986–87. Since the goods and services tax was introduced part way through this financial year we have both goods and services tax and sales tax records for this year. This information is presented in Table B25. We formed estimates of the allocation of goods and services taxes and sales taxes to the 18 consumer commodities using a 2 stage process — first we calculated the rates for the 18 commodities for 1986–87 from the SNZ allocation and then applied these rates to consumption for the other years where the taxes applied. We then adjusted the other years by a factor of proportionality to bring total estimated collections into line with actual tax collections in that year. This was necessary to allow for the fact that neither sales nor good and services taxes applied for all of the 1986–87 financial year and for changes in the composition of consumption through time. Separate estimates were formed of the sales tax applying to motor vehicles.

With respect to excise duties, alcohol and tobacco excises were allocated to their respective consumption commodities. The consumer sector's share of gasoline taxes, motor vehicle fees and road user fees were allocated to the Vehicle operations commodity. Gaming duties were allocated to the Recreation commodity and stamp, cheque and credit duties to the Other services commodity. Data on indirect taxes are presented in tables B26 and B27.

Non-residents were assumed to consume a subset of the other 17 consumption commodities and, consequently, the Non-resident expenditure commodity was allocated a share of the taxes which apply to the commodities non-residents consumed based on relative values. Non-residents' consumption is assumed to be made up of Food and beverages (25 per cent), Alcohol (12 per cent), Motor Vehicles (10 per cent), Vehicle operation (15 per cent), Public

² SNZ's experimental institutional sector accounts available from 1991 onwards could also be used to assist in allocation of the self-employed's income between capital and labour. While not providing this split directly, the sector accounts do distinguish between corporate and unincorporate operating surplus, and contain net interest costs for unincorporates.

transport (7 per cent), Recreation (16 per cent) and Tobacco (4 per cent). The shares of these commodities in non-residents' consumption are the same as their share in residents' consumption of this subset.

We encountered considerable difficulty obtaining the necessary detail on how import duties are spread across our individual import components. We earlier commissioned SNZ to construct estimates for the March years 1990–1996 (for which records were still available) which could be used to allocate import duties to our 9 merchandise import categories. The allocation for 1990 was used to pro-rate total import duties for the earlier years and the 1997 and 1998 allocations were assumed to be the same as that for 1996. Table B28 presents our estimates of the allocation of import duties.

To derive the producers' price series for the 18 consumption commodities we take the current price Household consumption expenditure matrix and subtract from it goods and services taxes, sales taxes, excises, motor vehicle taxes, gaming and stamp duties to get producer receipts. We then divide this by the constant price Household consumption expenditure series to get an implicit price for the producers' price series. We then rebase this price to equal one in 1972, and divide the producers' prices value by the new price to get a rebased quantity series. We follow the same procedure for imports except that we add import duties to the trade import value (which is in value for duty terms).

The business property tax series constructed in Diewert and Lawrence (1994) was updated to 1997. For the years 1992 to 1998, total property taxes were spread between residential and business properties using the average shares which applied between 1989 and 1991. Business property taxes were assumed to apply to Non-residential and other construction and Business and agricultural land at similar rates. Property tax data are presented in Table B29.

Capital Stocks

We use net capital stock estimates in the TFP database. In the case of the Non-residential and other construction capital stock we use the 1987 valuation of total Non-residential and other construction obtained from the *Who Gets What?* review (NZPC 1990) (deflated by 16 per cent to allow for non-market sector assets) as a starting point in forming the capital stock series. This is combined with an assumed depreciation rate of 2 per cent to form a real net capital stock series using the following formula:

$$(2) \quad \begin{aligned} S_t &= (1-d)S_{t-1} + A_t && \text{for } t > 1987 \\ S_t &= (S_{t+1} - A_{t+1}) / (1-d) && \text{for } t < 1987 \end{aligned}$$

where S_t is the capital stock in period t , A_t are period t additions or investment (expressed in 1987 prices) and d is the economic depreciation rate. The resulting 1987 constant dollar

capital stock is then converted to current prices using the corresponding investment price index.

The broad Plant and Machinery stock is disaggregated in this study into three components: Transport equipment, Electrical machinery and Plant and other machinery. The derivation of the capital formation series for these components was outlined above. Starting values are derived using import data and a declining balance net capital model. From the December 1974 *SNZ Monthly Abstract of Statistics* we have relevant import volume indices dating back to 1963. These are used to index capital expenditure in constant prices back to 1963. The average growth rate of capital expenditure between 1963 and 1995 is then calculated and used to index capital expenditure in constant prices back to 1956. The 1956 opening stock is assumed to be equal to capital expenditure in that year and is combined with the estimated capital expenditure time-series and assumed depreciation rates to form a capital stock time-series³. We use depreciation rates of 13 per cent for Transport equipment and Plant and other machinery and 20 per cent for Electrical machinery.

Estimates of the stock of agricultural inventories were built up from SNZ data on numbers of four types of livestock and unit values for each of these categories consisting of average export prices plus assistance based on information included in New Zealand Meat and Wool Board *Annual Reports* and OECD estimates of producer subsidy equivalents. The four livestock types considered were: sheep, cattle, deer and goats. An aggregate price index and quantity of livestock inventories was formed by aggregating the four components using a chained Fisher index.

Information on non-agricultural inventories was obtained from the *SNZ Monthly Abstract of Statistics* and *Key Statistics*. The value of nonagricultural inventories was taken to be the sum of stocks of materials and finished goods in manufacturing, retail stocks and the narrow definition of wholesale stocks. The deflator used for non-agricultural inventories was the price index for all New Zealand industry inputs (excluding labour) from the International Monetary Fund's *International Financial Statistics Yearbook*.

For the business and agricultural land series we used information obtained from Valuation New Zealand on price indexes for rural land and commercial and industrial property and assume that the quantity of land remains fixed over the period. We 'benchmark' the price indexes using a Valuation New Zealand estimate of \$80.9 billion in 1988 for the total value of land in New Zealand (which includes residential as well as business and agricultural land) to derive a starting value for the business and agricultural land stock. We combine the Valuation

³ It is noted that in manufacturing real, recorded capital stock write-offs may have lagged behind the removal of import protection. Specialised plant may have been recorded at higher values than justified for some years after restructuring had reduced its value substantially.

New Zealand figure with our own estimate of \$39.9 billion in 1988 for the value of residential land (see Diewert and Lawrence 1994) to derive an estimate of \$41.6 billion in 1988 for the value of business and agricultural land.

The values, prices and quantities of producer capital stocks are presented in tables B30, B31 and B32, respectively.

User Cost of Capital

In Diewert and Lawrence (1998a) we implemented an econometric model for the market production sector of the New Zealand economy. In that study it was appropriate to use an ex ante user cost approach where capital gains and interest rates are anticipated gains and rates rather than actual ex post gains and rates. However, in the present study we are attempting to evaluate the ex post or actual performance of the New Zealand economy and thus it is now more appropriate to use actual capital gains and interest rates that can be evaluated on an ex post or end of year basis.

We derive the ex post user cost of capital as follows. Suppose firms buy an asset at the beginning of a period at price P . Assume its price at the end of the period is $(1-d)(1+a)P$ where d is the depreciation rate and a is the actual asset-specific inflation rate over the period. Assuming no taxes and a nominal asset borrowing rate of r , the actual user cost of the asset is:

$$(3) \quad P - (1-d)(1+a)P / (1+r) = [r - a + d(1+a)]P / (1+r).$$

To bring taxes into the picture, we assume that the before tax nominal rate of return is R where:

$$(4) \quad R = r / (1-t)$$

where $0 < t < 1$ is the rate of capital income taxation.

Assume the firm borrows P at the before tax rate of return R at the beginning of the period. At the end of the period, the firm must pay back $P(1+R)$ but it has an asset worth $(1-d)(1+a)P$. Hence the net cost of using the asset over the period, at the end of the period, is:

$$(5) \quad P(1+R) - (1-d)(1+a)P = [R - a + d(1+a)]P$$

and if we discount this price to the beginning of the period, we obtain the following user cost:

$$(6) \quad [R - a + d(1+a)]P / (1+r).$$

To obtain an estimate for the period t after-tax nominal rate of return r^t , we insert the actual period t asset specific inflation rates \mathbf{a}_i^t into the following equation and solve for r^t :

$$(7) \quad \sum_i P_i^t (1 + \mathbf{a}_i^t) I_i^t + (1 + r^t) VA^t = \sum_i P_i^t [R^t - \mathbf{a}_i^t + \mathbf{d}_i (1 + \mathbf{a}_i^t) + \mathbf{t}_p^t] K_i^t \\ = \sum_i P_i^t [r^t - \mathbf{a}_i^t + \mathbf{d}_i^t (1 + \mathbf{a}_i^t) + \mathbf{t}_p^t] K_i^t + T^t$$

where:

VA^t = value of non-capital outputs less value of non-capital inputs;

P_i^t = period t investment price for the i th type of capital;

K_i^t = beginning of period t stock of the i th type of capital;

R^t = pre-tax nominal rate of return (ex-post) for period t ;

$r^t = (1 - \mathbf{t}^t) R^t$ = post-tax nominal period t rate of return;

I_i^t = period t quantity of investment for the i th type of capital;

\mathbf{t}_p^t = property tax rate; and

T^t = capital taxes paid in period t (excluding property taxes).

Once (7) has been solved for the nominal post-tax rate of return r^t (which is an average realised nominal rate of return), we derive an average capital income tax rate \mathbf{t}^t for period t as follows:

$$(8) \quad \mathbf{t}^t = T^t / [r^t (\sum_i P_i^t K_i^t) + T^t].$$

Having derived the capital tax rate we can then recover the pre-tax realised average nominal rate of return, R^t , using equation (4). The value of the investment output for capital type i in period t is then $P_i^t (1 + \mathbf{a}_i^t) I_i^t / (1 + r^t)$ while its input user cost value is $P_i^t [R^t - \mathbf{a}_i^t + \mathbf{d}_i (1 + \mathbf{a}_i^t) + \mathbf{t}_p^t] K_i^t / (1 + r^t)$. Note that the above model assumes that investment goods produced during the current year become a part of the productive capital stock at the beginning of the following year and, hence, should be valued at the current year's end of year prices, $P_i^t (1 + \mathbf{a}_i^t)$. The resulting rates of return, tax rates and ex post user costs of capital times the corresponding capital stocks are presented in tables B34 and B35.

The land asset-specific inflation rates were very high for the first half of the period to the point where they produced negative user costs for land for several years. This means that land effectively becomes an output of the production process in those years. It should be noted that the index number algorithm contained in the Shazam econometrics program (White 1978) cannot accurately accommodate negative prices even though they pose no problem in principle to the Fisher indexing method (provided the various inner products of prices and quantities are positive). To overcome this problem in Shazam, we constructed our own index number program to aggregate inputs and outputs.

The treatment of inventories in our TFP database requires some explanation. Treating the beginning of period t stock of inventories K^t as a normal capital input and assuming that the associated depreciation rate is zero leads to the following specialisation of the general user cost formula, (6) above:

$$(9) \quad [P^t(1+R^t) - P^t(1+a^t)]/(1+r^t) = [R^t - a^t]P^t/(1+r^t)$$

where R^t is the period t before tax nominal rate of return, $r^t = (1-t^t)R^t$ is the nominal after-tax rate of return, P^t is the beginning of period t asset price for inventories and a^t is the anticipated period t inventory inflation rate. The corresponding period t quantity of inventories used as an input is K^t . In addition to having K^t as an input, the period t change in inventories, $K^{t+1} - K^t$, is regarded as an "investment" net output, I^t , which has the end of period t anticipated price, $P^t(1+a^t)/(1+r^t)$. Note that the period t net contribution of inventories to production, V^t , is the value of the period t change in inventories less the user cost of the initial stock of inventories:

$$(10) \quad V^t = (K^{t+1} - K^t)P^t(1+a^t)/(1+r^t) \\ - K^t[P^t(1+R^t) - P^t(1+a^t)]/(1+r^t) \\ = K^{t+1}P^t(1+a^t)/(1+r^t) - K^tP^t(1+R^t)/(1+r^t).$$

A second way of treating inventories is as an input stock which fully depreciates during the period but the entire end of period stock of inventories is treated as an output. In this treatment of inventories, the depreciation rate d which occurs in (3) – (6) is set equal to one and the resulting user cost of the beginning of period t stock of inventories K^t defined by (6) becomes

$$(11) \quad [R^t - a^t + (1+a^t)]P^t/(1+r^t) = (1+R^t)P^t/(1+r^t).$$

On the other hand, the expected discounted end of period t price of inventories is $P^t(1+a^t)/(1+r^t)$ and the output quantity that is associated with this price is K^{t+1} . With this treatment of inventories, the expected discounted value of net inventory production is:

$$(12) \quad K^{t+1}P^t(1+a^t)/(1+r^t) - K^t(1+R^t)P^t/(1+r^t) = V^t$$

where V^t was defined earlier by (10). Thus, both treatments of inventories lead to the same contribution to production.

When calculating the total factor productivity of the New Zealand economy, we use the first treatment of inventories, so that our TFP estimates are more comparable with statistical agency practice. It is these user costs for inventories we report in Table B35. However, in previous econometric modelling in Diewert and Lawrence (1998a) we used the second treatment of inventories.

TFP Database

The data listed in tables B1 to B35 which are used to form the TFP database are in consumer prices. As noted at the outset, the data used in the TFP database itself are all in producer prices. The values, prices and quantities of the 39 output variables in the TFP database are listed in tables B36a–B36d, B37a–B37d and B38a–B38d, respectively. The values, prices and quantities of the 23 input variables in the TFP database are listed in tables B39a–B39c, B40a–B40c and B41a–B41c, respectively.

Table B2a: SNZ Final Consumption Data in Current Prices, 1972 to 1980, \$millions

<i>Item</i>	1972	1973	1974	1975	1976	1977	1978	1979	1980
Food	589	650	733	838	948	1,078	1,197	1,323	1,556
Beverages	102	108	135	156	210	233	324	361	405
Clothing and footwear	376	432	507	535	588	645	728	810	893
Imputed rent	410	470	535	628	789	915	1,037	1,126	1,221
Rentals and costs	145	159	179	214	259	304	356	386	430
Fuel and power	89	96	106	113	126	173	226	235	294
Furniture etc	158	197	265	341	421	472	506	552	614
Textiles etc	66	82	111	143	176	198	212	231	257
Other goods	73	95	118	127	137	147	158	179	220
Health services	157	176	204	245	280	300	338	398	469
Cars and vehicles	293	313	335	351	365	381	386	528	784
Vehicle operation	359	400	455	570	624	744	814	871	1,015
Public transport	152	163	187	220	245	285	325	393	443
Recreation	461	517	591	659	771	862	943	1,054	1,186
Hotels and restaurants	245	292	339	376	424	527	583	662	832
Tobacco	127	133	136	146	166	189	213	221	255
Personal	157	184	200	200	220	265	254	300	347
Post and telephone	69	79	93	104	115	129	155	184	206
Other services	115	135	147	146	161	194	186	220	254
Non-resident household expenditure in New Zealand	-41	-52	-72	-98	-131	-148	-148	-152	-181
Residents expenditure overseas	61	79	109	136	145	187	229	297	381
Alcohol consumed in restaurants	150	161	183	203	220	253	278	323	419
Alcohol consumed off- premises	91	96	121	140	192	211	299	333	371

Table B2b: SNZ Final Consumption Data in Current Prices, 1981 to 1989, \$millions

<i>Item</i>	<i>1981</i>	<i>1982</i>	<i>1983</i>	<i>1984</i>	<i>1985</i>	<i>1986</i>	<i>1987</i>	<i>1988</i>	<i>1989</i>
Food	1,829	2,237	2,527	2,720	3,032	3,487	4,076	4,693	4,910
Beverages	477	502	612	726	866	1,067	1,347	1,434	1,518
Clothing and footwear	1,006	1,199	1,361	1,381	1,505	1,657	1,939	2,100	2,007
Imputed rent	1,368	1,652	2,015	2,282	2,711	3,614	4,375	5,159	6,216
Rentals and costs	461	556	624	659	758	981	1,165	1,362	1,604
Fuel and power	334	361	451	469	485	591	732	850	929
Furniture etc	710	817	946	1,055	1,252	1,462	1,825	1,901	1,829
Textiles etc	297	342	396	414	472	530	643	674	665
Other goods	243	301	359	432	519	644	847	963	1,065
Health services	580	717	869	950	1,079	1,341	1,711	2,055	2,306
Cars and vehicles	980	1,178	1,174	1,283	1,618	1,698	1,766	1,927	1,902
Vehicle operation	1,254	1,360	1,575	1,763	1,985	2,555	2,655	2,915	3,162
Public transport	523	581	663	719	787	927	1,072	1,240	1,348
Recreation	1,361	1,496	1,679	1,803	2,018	2,303	2,784	3,091	3,319
Hotels and restaurants	1,052	1,279	1,492	1,646	1,921	2,277	2,669	3,012	3,019
Tobacco	292	351	412	467	502	552	684	852	914
Personal	429	538	603	671	772	942	1,160	1,298	1,380
Post and telephone	246	270	312	346	376	414	541	698	787
Other services	314	395	442	503	590	649	796	1,067	1,215
Non-resident household expenditure in New Zealand	-219	-273	-307	-422	-707	-927	-1,203	-1,416	-1,391
Residents expenditure overseas	423	499	520	524	681	690	845	924	1,121
Alcohol consumed in restaurants	530	648	704	727	784	865	935	1,060	1,079
Alcohol consumed off-premises	436	501	554	651	764	924	1,142	1,189	1,249

Table B2c: SNZ Final Consumption Data in Current Prices, 1990 to 1998, \$millions

<i>Item</i>	<i>1990</i>	<i>1991</i>	<i>1992</i>	<i>1993</i>	<i>1994</i>	<i>1995</i>	<i>1996</i>	<i>1997</i>	<i>1998</i>
Food	5,308	5,664	5,617	5,728	5,783	6,163	6,452	6,711	7,039
Beverages	1,613	1,868	1,845	1,898	1,915	1,971	2,072	2,121	2,242
Clothing and footwear	2,184	2,188	2,122	2,145	2,247	2,370	2,369	2,383	2,427
Imputed rent	6,745	7,325	7,554	7,513	7,702	8,065	8,887	9,475	9,919
Rentals and costs	1,731	1,862	1,893	1,993	2,082	2,357	2,510	2,698	2,845
Fuel and power	984	1,066	1,142	1,195	1,264	1,335	1,424	1,508	1,642
Furniture etc	1,903	1,815	1,780	1,950	2,326	2,540	2,545	2,576	2,607
Textiles etc	685	673	667	712	784	856	959	948	952
Other goods	1,097	1,161	1,237	1,269	1,355	1,460	1,531	1,537	1,652
Health services	2,495	2,779	3,149	3,336	3,624	3,836	4,280	4,624	5,036
Cars and vehicles	1,993	1,710	1,470	1,319	1,641	2,223	2,520	2,907	2,368
Vehicle operation	3,382	3,456	3,305	3,286	3,261	3,446	3,643	3,811	3,864
Public transport	1,432	1,539	1,533	1,599	1,618	1,842	2,178	2,254	2,249
Recreation	3,565	3,797	3,780	3,996	4,476	5,062	5,522	5,859	6,138
Hotels and restaurants	3,208	3,242	3,190	3,307	3,587	4,113	4,397	4,618	4,756
Tobacco	1,066	1,142	1,143	1,117	1,160	1,130	1,211	1,316	1,336
Personal	1,451	1,544	1,590	1,583	1,618	1,738	1,903	1,900	2,007
Post and telephone	1,000	1,057	1,123	1,152	1,181	1,269	1,455	1,515	1,722
Other services	1,307	1,424	1,344	1,381	1,381	1,451	1,657	1,674	1,735
Non-resident household expenditure in New Zealand	-1,525	-1,540	-1,741	-1,900	-2,109	-2,509	-3,239	-3,031	-2,784
Residents expenditure overseas	1,110	1,168	1,182	1,216	1,186	1,238	1,287	1,355	1,461
Alcohol consumed in restaurants	1,132	1,076	1,037	1,040	1,096	1,186	1,211	1,271	1,288
Alcohol consumed off-premises	1,313	1,533	1,508	1,548	1,549	1,572	1,659	1,698	1,800

Table B3a: SNZ Consumption Data in Constant 1991–92 Prices, 1972 to 1980, \$m

<i>Item</i>	1972	1973	1974	1975	1976	1977	1978	1979	1980
Food	4,668	4,913	4,890	5,092	5,073	4,886	4,682	4,689	4,572
Beverages	637	643	707	746	881	828	993	1,003	934
Clothing and footwear	2,598	2,827	3,078	2,870	2,752	2,624	2,520	2,466	2,433
Imputed rent	4,876	5,029	5,204	5,400	5,593	5,760	5,905	6,024	6,126
Rentals and costs	1,399	1,440	1,499	1,588	1,660	1,712	1,759	1,757	1,819
Fuel and power	927	954	1,005	1,007	1,026	1,027	997	981	901
Furniture etc	837	991	1,251	1,456	1,565	1,501	1,390	1,358	1,323
Textiles etc	419	496	627	730	784	752	696	680	663
Other goods	456	562	678	682	672	602	578	586	649
Health services	2,560	2,439	2,487	2,523	2,461	2,257	2,125	2,201	2,211
Cars and vehicles	1,837	1,843	1,869	1,701	1,426	1,256	1,125	1,373	1,728
Vehicle operation	2,850	2,978	3,218	3,503	3,093	3,110	3,011	2,873	2,837
Public transport	1,035	1,039	1,134	1,160	1,041	1,022	1,029	1,111	1,062
Recreation	3,391	3,584	3,742	3,731	3,779	3,642	3,479	3,504	3,408
Hotels and restaurants	2,090	2,346	2,460	2,457	2,406	2,565	2,450	2,487	2,641
Tobacco	1,731	1,754	1,817	1,942	1,920	1,856	1,847	1,802	1,759
Personal	1,449	1,613	1,538	1,296	1,220	1,250	1,032	1,079	1,055
Post and telephone	572	623	641	605	577	546	565	595	565
Other services	1,319	1,468	1,400	1,180	1,110	1,138	940	982	960
Non-resident household expenditure in New Zealand	-321	-384	-480	-588	-680	-660	-577	-535	-549
Residents expenditure overseas	461	559	728	753	621	675	776	952	1,090
Alcohol consumed in restaurants	1,668	1,774	1,791	1,856	1,804	1,831	1,829	1,757	1,688
Alcohol consumed off- premises	1,084	1,153	1,165	1,206	1,173	1,190	1,254	1,245	1,261

Table B3b: SNZ Consumption Data in Constant 1991–92 Prices, 1981 to 1989, \$m

<i>Item</i>	<i>1981</i>	<i>1982</i>	<i>1983</i>	<i>1984</i>	<i>1985</i>	<i>1986</i>	<i>1987</i>	<i>1988</i>	<i>1989</i>
Food	4,525	4,766	4,885	5,045	5,229	5,300	5,540	5,842	5,762
Beverages	1,091	1,143	1,279	1,429	1,551	1,655	1,838	1,670	1,702
Clothing and footwear	2,426	2,596	2,630	2,492	2,578	2,515	2,570	2,432	2,220
Imputed rent	6,218	6,284	6,426	6,557	6,688	6,843	6,986	7,098	7,206
Rentals and costs	1,767	1,872	1,780	1,773	1,785	1,792	1,806	1,824	1,840
Fuel and power	902	872	952	987	995	996	1,038	1,054	1,057
Furniture etc	1,354	1,376	1,441	1,568	1,773	1,833	2,005	1,947	1,890
Textiles etc	678	689	721	731	768	727	764	721	713
Other goods	631	706	734	845	969	1,074	1,165	1,201	1,227
Health services	2,205	2,224	2,312	2,395	2,478	2,603	2,856	2,970	3,140
Cars and vehicles	1,786	1,839	1,606	1,611	1,760	1,629	1,558	1,629	1,832
Vehicle operation	2,897	2,691	2,731	2,887	2,871	3,067	3,146	3,196	3,467
Public transport	1,036	986	985	1,094	1,140	1,191	1,199	1,519	1,612
Recreation	3,358	3,196	3,111	3,164	3,228	3,380	3,653	3,672	3,789
Hotels and restaurants	2,798	2,938	3,011	3,207	3,379	3,464	3,607	3,635	3,432
Tobacco	1,723	1,792	1,754	1,782	1,770	1,638	1,469	1,514	1,446
Personal	1,101	1,199	1,162	1,263	1,379	1,472	1,617	1,562	1,492
Post and telephone	568	541	541	572	612	654	705	864	917
Other services	1,002	1,092	1,058	1,136	1,240	1,131	1,130	1,353	1,402
Non-resident household expenditure in New Zealand	-572	-618	-602	-791	-1,213	-1,374	-1,552	-1,702	-1,605
Residents expenditure overseas	1,029	1,083	1,029	925	1,081	963	1,119	1,223	1,463
Alcohol consumed in restaurants	1,611	1,600	1,361	1,339	1,316	1,252	1,257	1,288	1,233
Alcohol consumed off- premises	1,251	1,284	1,231	1,356	1,444	1,515	1,637	1,438	1,438

Table B3c: SNZ Consumption Data in Constant 1991–92 Prices, 1990 to 1998, \$m

<i>Item</i>	1990	1991	1992	1993	1994	1995	1996	1997	1998
Food	5,551	5,601	5,616	5,650	5,709	6,094	6,145	6,273	6,427
Beverages	1,702	1,853	1,846	1,892	1,879	1,866	1,896	1,893	2,207
Clothing and footwear	2,338	2,241	2,122	2,124	2,202	2,339	2,445	2,468	2,515
Imputed rent	7,317	7,442	7,554	7,648	7,742	7,847	7,969	8,084	8,200
Rentals and costs	1,857	1,877	1,893	1,906	1,920	1,936	1,957	1,977	1,997
Fuel and power	1,082	1,122	1,142	1,103	1,064	1,041	1,013	1,022	1,045
Furniture etc	1,887	1,785	1,780	1,949	2,306	2,500	2,508	2,614	2,738
Textiles etc	726	692	667	692	764	839	872	850	871
Other goods	1,181	1,173	1,237	1,270	1,336	1,438	1,476	1,470	1,513
Health services	3,077	3,132	3,149	3,200	3,293	3,383	3,721	3,910	4,146
Cars and vehicles	2,031	1,688	1,471	1,273	1,442	1,876	2,211	2,643	2,366
Vehicle operation	3,576	3,464	3,305	3,200	3,196	3,449	3,613	3,720	3,731
Public transport	1,612	1,617	1,533	1,647	1,699	1,879	2,187	2,281	2,352
Recreation	3,766	3,808	3,776	3,860	4,197	4,712	4,954	5,345	5,685
Hotels and restaurants	3,454	3,331	3,189	3,266	3,486	3,932	4,328	4,482	4,451
Tobacco	1,346	1,325	1,144	1,050	1,074	1,040	1,009	942	908
Personal	1,505	1,546	1,590	1,572	1,605	1,719	1,785	1,784	1,928
Post and telephone	1,079	1,089	1,123	1,134	1,164	1,252	1,390	1,432	1,493
Other services	1,408	1,461	1,344	1,392	1,378	1,400	1,466	1,486	1,540
Non-resident household expenditure in New Zealand	-1,655	-1,577	-1,740	-1,904	-2,085	-2,420	-3,031	-2,815	-2,551
Residents expenditure overseas	1,271	1,261	1,182	1,121	1,101	1,174	1,314	1,433	1,542
Alcohol consumed in restaurants	1,231	1,122	1,038	1,016	1,041	1,099	1,077	1,089	1,066
Alcohol consumed off-premises	1,412	1,522	1,502	1,526	1,511	1,443	1,469	1,452	1,760

Table B4: Government Final and Intermediate Consumption Expenditure

<i>Year</i>	<i>Government Consumption of Intermediates</i>			<i>Price Index</i>	<i>Quantity \$m1972</i>
	<i>Central Govt \$m</i>	<i>Local Govt \$m</i>	<i>Total Govt \$m</i>		
1972	220	78	298	1.000	298
1973	250	105	355	1.007	353
1974	265	126	391	1.016	385
1975	329	163	492	1.159	425
1976	413	189	602	1.415	425
1977	477	201	678	1.543	440
1978	604	255	859	1.532	561
1979	719	291	1,010	1.886	536
1980	787	332	1,119	2.225	503
1981	958	418	1,376	3.025	455
1982	1,211	471	1,682	3.570	471
1983	1,392	561	1,953	4.244	460
1984	1,505	662	2,167	4.446	487
1985	1,779	738	2,517	4.982	505
1986	2,054	848	2,902	5.612	517
1987	2,693	966	3,659	6.168	593
1988	3,005	1,068	4,073	6.529	624
1989	3,215	1,176	4,391	7.046	623
1990	3,656	1,252	4,908	7.659	641
1991	4,215	1,417	5,632	8.012	703
1992	4,201	1,472	5,673	8.187	693
1993	4,438	1,521	5,959	8.206	726
1994	4,433	1,483	5,916	8.382	706
1995	4,343	1,555	5,898	8.490	695
1996	4,690	1,628	6,318	8.588	736
1997	4,959	1,692	6,651	8.605	773
1998	5,749	1,662	7,411	8.644	857

Table B5: Market Sector Gross Fixed Capital Formation

<i>Year</i>	<i>Residential Buildings</i>	<i>Non-residential and Other Construction</i>	<i>Transport Equipment</i>	<i>Electrical Machinery</i>	<i>Plant and Other Machinery</i>
	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>
1972	306	428	282	62	305
1973	416	480	331	66	410
1974	562	567	377	85	422
1975	683	726	428	141	494
1976	769	877	551	165	593
1977	855	961	520	188	722
1978	676	1,114	544	160	738
1979	716	1,134	692	173	820
1980	731	1,154	746	212	882
1981	881	1,341	799	227	1,126
1982	1,180	1,859	1,217	352	1,580
1983	1,310	2,164	1,195	400	2,211
1984	1,518	2,276	1,120	541	2,603
1985	1,775	2,496	1,549	747	2,875
1986	2,059	3,039	1,783	891	3,440
1987	2,423	3,553	1,539	1,124	2,997
1988	2,746	4,056	1,556	1,096	3,228
1989	2,797	3,977	961	1,171	3,216
1990	3,342	3,795	1,618	1,495	3,234
1991	3,420	3,353	1,423	1,792	2,896
1992	2,950	3,106	1,200	1,457	2,302
1993	3,097	2,718	1,619	1,604	2,733
1994	3,806	3,044	1,988	1,706	3,760
1995	4,705	3,545	2,402	2,040	4,294
1996	5,035	4,308	2,541	2,192	4,520
1997	5,395	4,556	2,816	2,159	4,456
1998	5,785	4,557	2,131	2,269	4,298

Table B6: Market Sector Gross Fixed Capital Formation Price Indexes

<i>Year</i>	<i>Residential Buildings Index</i>	<i>Non-residential and Other Construction Index</i>	<i>Transport Equipment Index</i>	<i>Electrical Machinery Index</i>	<i>Plant and Other Machinery Index</i>
1972	1.000	1.000	1.000	1.000	1.000
1973	1.095	1.091	1.090	1.019	1.089
1974	1.284	1.277	1.083	1.016	1.053
1975	1.605	1.584	1.287	1.148	1.186
1976	1.777	1.788	1.798	1.518	1.579
1977	1.944	1.845	1.999	1.828	2.014
1978	2.171	1.896	2.277	1.805	2.226
1979	2.351	1.885	2.666	1.892	2.584
1980	2.549	1.995	2.717	2.033	2.689
1981	2.920	2.137	3.099	2.368	3.137
1982	3.531	2.814	3.645	2.590	3.477
1983	4.061	3.167	4.096	2.774	3.935
1984	4.194	3.255	4.348	2.938	4.321
1985	4.559	3.475	4.890	3.224	5.063
1986	5.233	3.901	5.528	3.261	5.435
1987	5.060	4.345	6.390	3.424	5.956
1988	7.154	4.737	6.510	2.947	5.734
1989	6.941	5.310	5.958	2.795	5.767
1990	7.538	5.321	5.756	2.785	6.029
1991	7.857	5.504	5.656	2.741	5.987
1992	7.968	5.560	5.935	2.835	6.069
1993	8.029	5.554	6.378	3.068	6.113
1994	8.435	5.638	6.692	3.112	6.179
1995	9.184	5.777	6.790	2.900	6.410
1996	9.802	5.919	6.796	2.789	6.560
1997	10.222	5.989	6.722	2.715	6.549
1998	10.309	5.971	6.529	2.666	6.554

Table B7: Government Sector Gross Fixed Capital Formation

<i>Year</i>	<i>Non-residential and Other Construction</i>	<i>Transport Equipment</i>	<i>Electrical Machinery</i>	<i>Plant and Other Machinery</i>	<i>Total</i>
	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>
1972	94	17	4	17	132
1973	128	23	5	23	179
1974	123	23	5	23	174
1975	158	29	7	29	223
1976	207	40	9	34	290
1977	204	35	5	43	287
1978	215	38	10	49	312
1979	232	49	12	51	344
1980	225	42	8	66	341
1981	241	47	13	79	380
1982	254	57	13	85	409
1983	292	48	20	136	443
1984	322	48	42	140	464
1985	333	58	18	141	477
1986	454	72	65	175	660
1987	434	77	33	180	624
1988	443	66	25	167	568
1989	555	72	9	135	554
1990	593	75	19	131	580
1991	684	71	19	136	598
1992	346	60	17	99	420
1993	337	52	13	104	400
1994	311	50	12	85	361
1995	452	50	11	105	423
1996	415	54	11	101	418
1997	514	54	14	125	483
1998	563	59	15	137	528

Table B8: Exports

<i>Year</i>	<i>Butter</i>	<i>Cheese</i>	<i>Meat</i>	<i>Wool</i>	<i>Dairy</i>	<i>Fish & Forestry Preps.</i>	<i>Aluminum</i>	<i>Trans. Equip.</i>	<i>Other Merch.</i>	<i>Services</i>	
<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	
1972	189	58	413	199	191	21	82	11	22	77	251
1973	171	80	490	364	257	20	87	27	28	103	301
1974	129	68	573	400	303	20	109	32	37	143	380
1975	116	39	455	278	286	21	130	38	52	140	472
1976	224	72	506	348	294	28	148	66	67	177	604
1977	268	78	737	653	441	43	219	87	83	322	718
1978	292	79	787	585	497	54	245	124	101	405	779
1979	290	72	998	662	537	64	276	132	130	491	867
1980	380	88	1,149	893	731	123	416	160	160	614	1,077
1981	468	136	1,400	899	736	158	534	172	212	829	1,288
1982	575	176	1,551	904	968	206	562	236	250	953	1,625
1983	750	182	1,752	964	1,167	279	508	281	240	1,103	1,905
1984	566	226	1,873	1,107	1,337	317	595	420	278	1,368	2,268
1985	711	231	2,007	1,397	1,782	508	771	495	398	1,867	2,939
1986	658	269	1,927	1,297	2,052	537	711	449	436	2,143	3,178
1987	540	273	2,140	1,511	2,303	698	765	480	420	1,982	3,593
1988	582	282	2,059	1,604	2,665	659	917	601	531	2,088	3,912
1989	624	290	2,210	1,819	2,894	732	1,155	762	613	2,375	4,067
1990	594	320	2,435	1,472	3,055	789	1,378	805	678	2,822	4,120
1991	581	362	2,552	977	3,236	766	1,547	764	696	3,245	4,274
1992	703	390	2,799	1,079	3,337	1,044	1,760	658	744	3,580	4,651
1993	783	505	3,105	971	3,692	1,175	2,093	649	938	3,942	5,096
1994	849	511	3,017	973	3,614	1,175	2,570	619	1,117	4,337	5,642
1995	721	602	2,739	1,313	3,822	1,178	2,572	762	1,266	5,006	6,430
1996	845	611	2,697	1,090	3,689	1,205	2,661	780	1,344	4,632	7,118
1997	881	750	2,753	958	4,160	1,136	2,377	723	1,410	4,875	6,808
1998	942	888	2,936	913	4,338	1,062	2,292	857	1,316	5,338	6,531

Table B9: Export Price Indexes

<i>Year</i>	<i>Butter Index</i>	<i>Cheese Index</i>	<i>Meat Index</i>	<i>Wool Index</i>	<i>Dairy Index</i>	<i>Fish & Forestry Preps. Index</i>	<i>Aluminum Index</i>	<i>Trans. Equip. Index</i>	<i>Other Merch. Index</i>	<i>Services Index</i>	
1972	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
1973	0.903	1.241	1.176	1.731	1.212	1.077	1.011	0.986	1.023	1.551	1.066
1974	0.727	1.256	1.518	2.604	1.341	1.125	1.240	0.977	1.124	1.629	1.122
1975	0.780	1.054	1.238	1.975	1.465	1.160	1.531	1.188	1.279	1.856	1.290
1976	1.037	1.333	1.242	1.988	1.507	1.437	1.778	1.772	1.603	2.169	1.604
1977	1.233	1.497	1.634	3.354	1.745	1.950	1.994	2.325	1.937	2.491	1.901
1978	1.405	1.514	1.745	3.571	1.967	2.273	2.059	2.434	2.085	2.715	2.148
1979	1.537	1.625	2.165	3.536	2.173	2.375	2.143	2.699	2.217	2.957	2.410
1980	1.678	1.943	2.779	4.435	2.620	2.581	2.748	3.256	2.641	3.783	2.843
1981	2.066	2.339	3.030	4.454	3.011	2.722	3.423	3.765	3.000	4.101	3.440
1982	2.997	2.911	3.331	4.558	3.210	3.106	3.895	4.140	3.467	5.074	4.013
1983	3.224	3.548	3.433	4.402	3.621	3.858	4.026	4.312	3.816	5.808	4.581
1984	3.370	3.491	3.655	4.938	3.723	4.346	4.327	5.318	4.271	6.260	4.813
1985	3.326	3.884	4.263	6.140	4.258	5.881	5.630	5.742	4.951	7.297	5.205
1986	3.046	4.040	4.133	6.396	4.439	6.427	5.580	5.395	5.427	7.475	5.756
1987	2.804	3.825	3.879	6.746	4.612	7.518	5.858	5.706	5.671	7.329	6.386
1988	2.583	3.748	3.839	7.928	5.001	7.022	6.175	6.300	6.081	7.725	6.784
1989	2.833	4.538	4.077	8.570	5.086	6.639	6.936	8.188	6.926	9.030	7.080
1990	3.671	5.418	4.878	8.424	5.885	7.250	7.224	7.603	7.378	9.743	7.378
1991	3.512	5.036	5.215	6.707	5.246	6.801	7.112	7.188	7.452	9.884	7.731
1992	3.545	5.175	5.173	5.500	5.370	8.000	7.019	6.033	7.350	9.657	7.940
1993	4.103	5.956	5.514	5.969	6.024	9.104	7.511	6.229	7.396	10.547	7.945
1994	3.854	5.696	5.494	5.449	5.786	8.626	9.218	5.511	6.906	10.083	7.900
1995	3.469	5.156	4.885	6.522	5.521	8.758	8.618	6.844	6.453	10.359	7.994
1996	3.878	5.225	4.413	6.818	5.377	8.209	8.853	6.942	6.261	9.674	8.184
1997	3.306	5.070	4.593	6.116	5.306	7.960	7.566	5.846	6.471	9.427	8.233
1998	3.413	5.261	4.585	5.863	5.253	7.776	7.427	6.620	6.040	9.584	8.381

Table B10: Imports

<i>Year</i>	<i>Food and Beverage</i>	<i>Petrol. Products</i>	<i>Non-Fuel Crude Materials</i>	<i>Textiles, Clothing</i>	<i>Iron and Steel</i>	<i>Non-Electric Machin'y</i>	<i>Electric Machin'y</i>	<i>Trans. Equipm't</i>	<i>Other Merch.</i>	<i>Services</i>
<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>
1972	77	86	88	109	60	178	65	221	345	290
1973	88	99	96	111	70	197	70	224	388	348
1974	114	134	128	165	102	235	89	267	537	453
1975	154	337	192	209	200	384	147	354	840	555
1976	183	415	169	154	149	398	173	436	753	642
1977	177	492	236	236	193	470	197	477	960	746
1978	195	500	248	222	177	492	169	410	995	922
1979	193	474	259	247	177	489	182	471	1,064	1,107
1980	259	899	285	346	237	631	224	629	1,504	1,350
1981	283	1,227	336	319	227	719	240	680	1,544	1,696
1982	386	1,278	403	416	308	894	367	1,042	2,059	2,082
1983	423	1,424	476	461	355	1,135	421	953	2,276	2,431
1984	453	1,308	526	491	359	1,426	565	782	2,636	2,459
1985	634	1,457	680	724	522	1,668	776	1,285	3,901	2,861
1986	583	1,593	651	650	439	1,952	927	1,608	3,706	3,365
1987	706	699	485	710	378	1,717	1,173	1,515	3,990	3,842
1988	706	783	512	636	411	1,893	1,138	1,803	4,183	3,659
1989	792	618	580	583	276	1,812	1,207	1,502	4,306	4,000
1990	970	926	644	682	358	2,062	1,537	2,743	5,415	4,067
1991	962	1,245	651	640	263	2,272	1,844	2,493	5,387	4,204
1992	982	1,075	641	660	267	2,074	1,496	2,245	5,595	4,622
1993	1,121	1,102	725	740	312	2,389	1,643	2,466	6,485	5,176
1994	1,231	1,097	731	727	364	2,814	1,733	2,614	6,780	4,780
1995	1,349	1,080	750	778	393	3,242	2,074	3,522	7,487	5,107
1996	1,396	1,232	768	710	386	3,469	2,225	3,406	7,823	5,326
1997	1,416	1,343	722	662	399	3,396	2,200	3,351	7,774	5,473
1998	1,571	1,401	757	698	375	3,473	2,316	3,454	8,384	5,707

Table B11: Import Price Indexes

<i>Year</i>	<i>Food and Beverage Index</i>	<i>Petrol. Products Index</i>	<i>Non-Fuel Crude Materials Index</i>	<i>Textiles, Clothing Index</i>	<i>Iron and Steel Index</i>	<i>Non-Electric Machin'y Index</i>	<i>Electric Machin'y Index</i>	<i>Trans. Equipm't Index</i>	<i>Other Merch. Index</i>	<i>Services Index</i>
1972	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1973	1.097	0.999	1.011	1.052	1.026	1.089	1.019	1.090	1.014	1.066
1974	1.230	1.253	1.088	1.139	1.149	1.053	1.016	1.083	1.104	1.122
1975	1.391	3.017	1.566	1.343	1.664	1.186	1.148	1.287	1.454	1.290
1976	1.875	3.784	2.112	1.598	2.107	1.579	1.518	1.798	1.846	1.604
1977	2.151	4.883	2.467	1.866	2.391	2.014	1.828	1.999	2.200	1.901
1978	2.566	5.142	2.454	1.981	2.316	2.226	1.805	2.277	2.308	2.148
1979	2.393	5.023	2.420	2.019	2.645	2.584	1.892	2.666	2.296	2.410
1980	2.433	8.530	2.784	2.250	3.096	2.689	2.033	2.717	2.810	2.843
1981	3.010	13.229	3.536	2.554	3.582	3.137	2.368	3.099	3.317	3.440
1982	3.039	16.176	4.253	2.844	4.041	3.477	2.590	3.525	3.658	4.013
1983	3.399	17.890	4.730	3.114	4.291	3.935	2.774	4.011	3.972	4.581
1984	3.744	17.350	5.143	3.307	4.503	4.321	2.938	4.704	4.325	5.127
1985	4.487	20.127	6.039	4.177	5.550	5.063	3.224	5.861	5.211	5.865
1986	4.545	20.235	6.067	4.421	5.467	5.435	3.261	6.236	5.410	6.357
1987	4.229	12.528	5.468	4.354	5.416	5.956	3.424	7.593	5.179	6.468
1988	3.836	11.530	5.222	4.270	5.176	5.734	2.947	7.574	4.943	6.194
1989	4.097	9.484	5.923	4.330	6.557	5.767	2.795	7.494	5.324	6.423
1990	4.381	12.488	5.969	4.526	7.829	6.029	2.785	7.740	5.568	7.135
1991	4.413	15.493	6.253	4.615	7.383	5.987	2.741	7.952	5.494	7.711
1992	4.473	13.668	6.207	4.742	7.871	5.870	2.835	8.848	5.477	8.220
1993	4.634	14.413	6.285	4.928	7.675	6.521	3.068	10.214	5.639	8.745
1994	4.447	12.540	5.778	4.536	7.085	6.311	3.112	10.947	5.419	8.529
1995	4.433	11.467	5.929	4.605	6.882	6.257	2.900	11.067	5.313	8.339
1996	4.319	11.552	5.931	4.500	7.414	6.040	2.789	10.997	5.371	8.029
1997	4.404	12.494	5.759	4.307	6.952	5.801	2.715	10.650	5.042	7.862
1998	4.544	12.128	5.907	4.522	7.039	5.642	2.666	11.110	5.104	8.087

Table B12: Subsidies

<i>Year</i>	<i>Agriculture</i> \$m	<i>Forestry and Logging</i> \$m	<i>Food, Beverages and Tobacco</i> \$m	<i>Chemicals, Plastics, etc</i> \$m	<i>Trade, Hotels, etc</i> \$m	<i>Transport and Storage</i> \$m	<i>Total Value</i> \$m	<i>Price Index</i>	<i>Quantity</i> \$m1972
1972	30.0	1.1	28.7	27.6	8.8	12.1	108	1.000	108
1973	18.0	1.1	41.9	37.5	15.4	15.4	129	1.176	110
1974	9.0	1.3	70.4	19.6	36.5	26.1	163	1.606	101
1975	13.0	1.3	76.4	42.0	25.5	80.2	238	2.456	97
1976	88.0	1.2	69.6	78.0	40.8	113.9	392	4.580	85
1977	37.0	5.7	45.2	73.5	27.1	54.3	243	2.580	94
1978	30.0	6.8	52.9	64.2	27.0	100.2	281	3.297	85
1979	110.0	8.8	66.2	82.7	37.5	122.4	428	4.938	87
1980	55.0	10.0	43.4	52.4	40.1	151.5	352	3.913	90
1981	39.0	7.0	49.0	46.7	51.4	155.3	348	3.909	89
1982	291.0	11.1	44.4	45.5	31.1	155.3	578	6.385	91
1983	469.0	9.7	39.7	39.7	30.1	167.5	756	8.021	94
1984	377.0	18.5	25.0	34.7	32.6	172.6	660	7.005	94
1985	257.0	87.7	31.0	33.2	33.2	156.2	598	6.036	99
1986	97.0	7.7	15.5	18.8	23.2	199.8	362	3.484	104
1987	39.0	11.4	6.8	9.1	11.4	214.4	292	2.670	109
1988	36.1	10.6	6.3	8.5	10.6	199.0	271	2.527	107
1989	24.0	7.0	4.2	5.6	7.0	132.2	180	1.638	110
1990	27.5	8.0	4.8	6.4	8.0	151.2	206	1.876	110
1991	27.3	8.0	4.8	6.4	8.0	150.5	205	1.966	104
1992	32.1	9.4	5.6	7.5	9.4	176.9	241	2.308	104
1993	42.1	12.3	7.4	9.9	12.3	232.0	316	2.976	106
1994	41.3	12.1	7.2	9.7	12.1	227.6	310	2.679	116
1995	43.3	12.7	7.6	10.1	12.7	238.6	325	2.601	125
1996	42.3	12.4	7.4	9.9	12.4	232.7	317	2.346	135
1997	42.4	12.4	7.4	9.9	12.4	233.5	318	2.225	143
1998	42.5	12.4	7.4	10.0	12.4	234.2	319	2.142	149

Table B13: Occupations by Total Numbers Employed, Census Years

<i>Occupation</i>	<i>Census Years</i>					
	<i>1971</i>	<i>1976</i>	<i>1981</i>	<i>1986</i>	<i>1991</i>	<i>1996</i>
Professional, Technical, Managerial	175,144	232,716	246,690	299,007	336,207	409,452
Clerical, Sales, Service, Armed Forces	417,331	476,109	509,913	564,048	553,113	632,760
Agricultural, Transport, Labourers	560,131	607,614	602,793	622,650	487,482	531,096
Not Adequately Defined	6,539	15,150	27,834	13,713	23,598	57,501
Total	1,159,145	1,331,592	1,387,230	1,499,421	1,400,400	1,630,809

Table B14: Distribution of Hours Worked by Numbers Employed, Census Years

<i>Total Hours Worked per Week</i>	<i>Census Years</i>					
	<i>1971</i>	<i>1976</i>	<i>1981</i>	<i>1986</i>	<i>1991</i>	<i>1996</i>
1–5	8,973	14,106	20,658	20,271	25,926	52,545
6–10	22,402	30,702	40,767	48,378	57,396	88,914
11–15	16,730	23,754	30,501	35,562	40,854	56,892
16–19	8,373	13,266	18,606	24,822	25,836	76,986
20–24	32,887	41,325	50,247	55,404	63,564	50,949
25–29	20,440	27,420	29,400	31,791	35,625	65,775
30+	1,032,911	1,106,037	1,167,681	1,235,037	1,151,199	1,146,534
Not Specified	5,002	63,594	29,364	48,156	–	92,217
Total	1,159,145	1,331,589	1,387,230	1,499,418	1,400,403	1,630,809

Table B15: Occupations by Total Hours Worked by Numbers Employed, 1991

<i>Occupation</i>	<i>Total Hours Worked</i>						
	<i>1–5</i>	<i>6–10</i>	<i>11–15</i>	<i>16–19</i>	<i>20–24</i>	<i>25–29</i>	<i>30+</i>
Professional, Technical, Managerial	5,136	10,065	7,536	6,297	13,758	6,810	286,605
Clerical, Sales, Service, Armed Forces	15,285	33,339	25,347	14,448	33,282	20,697	410,718
Agricultural, Transport, Labourers	4,434	12,018	6,933	4,569	15,162	7,518	436,851
Not Adequately Defined	111	177	93	54	132	63	2,265
Total	25,923	57,399	40,854	25,836	63,564	35,625	1,151,196

Table B16: Estimated Total Employment by Occupation

<i>Year</i>	<i>Professional, Technical, Managerial</i> '000	<i>Clerical, Sales, Service, Armed Forces</i> '000	<i>Agricultural, Transport, Labourers</i> '000	<i>Total</i> '000
1972	196.18	452.62	610.10	1,258.90
1973	205.51	459.54	614.87	1,279.93
1974	219.33	475.75	631.81	1,326.90
1975	234.03	492.81	649.54	1,376.38
1976	244.72	500.67	654.89	1,400.28
1977	249.67	511.87	662.08	1,423.63
1978	253.06	519.89	664.95	1,437.90
1979	253.73	522.34	660.65	1,436.73
1980	257.13	530.42	663.38	1,450.93
1981	258.34	533.99	660.40	1,452.73
1982	266.61	540.55	656.56	1,463.73
1983	273.99	545.17	650.24	1,469.40
1984	280.11	547.26	640.85	1,468.23
1985	294.82	565.86	650.47	1,511.15
1986	308.90	582.71	657.42	1,549.03
1987	321.18	587.94	638.36	1,547.48
1988	333.19	592.74	618.90	1,544.83
1989	335.38	580.59	582.51	1,498.48
1990	341.48	575.96	554.81	1,472.25
1991	354.66	583.47	539.13	1,477.25
1992	355.18	576.98	533.84	1,466.00
1993	362.96	582.24	539.43	1,484.63
1994	377.75	598.45	555.18	1,531.38
1995	399.60	625.22	580.80	1,605.63
1996	422.52	652.96	607.39	1,682.88
1997	438.38	669.18	623.32	1,730.88
1998	441.93	666.38	621.56	1,729.88

Table B17: Estimated General Government Employment by Occupation

<i>Year</i>	<i>Professional, Technical, Managerial</i> '000	<i>Clerical, Sales, Service, Armed Forces</i> '000	<i>Agricultural, Transport, Labourers</i> '000	<i>Total</i> '000
1972	63.34	84.77	51.24	199.35
1973	65.08	87.10	52.65	204.83
1974	68.10	91.15	55.10	214.35
1975	71.74	96.02	58.04	225.80
1976	75.91	101.60	61.41	238.93
1977	77.70	103.99	62.86	244.55
1978	78.78	105.44	63.73	247.95
1979	81.03	108.45	65.55	255.03
1980	81.72	109.38	66.12	257.23
1981	81.23	108.72	65.72	255.68
1982	81.09	108.53	65.60	255.23
1983	80.09	107.19	64.79	252.08
1984	79.63	106.58	64.42	250.63
1985	78.95	105.67	63.88	248.50
1986	79.56	106.48	64.36	250.40
1987	80.39	107.60	65.04	253.03
1988	78.71	105.34	63.68	247.73
1989	76.95	102.99	62.26	242.20
1990	76.30	102.12	61.73	240.15
1991	77.37	103.56	62.60	243.53
1992	76.25	102.06	61.69	240.00
1993	74.17	99.27	60.01	233.45
1994	75.00	100.39	60.68	236.08
1995	75.23	100.69	60.86	236.78
1996	74.39	99.56	60.18	234.13
1997	75.97	101.68	61.46	239.10
1998	76.92	102.95	62.23	242.10

Table B18: Estimated Market Sector Full-Time Equivalent Employment by Occupation

<i>Year</i>	<i>Professional, Technical, Managerial</i> '000	<i>Clerical, Sales, Service</i> '000	<i>Agricultural, Transport, Labourers</i> '000	<i>Total</i> '000
1972	127.54	323.66	550.23	1,001.44
1973	134.47	326.83	552.06	1,013.36
1974	144.42	336.59	564.77	1,045.78
1975	154.56	346.32	577.69	1,078.57
1976	160.34	347.37	578.05	1,085.76
1977	162.74	353.70	581.45	1,097.89
1978	164.29	358.04	581.19	1,103.53
1979	162.19	356.21	573.09	1,091.49
1980	164.10	360.97	572.99	1,098.06
1981	165.06	363.21	568.33	1,096.60
1982	172.73	368.60	564.20	1,105.52
1983	180.34	373.30	558.35	1,111.99
1984	186.27	375.22	549.19	1,110.67
1985	200.36	391.42	558.29	1,150.06
1986	212.64	404.64	563.86	1,181.14
1987	222.11	406.04	542.30	1,170.45
1988	233.53	409.88	522.47	1,165.88
1989	235.92	399.56	487.03	1,122.51
1990	240.83	394.35	459.19	1,094.36
1991	250.50	397.31	441.45	1,089.26
1992	249.41	389.16	432.92	1,071.50
1993	255.56	391.67	435.05	1,082.28
1994	265.12	399.69	444.05	1,108.86
1995	281.06	416.51	461.98	1,159.54
1996	298.44	434.74	481.03	1,214.21
1997	307.33	441.02	488.58	1,236.93
1998	306.16	433.09	481.09	1,220.35

Table B18a: Estimated Market Sector Average Hours Worked by Occupation

<i>Year</i>	<i>Professional, Technical, Managerial hours/week</i>	<i>Clerical, Sales, Service hours/week</i>	<i>Agricultural, Transport, Labourers hours/week</i>	<i>Total hours/week</i>
1972	44.26	40.56	45.39	43.21
1973	44.14	40.45	45.27	43.10
1974	44.02	40.34	45.15	42.98
1975	43.91	40.24	45.02	42.86
1976	43.79	40.13	44.90	42.75
1977	43.62	39.98	44.73	42.59
1978	43.46	39.83	44.56	42.43
1979	43.29	39.67	44.40	42.27
1980	43.13	39.52	44.23	42.11
1981	42.96	39.37	44.06	41.94
1982	42.92	39.33	44.01	41.90
1983	42.88	39.29	43.97	41.86
1984	42.83	39.25	43.92	41.82
1985	42.79	39.21	43.88	41.77
1986	42.74	39.17	43.83	41.73
1987	42.52	38.97	43.61	41.51
1988	42.30	38.77	43.38	41.30
1989	42.09	38.57	43.16	41.09
1990	41.87	38.37	42.93	40.87
1991	41.65	38.17	42.71	40.66
1992	41.22	37.78	42.27	40.24
1993	40.80	37.39	41.83	39.83
1994	40.37	37.00	41.40	39.41
1995	39.94	36.61	40.96	39.00
1996	39.52	36.22	40.52	38.58
1997	39.09	35.83	40.09	38.17
1998	38.67	35.44	39.65	37.75

Table B19: Estimated Ordinary–Time Earnings by Occupation

<i>Year</i>	<i>Professional, Technical, Managerial \$/person/year</i>	<i>Clerical, Sales, Service, Armed Forces \$/person/year</i>	<i>Agricultural, Transport, Labourers \$/person/year</i>
1972	4,161.13	3,011.13	3,438.55
1973	4,729.62	3,379.39	3,778.49
1974	5,432.91	3,863.80	4,322.47
1975	6,142.06	4,373.63	4,898.77
1976	6,857.07	4,879.86	5,458.92
1977	7,999.91	5,480.87	6,218.90
1978	9,737.89	6,914.75	7,908.84
1979	10,919.80	7,977.80	9,134.97
1980	12,743.11	9,229.06	10,562.88
1981	15,173.00	10,948.21	12,610.86
1982	18,053.39	13,014.67	14,962.70
1983	19,295.97	14,093.01	16,227.88
1984	19,317.70	14,099.17	16,242.44
1985	20,028.18	14,732.57	16,979.11
1986	22,648.94	16,375.48	19,144.43
1987	26,734.70	19,023.36	21,607.26
1988	28,915.41	20,503.45	23,188.42
1989	31,123.62	21,835.96	24,703.12
1990	32,256.57	22,609.54	25,699.11
1991	33,651.46	23,495.78	26,728.11
1992	34,263.74	23,929.04	27,192.33
1993	34,446.83	24,149.70	27,513.14
1994	34,860.19	24,367.04	27,953.35
1995	35,308.00	24,656.84	28,393.56
1996	35,910.82	25,025.12	28,950.70
1997	36,668.65	25,459.82	29,542.23
1998	37,555.66	25,912.62	30,120.01

Table B20: Estimated Market Sector Labour Cost by Occupation

<i>Year</i>	<i>Professional, Technical, Managerial</i> \$m	<i>Clerical, Sales, Service</i> \$m	<i>Agricultural, Transport, Labourers</i> \$m	<i>Total</i> \$m
1972	530.72	974.58	1,892.01	3,397.31
1973	636.01	1,104.47	2,085.94	3,826.43
1974	784.64	1,300.50	2,441.21	4,526.36
1975	949.35	1,514.66	2,829.96	5,293.96
1976	1,099.48	1,695.10	3,155.52	5,950.09
1977	1,301.87	1,938.59	3,615.99	6,856.44
1978	1,599.87	2,475.77	4,596.54	8,672.18
1979	1,771.11	2,841.77	5,235.18	9,848.06
1980	2,091.14	3,331.45	6,052.42	11,475.01
1981	2,504.44	3,976.49	7,167.19	13,648.12
1982	3,118.29	4,797.15	8,441.89	16,357.34
1983	3,479.84	5,260.89	9,060.87	17,801.60
1984	3,598.26	5,290.24	8,920.18	17,808.68
1985	4,012.79	5,766.57	9,479.26	19,258.63
1986	4,816.11	6,626.16	10,794.70	22,236.97
1987	5,937.93	7,724.31	11,717.59	25,379.83
1988	6,752.64	8,403.98	12,115.27	27,271.89
1989	7,342.76	8,724.68	12,031.15	28,098.59
1990	7,768.30	8,916.03	11,800.69	28,485.02
1991	8,429.69	9,335.12	11,799.17	29,563.98
1992	8,545.67	9,312.33	11,772.19	29,630.20
1993	8,803.13	9,458.78	11,969.60	30,231.51
1994	9,242.06	9,739.34	12,412.71	31,394.10
1995	9,923.64	10,269.75	13,117.18	33,310.56
1996	10,717.19	10,879.53	13,926.02	35,522.75
1997	11,269.44	11,228.24	14,433.89	36,931.57
1998	11,498.20	11,222.42	14,490.55	37,211.17

Table B21: HLFS Labour Data

<i>Year</i>	<i>Full-time Numbers</i>	<i>Part-time Numbers</i>	<i>Total Numbers</i>	<i>Total Hours</i>
	<i>'000</i>	<i>'000</i>	<i>'000</i>	
1972	1,070	136	1,206	162,121,360
1973	1,083	140	1,223	166,144,520
1974	1,119	157	1,276	170,267,517
1975	1,161	178	1,339	179,669,236
1976	1,180	179	1,359	187,638,318
1977	1,196	184	1,380	189,200,045
1978	1,206	192	1,398	192,630,028
1979	1,203	198	1,401	193,970,310
1980	1,226	205	1,431	195,925,159
1981	1,228	200	1,429	200,107,698
1982	1,229	207	1,436	199,490,615
1983	1,238	213	1,451	202,171,304
1984	1,220	217	1,438	205,374,234
1985	1,252	229	1,481	206,700,717
1986	1,296	245	1,541	215,313,200
1987	1,283	265	1,548	220,755,000
1988	1,277	274	1,551	219,597,000
1989	1,212	281	1,493	208,970,000
1990	1,193	277	1,470	207,359,000
1991	1,178	301	1,479	206,907,000
1992	1,147	314	1,461	202,512,000
1993	1,165	316	1,481	206,681,000
1994	1,205	325	1,529	216,026,000
1995	1,259	347	1,606	228,603,000
1996	1,323	363	1,686	238,530,000
1997	1,346	388	1,734	242,638,000
1998	1,342	394	1,736	242,392,000

Table B22: Producer Fuel Use and Taxes

<i>Year</i>	<i>Energy Use Petajoules</i>	<i>Composite Fuel Price Index</i>	<i>Producers' Fuel Costs \$m</i>	<i>Producer Fuel Taxes \$m</i>	<i>Implied Tax Rate per cent</i>	<i>Tax Input Price Index</i>	<i>Tax Input Quantity \$m1972</i>
1972	147	1.000	324	57	17.7	1.000	57.4
1973	155	1.066	363	68	18.8	1.133	60.4
1974	142	1.121	355	75	21.1	1.334	56.1
1975	152	1.292	442	77	17.5	1.276	60.6
1976	153	1.602	563	119	21.1	1.906	62.2
1977	153	1.901	673	134	19.9	2.136	62.7
1978	152	2.147	760	159	20.9	2.528	62.7
1979	147	2.408	827	202	24.4	3.319	60.8
1980	144	2.841	943	200	21.2	3.402	58.8
1981	142	3.437	1,111	203	18.3	3.554	57.2
1982	139	4.012	1,273	220	17.3	3.909	56.2
1983	137	4.579	1,429	269	18.9	4.874	55.3
1984	137	4.848	1,506	297	19.7	5.398	55.0
1985	139	5.684	1,794	345	19.2	6.172	55.9
1986	137	6.257	1,966	390	19.8	7.008	55.7
1987	141	5.279	1,686	542	32.1	9.572	56.6
1988	142	5.489	1,746	855	49.0	15.175	56.4
1989	149	5.310	1,708	825	48.3	14.479	57.0
1990	156	5.180	1,696	701	41.4	12.095	58.0
1991	162	5.450	1,776	609	34.3	10.555	57.7
1992	163	5.142	1,661	579	34.9	10.122	57.2
1993	171	5.328	1,820	598	32.8	9.880	60.5
1994	175	5.081	1,791	615	34.3	9.849	62.4
1995	189	4.973	1,906	637	33.4	9.382	67.9
1996	196	5.019	1,997	635	31.8	9.014	70.5
1997	198	5.099	2,033	606	29.8	8.581	70.6
1998	202	5.155	2,072	639	30.8	8.978	71.2

Table B23: Forestry and Oil and Gas Resource Use and Rents

<i>Year</i>	<i>Roundwood Production '000m³</i>	<i>Forestry Rents \$m</i>	<i>Forestry Input Price Index</i>	<i>Oil and Gas Production petajoules</i>	<i>Oil and Gas Rents \$m</i>	<i>Oil and Gas Input Price Index</i>
1972	7,966	19	1.000	12.8	4.0	1.000
1973	8,243	27	1.373	14.2	3.3	0.744
1974	8,577	38	1.848	16.7	5.1	0.980
1975	8,400	23	1.128	18.8	21.4	3.641
1976	8,304	19	0.969	29.3	34.7	3.798
1977	9,754	44	1.874	64.3	28.6	1.426
1978	9,266	46	2.095	86.0	42.3	1.576
1979	8,974	56	2.598	72.6	0.8	0.035
1980	9,931	97	4.087	49.2	19.0	1.238
1981	10,245	170	6.965	49.6	12.5	0.808
1982	9,960	188	7.914	70.9	55.6	2.515
1983	9,627	205	8.919	106.1	170.0	5.137
1984	9,335	284	12.773	118.4	171.6	4.648
1985	9,626	533	23.206	154.5	172.9	3.587
1986	10,195	689	28.331	200.1	544.4	8.724
1987	9,613	887	38.677	226.7	261.8	3.702
1988	9,688	1,105	47.821	231.6	290.7	4.024
1989	10,619	1,294	51.090	246.6	290.0	3.770
1990	11,486	1,401	51.139	257.6	467.6	5.820
1991	13,454	1,424	44.376	263.9	642.1	7.799
1992	13,903	1,453	43.817	279.8	621.0	7.114
1993	14,690	1,733	49.461	284.3	509.6	5.747
1994	14,871	2,687	75.767	279.2	378.7	4.348
1995	16,183	2,798	72.494	260.3	288.7	3.556
1996	16,692	2,862	71.885	254.7	276.6	3.481
1997	16,074	2,538	66.192	300.8	376.6	4.013
1998	16,400	2,688	68.716	305.8	383.3	4.018

Table B24: Direct Taxation

<i>Year</i>	<i>Individual Income Tax</i>	<i>Company Income Tax</i>	<i>Payroll Tax</i>	<i>Withholding Taxes</i>	<i>Source Deductions</i>	<i>Fringe Benefits Tax</i>	<i>Total Labour Taxes</i>	<i>Total Capital Taxes</i>
	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>
1972	851	300	41	11	656		814	388
1973	1,001	304	46	10	740		943	418
1974	1,304	383	34	12	938		1,192	540
1975	1,684	439	1	13	1,288		1,527	610
1976	1,874	407	0	15	1,479		1,717	579
1977	2,313	499	0	17	1,768		2,096	733
1978	2,927	546	0	17	2,265		2,663	826
1979	3,214	426	0	21	2,574		2,959	702
1980	3,805	647	0	21	3,034		3,498	975
1981	4,698	585	0	24	3,837		4,355	952
1982	5,832	667	0	36	4,895		5,459	1,077
1983	6,591	850	0	55	5,526		6,167	1,329
1984	6,707	702	0	44	5,413		6,192	1,262
1985	7,185	1,113	0	51	5,930		6,685	1,664
1986	9,212	1,270	104	86	7,464	104	8,620	2,052
1987	11,073	1,221	167	138	8,495	167	10,213	2,386
1988	11,609	2,026	213	165	8,642	213	10,641	3,372
1989	12,863	1,903	521	212	9,247	521	11,944	3,555
1990	13,400	2,531	483	884	10,078	483	12,560	4,738
1991	13,177	1,762	485	1,430	10,122	485	12,445	4,409
1992	12,405	1,800	446	1,185	10,140	445	11,949	3,887
1993	13,138	2,394	390	996	10,528	390	12,489	4,429
1994	13,527	3,001	313	1,052	10,901	294	12,794	5,099
1995	14,857	3,967	296	1,025	11,765	301	13,922	6,223
1996	15,626	4,063	322	1,564	12,539	327	14,719	6,856
1997	15,324	3,233	320	1,932	12,264	336	14,426	6,383
1998	15,669	3,721	320	1,870	12,773	340	14,836	6,744

Table B25: SNZ Allocation of Commodity Taxes for 1986–87

<i>Item</i>	<i>Sales Tax</i>	<i>Goods and Services Tax</i>	<i>Excise Duties</i>
	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>
Food	21	190	0
Beverages	15	63	159
Clothing and footwear	0	90	0
Imputed rent	0	0	0
Rentals and costs	0	4	0
Fuel and power	0	34	0
Furniture etc	93	85	0
Textiles etc	72	30	0
Other goods	37	38	0
Health services	0	79	0
Cars and vehicles	145	82	59
Vehicle operation	79	120	240
Public transport	0	27	0
Recreation	29	131	0
Hotels and restaurants	0	115	130
Tobacco	0	32	158
Personal	32	54	0
Post and telephone	0	25	0
Other services	0	11	0

Table B26: Sales Taxes and Excise Duties

<i>Year</i>	<i>Sales Tax on Motor Vehicles \$m</i>	<i>Other Sales Tax \$m</i>	<i>Goods and Services Tax \$m</i>	<i>Tobacco Excise \$m</i>	<i>Alcohol Excise \$m</i>
1972	77	62	–	48	70
1973	100	71	–	50	72
1974	165	101	–	54	72
1975	129	106	–	57	75
1976	138	173	–	61	80
1977	149	204	–	61	91
1978	148	224	–	76	106
1979	170	280	–	77	103
1980	182	442	–	76	101
1981	231	544	–	84	99
1982	311	773	–	99	113
1983	341	871	–	177	135
1984	375	937	–	233	142
1985	417	1,144	–	247	154
1986	463	1,091	–	271	160
1987	411	759	1,229	334	158
1988	312	–	3,319	442	465
1989	183	–	4,339	420	469
1990	89	–	5,412	415	547
1991	22	–	6,043	412	568
1992	2	–	5,630	416	582
1993	–	–	5,863	432	587
1994	–	–	6,584	425	596
1995	–	–	6,802	428	619
1996	–	–	7,149	433	633
1997	–	–	7,609	442	658
1998	–	–	7,954	438	670

Table B27: Other Indirect Taxes

Year	<i>Motor Vehicle Fees</i> \$m	<i>Road User Fees</i> \$m	<i>Gasoline Taxes</i> \$m	<i>Energy Resource Tax</i> \$m	<i>Gaming Duties</i> \$m	<i>Stamp Check Duties</i> \$m
1972	19	17	79	–	17	14
1973	20	17	99	–	18	19
1974	22	18	108	–	21	29
1975	21	20	110	–	23	25
1976	24	20	183	–	28	25
1977	21	22	212	4	31	32
1978	43	20	236	33	36	29
1979	46	50	284	29	42	30
1980	46	52	283	19	48	34
1981	47	69	278	20	53	48
1982	47	83	294	24	58	72
1983	86	97	335	40	64	69
1984	97	97	381	44	72	82
1985	102	164	401	53	77	103
1986	122	211	416	72	79	127
1987	129	211	708	83	75	199
1988	120	241	1,312	78	64	246
1989	118	265	1,292	84	76	115
1990	157	282	977	91	86	106
1991	154	285	856	87	83	77
1992	140	302	834	100	87	105
1993	140	321	865	97	102	118
1994	147	352	843	97	114	144
1995	157	382	847	85	124	166
1996	152	410	810	94	126	216
1997	155	426	725	104	129	183
1998	158	466	819	87	139	186

Table B28: Import Duties

<i>Year</i>	<i>Food and Petroleum Beverages</i>	<i>Non-Fuel Crude Materials</i>	<i>Textiles, Clothing</i>	<i>Iron and Steel</i>	<i>Non-Electrical Machin'y</i>	<i>Electrical Machin'y</i>	<i>Transport Equipm't</i>	<i>Other</i>	
<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	
1972	7.2	13.1	–	7.6	0.5	2.5	7.1	25.5	14.2
1973	8.1	14.9	–	8.6	0.5	2.8	8.0	28.8	16.1
1974	11.1	20.3	–	11.7	0.7	3.8	10.9	39.3	21.9
1975	13.2	24.1	–	13.9	0.8	4.6	13.0	46.8	26.1
1976	11.6	21.1	–	12.2	0.7	4.0	11.4	40.9	22.8
1977	13.7	24.9	–	14.4	0.9	4.7	13.5	48.3	26.9
1978	13.9	25.5	–	14.7	0.9	4.8	13.7	49.4	27.5
1979	15.4	28.0	–	16.2	1.0	5.3	15.1	54.3	30.3
1980	19.7	35.9	–	20.7	1.2	6.8	19.4	69.7	38.8
1981	21.4	39.1	–	22.5	1.4	7.4	21.1	75.8	42.2
1982	31.3	57.1	0.1	32.9	2.0	10.8	30.8	110.7	61.6
1983	32.3	58.9	0.1	34.0	2.0	11.2	31.8	114.2	63.6
1984	39.9	72.8	0.1	42.0	2.5	13.8	39.3	141.2	78.7
1985	55.9	102.0	0.1	58.8	3.5	19.3	55.1	197.9	110.2
1986	49.7	90.6	0.1	52.2	3.1	17.2	48.9	175.7	97.9
1987	53.5	97.6	0.1	56.3	3.4	18.5	52.7	189.3	105.5
1988	49.1	89.6	0.1	51.6	3.1	17.0	48.4	173.7	96.7
1989	58.3	106.3	0.1	61.3	3.7	20.1	57.4	206.2	114.9
1990	64.5	117.7	0.1	67.9	4.1	22.3	63.6	228.3	127.2
1991	77.4	107.7	0.1	64.1	1.6	18.2	46.9	173.9	111.1
1992	69.9	136.6	0.4	88.9	1.6	12.3	27.6	147.8	108.6
1993	66.6	113.5	0.4	119.7	1.6	13.9	25.2	171.3	109.9
1994	69.5	136.0	0.9	125.2	1.4	13.5	23.6	206.9	109.9
1995	78.0	171.3	0.5	140.1	2.3	15.1	22.8	281.1	111.6
1996	85.3	234.9	0.6	139.7	2.3	19.6	20.9	282.8	112.9
1997	96.9	266.9	0.7	158.7	2.6	22.2	23.8	321.3	128.3
1998	88.9	245.0	0.6	145.7	2.4	20.4	21.8	295.0	117.7

Table B29: Property Taxes

<i>Year</i>	<i>Local Rates</i> \$m	<i>Land Tax</i> \$m	<i>Total Property Tax</i> \$m	<i>Residential Property Tax</i> \$m	<i>Business Property Tax</i> \$m
1972	126	4	130	52	78
1973	149	3	152	65	87
1974	154	3	157	70	87
1975	192	3	196	74	122
1976	237	3	240	89	151
1977	278	7	284	117	167
1978	316	8	324	140	184
1979	371	10	380	174	206
1980	464	11	475	208	267
1981	503	12	515	247	268
1982	613	34	646	302	344
1983	725	34	759	368	391
1984	769	36	805	406	399
1985	813	44	857	428	429
1986	920	56	975	503	472
1987	1,059	64	1,122	593	529
1988	1,246	71	1,317	724	593
1989	1,265	153	1,418	863	555
1990	1,366	271	1,637	939	698
1991	1,444	172	1,616	1,021	595
1992	1,586	9	1,595	965	631
1993	1,588	5	1,593	963	630
1994	1,638	0	1,638	990	647
1995	1,718	1	1,719	1,040	680
1996	1,769	1	1,770	1,071	700
1997	1,769	1	1,770	1,071	700
1998	1,769	1	1,770	1,071	700

Table B30: Capital Stock Values

<i>Year</i>	<i>Non– residential and Other Construction</i>	<i>Transport Equipment</i>	<i>Electrical Equipment</i>	<i>Plant and Other Machinery</i>	<i>Livestock Inventories</i>	<i>Non– agricultural Inventories</i>	<i>Business and Agricultural Land</i>
	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>
1972	8,787	1,348	259	1,595	1,207	1,649	4,452
1973	9,857	1,609	277	1,921	1,765	1,698	4,804
1974	11,875	1,768	306	2,038	1,818	2,055	6,305
1975	15,142	2,256	417	2,491	1,066	2,725	9,139
1976	17,566	3,292	607	3,477	1,526	3,075	10,590
1977	18,663	3,706	772	4,582	1,920	3,616	11,905
1978	19,783	4,215	771	5,143	1,830	3,855	12,946
1979	20,387	4,986	819	6,013	2,935	4,076	14,037
1980	22,347	5,168	916	6,326	3,271	5,288	15,592
1981	24,691	5,926	1,080	7,547	3,329	5,803	18,465
1982	33,631	7,282	1,297	8,858	3,317	6,714	24,982
1983	39,181	8,314	1,512	10,934	3,650	7,101	32,319
1984	41,696	8,797	1,822	13,048	3,854	7,004	33,093
1985	46,047	10,157	2,347	16,177	5,493	8,352	36,174
1986	53,471	11,772	2,789	18,546	4,860	9,636	39,175
1987	61,740	13,379	3,467	20,679	5,333	10,246	41,600
1988	69,845	13,413	3,484	20,550	4,909	10,593	44,120
1989	81,267	11,641	3,813	21,196	5,430	10,498	44,588
1990	83,794	11,404	4,535	22,513	6,936	11,309	47,464
1991	88,862	11,171	5,363	22,345	6,401	11,503	51,637
1992	91,359	11,400	5,895	22,010	6,681	10,913	51,131
1993	92,539	12,276	6,707	22,021	7,895	11,192	56,847
1994	94,831	13,194	7,149	23,124	7,602	11,893	67,920
1995	98,336	14,048	7,369	25,166	6,353	12,605	80,555
1996	102,364	14,773	7,862	26,926	5,686	13,257	88,364
1997	105,877	15,529	8,283	27,841	6,356	13,238	90,673
1998	107,989	15,253	8,775	28,538	6,743	13,091	89,456

Table B31: Capital Stock Prices

<i>Year</i>	<i>Non– residential and Other Construction Index</i>	<i>Transport Equipment Index</i>	<i>Electrical Equipment Index</i>	<i>Plant and Other Machinery Index</i>	<i>Livestock Inventories Index</i>	<i>Non– agricultural Inventories Index</i>	<i>Business and Agricultural Land Index</i>
1972	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1973	1.091	1.090	1.019	1.089	1.372	1.069	1.079
1974	1.277	1.083	1.016	1.053	1.419	1.205	1.416
1975	1.584	1.287	1.148	1.186	0.814	1.303	2.053
1976	1.788	1.798	1.518	1.579	1.170	1.476	2.379
1977	1.845	1.999	1.828	2.014	1.493	1.806	2.674
1978	1.896	2.277	1.805	2.226	1.429	2.102	2.908
1979	1.885	2.666	1.892	2.584	2.319	2.345	3.153
1980	1.995	2.717	2.033	2.689	2.653	2.760	3.502
1981	2.137	3.099	2.368	3.137	2.608	3.392	4.147
1982	2.814	3.645	2.590	3.477	2.610	3.964	5.611
1983	3.167	4.096	2.774	3.935	2.895	4.562	7.259
1984	3.255	4.348	2.938	4.321	3.144	4.811	7.433
1985	3.475	4.890	3.224	5.063	4.387	5.155	8.125
1986	3.901	5.528	3.261	5.435	3.818	5.945	8.799
1987	4.345	6.390	3.424	5.956	4.015	6.287	9.344
1988	4.737	6.510	2.947	5.734	3.785	6.785	9.910
1989	5.310	5.958	2.795	5.767	4.123	7.141	10.015
1990	5.321	5.756	2.785	6.029	5.409	7.646	10.661
1991	5.504	5.656	2.741	5.987	4.896	7.998	11.598
1992	5.560	5.935	2.835	6.069	5.098	8.070	11.485
1993	5.554	6.378	3.068	6.113	6.076	8.237	12.768
1994	5.638	6.692	3.112	6.179	5.854	8.437	15.256
1995	5.777	6.790	2.900	6.410	4.635	8.549	18.094
1996	5.919	6.796	2.789	6.560	4.048	8.613	19.848
1997	5.989	6.722	2.715	6.549	4.643	8.661	20.366
1998	5.971	6.529	2.666	6.554	4.887	8.701	20.093

Table B32: Capital Stock Quantities

<i>Year</i>	<i>Non– residential and Other Construction</i>	<i>Transport Equipment</i>	<i>Electrical Equipment</i>	<i>Plant and Other Machinery</i>	<i>Livestock Inventories</i>	<i>Non– agricultural Inventories</i>	<i>Business and Agricultural Land</i>
	<i>\$m1972</i>	<i>\$m1972</i>	<i>\$m1972</i>	<i>\$m1972</i>	<i>\$m1972</i>	<i>\$m1972</i>	<i>\$m1972</i>
1972	8,787	1,348	259	1,595	1,207	1,649	4,452
1973	9,039	1,476	272	1,763	1,286	1,588	4,452
1974	9,299	1,633	301	1,935	1,281	1,705	4,452
1975	9,557	1,753	364	2,100	1,310	2,092	4,452
1976	9,824	1,832	400	2,202	1,304	2,084	4,452
1977	10,118	1,854	423	2,275	1,286	2,003	4,452
1978	10,437	1,852	427	2,310	1,281	1,834	4,452
1979	10,815	1,870	433	2,327	1,266	1,738	4,452
1980	11,201	1,902	450	2,353	1,233	1,916	4,452
1981	11,555	1,912	456	2,406	1,277	1,711	4,452
1982	11,952	1,998	501	2,548	1,271	1,694	4,452
1983	12,373	2,030	545	2,778	1,261	1,556	4,452
1984	12,809	2,023	620	3,020	1,226	1,456	4,452
1985	13,252	2,077	728	3,195	1,252	1,620	4,452
1986	13,705	2,130	855	3,413	1,273	1,621	4,452
1987	14,210	2,094	1,013	3,472	1,328	1,630	4,452
1988	14,744	2,061	1,182	3,584	1,297	1,561	4,452
1989	15,305	1,954	1,364	3,675	1,317	1,470	4,452
1990	15,748	1,981	1,628	3,734	1,282	1,479	4,452
1991	16,146	1,975	1,957	3,732	1,308	1,438	4,452
1992	16,433	1,921	2,079	3,626	1,311	1,352	4,452
1993	16,663	1,925	2,186	3,602	1,299	1,359	4,452
1994	16,819	1,972	2,297	3,742	1,299	1,410	4,452
1995	17,022	2,069	2,541	3,926	1,371	1,474	4,452
1996	17,295	2,174	2,819	4,104	1,405	1,539	4,452
1997	17,677	2,310	3,051	4,251	1,369	1,528	4,452
1998	18,085	2,336	3,291	4,354	1,380	1,505	4,452

Table B33: Asset-specific Inflation Rates

<i>Year</i>	<i>Non-residential and Other Construction</i>	<i>Transport Equipment</i>	<i>Electrical Equipment</i>	<i>Plant and Other Machinery</i>	<i>Livestock Inventories</i>	<i>Non-agricultural Inventories</i>	<i>Business and Agricultural Land</i>
	%	%	%	%	%	%	%
1972	9.1	9.0	1.9	8.9	37.2	6.9	7.9
1973	17.1	-0.6	-0.3	-3.3	3.5	12.7	31.2
1974	24.1	18.8	13.0	12.6	-42.7	8.1	45.0
1975	12.9	39.7	32.2	33.1	43.8	13.3	15.9
1976	3.2	11.2	20.4	27.6	27.6	22.4	12.4
1977	2.8	13.9	-1.2	10.5	-4.3	16.4	8.7
1978	-0.6	17.1	4.8	16.1	62.3	11.5	8.4
1979	5.8	1.9	7.4	4.1	14.4	17.7	11.1
1980	7.1	14.0	16.5	16.7	-1.7	22.9	18.4
1981	31.7	17.6	9.4	10.8	0.1	16.9	35.3
1982	12.5	12.4	7.1	13.2	10.9	15.1	29.4
1983	2.8	6.1	5.9	9.8	8.6	5.4	2.4
1984	6.7	12.5	9.7	17.2	39.5	7.1	9.3
1985	12.3	13.1	1.1	7.3	-13.0	15.3	8.3
1986	11.4	15.6	5.0	9.6	5.2	5.7	6.2
1987	9.0	1.9	-13.9	-3.7	-5.7	7.9	6.1
1988	12.1	-8.5	-5.2	0.6	8.9	5.2	1.1
1989	0.2	-3.4	-0.4	4.5	31.2	7.1	6.5
1990	3.4	-1.7	-1.6	-0.7	-9.5	4.6	8.8
1991	1.0	4.9	3.4	1.4	4.1	0.9	-1.0
1992	-0.1	7.5	8.2	0.7	19.2	2.1	11.2
1993	1.5	4.9	1.4	1.1	-3.6	2.4	19.5
1994	2.5	1.5	-6.8	3.7	-20.8	1.3	18.6
1995	2.5	0.1	-3.8	2.3	-12.7	0.7	9.7
1996	1.2	-1.1	-2.6	-0.2	14.7	0.6	2.6
1997	-0.3	-2.9	-1.8	0.1	5.3	0.5	-1.3
1998	1.1	-1.3	-2.8	0.7	2.4	0.6	3.7

Table B34: Rates of Return and Capital Tax Rates

<i>Year</i>	<i>Pre-tax Rate of Return</i> R^t %	<i>Post-tax Rate of Return</i> r^t %	<i>Weighted Average Real Post-tax Rate of Return</i> %	<i>Capital Income Tax Rate</i> t^t %	<i>Property Tax Rate</i> t_p^t %
1972	16.07	14.06	3.23	12.51	0.59
1973	24.20	22.30	10.77	7.87	0.59
1974	30.09	28.03	17.40	6.86	0.48
1975	19.42	17.58	-0.62	9.45	0.50
1976	13.63	12.19	2.25	10.58	0.54
1977	8.91	7.29	1.47	18.20	0.55
1978	8.52	6.82	-0.24	19.98	0.56
1979	9.93	8.62	1.71	13.26	0.60
1980	11.42	9.76	-0.57	14.50	0.70
1981	25.93	24.51	2.63	5.49	0.62
1982	16.48	15.23	2.26	7.59	0.59
1983	4.50	3.21	-1.56	28.70	0.55
1984	14.59	13.44	2.66	7.91	0.53
1985	12.84	11.51	1.90	10.39	0.52
1986	13.23	11.76	1.19	11.06	0.51
1987	8.73	7.21	3.07	17.46	0.51
1988	9.73	7.70	1.44	20.78	0.52
1989	8.19	6.20	4.09	24.32	0.44
1990	8.01	5.62	4.03	29.88	0.51
1991	5.15	2.88	1.28	44.16	0.44
1992	8.80	6.79	4.92	22.89	0.44
1993	11.23	9.18	7.56	18.25	0.42
1994	12.14	9.95	9.30	18.00	0.40
1995	10.59	8.16	6.96	22.95	0.38
1996	8.13	5.55	4.56	31.78	0.36
1997	6.13	3.71	4.02	39.59	0.36
1998	8.51	6.04	5.34	28.98	0.35

Table B35: Capital User Cost Values

<i>Year</i>	<i>Non– residential and Other Construction</i>	<i>Transport Equipment</i>	<i>Electrical Equipment</i>	<i>Plant and Other Machinery</i>	<i>Livestock Inventories</i>	<i>Non– agricultural Inventories</i>	<i>Business and Agricultural Land</i>
	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>
1972	754	251	78	298	-224	133	342
1973	809	496	101	629	299	159	-253
1974	833	369	95	511	1,033	353	-708
1975	1,200	-40	48	77	-221	142	315
1976	2,047	495	93	81	-190	-239	164
1977	1,522	340	215	546	237	-253	80
1978	2,154	262	178	363	-922	-109	79
1979	1,278	976	181	1,074	-121	-292	-70
1980	1,458	574	152	572	392	-552	-896
1981	-496	1,123	333	1,788	691	423	-1,296
1982	1,979	1,182	347	1,383	159	80	-2,668
1983	1,632	979	290	950	-145	-65	829
1984	3,866	1,299	430	1,455	-848	460	1,697
1985	1,373	1,319	672	2,823	1,272	-187	1,643
1986	2,202	1,333	729	2,968	351	646	2,646
1987	1,378	2,509	1,290	4,815	719	76	1,237
1988	259	3,749	1,095	4,242	37	441	3,762
1989	7,981	2,645	1,023	3,440	-1,176	111	917
1990	5,681	2,433	1,257	4,610	1,149	365	-120
1991	5,700	1,504	1,168	3,682	64	476	3,301
1992	9,704	1,635	1,227	4,363	-650	687	-929
1993	10,305	2,243	1,848	4,699	1,076	902	-4,075
1994	10,459	2,864	2,444	4,601	2,280	1,169	-3,749
1995	9,607	3,055	2,292	5,016	1,366	1,147	950
1996	9,041	3,090	2,253	5,429	-354	951	4,925
1997	8,970	3,239	2,202	5,120	54	724	6,848
1998	9,948	3,255	2,542	5,613	386	978	4,393

Table B36a: TFP Database – Output Values

<i>Consumer Commodities</i>										
<i>Year</i>	<i>Food & Beverage \$m</i>	<i>Alcohol \$m</i>	<i>Clothing & footwear \$m</i>	<i>Fuel & power \$m</i>	<i>Furniture etc \$m</i>	<i>Textiles etc \$m</i>	<i>Other goods \$m</i>	<i>Health services \$m</i>	<i>Motor vehicles \$m</i>	<i>Vehicle operation \$m</i>
1972	594	191	376	89	143	52	67	157	254	303
1973	656	205	432	96	179	66	87	176	266	333
1974	739	248	507	106	238	85	107	204	259	384
1975	846	284	535	113	309	114	117	245	295	499
1976	954	346	588	126	367	127	122	280	312	519
1977	1,086	397	645	173	409	140	130	300	320	628
1978	1,206	492	728	226	437	149	140	338	327	678
1979	1,331	567	810	235	467	153	156	398	456	698
1980	1,557	692	893	294	483	137	180	469	693	840
1981	1,830	853	1,006	334	550	150	196	580	855	1,070
1982	2,180	1,008	1,199	361	593	136	230	717	1,029	1,162
1983	2,518	1,037	1,361	451	692	162	276	869	1,010	1,333
1984	2,725	1,101	1,381	469	778	175	335	950	1,089	1,495
1985	3,051	1,253	1,505	485	906	185	396	1,079	1,414	1,680
1986	3,551	1,477	1,657	591	1,132	267	519	1,341	1,484	2,216
1987	4,044	1,666	1,852	699	1,510	434	717	1,634	1,481	2,066
1988	4,427	1,681	1,873	758	1,695	601	863	1,834	1,558	1,848
1989	4,508	1,730	1,735	803	1,580	574	926	1,995	1,531	1,949
1990	4,777	1,811	1,846	831	1,607	578	933	2,110	2,046	2,156
1991	5,056	1,944	1,829	890	1,515	562	976	2,324	2,268	2,233
1992	5,071	1,904	1,793	965	1,503	563	1,052	2,663	1,583	2,157
1993	5,167	1,926	1,809	1,008	1,643	600	1,077	2,816	1,482	2,128
1994	5,182	1,973	1,877	1,056	1,942	654	1,140	3,031	1,812	2,082
1995	5,593	2,094	2,004	1,129	2,146	723	1,242	3,246	2,331	2,264
1996	5,886	2,209	2,016	1,211	2,164	815	1,310	3,645	2,718	2,464
1997	6,093	2,279	2,019	1,278	2,182	803	1,310	3,922	3,022	2,607
1998	6,359	2,377	2,046	1,384	2,197	802	1,402	4,250	2,249	2,582

Table B36b: TFP Database – Output Values

Year	<i>Consumer Commodities</i>							<i>Govt.</i>		<i>Govt.</i>
	<i>Public transport</i> \$m	<i>Recreation</i> \$m	<i>Hotels</i> \$m	<i>Tobacco</i> \$m	<i>Personal</i> \$m	<i>Post & telephone</i> \$m	<i>Other services</i> \$m	<i>Non-res. Expend.</i> \$m	<i>Intermediates</i> \$m	<i>Investment</i> \$m
1972	152	435	96	58	149	69	102	38	298	132
1973	163	489	131	62	175	79	116	47	355	183
1974	187	558	155	66	189	93	118	65	391	181
1975	220	624	172	73	190	104	122	90	492	239
1976	245	724	204	88	205	115	136	120	602	327
1977	285	808	273	100	246	129	162	135	678	330
1978	325	882	306	110	235	155	158	135	859	360
1979	393	980	339	121	275	184	190	139	1,010	404
1980	443	1,087	413	156	307	206	220	166	1,119	397
1981	523	1,247	521	196	376	246	266	202	1,376	450
1982	581	1,356	631	242	458	270	322	252	1,682	524
1983	663	1,525	788	281	515	312	373	280	1,953	627
1984	719	1,637	919	330	576	346	422	384	2,167	687
1985	787	1,831	1,137	356	656	376	486	645	2,517	713
1986	927	2,123	1,412	402	827	414	522	854	2,902	960
1987	1,046	2,514	1,623	505	1,027	517	586	1,059	3,659	886
1988	1,167	2,692	1,650	323	1,157	623	787	1,139	4,073	819
1989	1,249	2,791	1,564	347	1,192	681	1,052	1,091	4,391	823
1990	1,312	2,926	1,617	382	1,225	846	1,139	1,186	4,908	848
1991	1,402	3,085	1,657	414	1,289	884	1,270	1,193	5,632	916
1992	1,404	3,106	1,676	416	1,343	950	1,184	1,363	5,673	522
1993	1,463	3,270	1,760	391	1,334	972	1,202	1,482	5,959	507
1994	1,474	3,627	1,906	412	1,351	988	1,176	1,632	5,916	458
1995	1,688	4,156	2,281	385	1,468	1,074	1,224	1,968	5,898	617
1996	2,002	4,573	2,507	457	1,618	1,239	1,380	2,571	6,318	581
1997	2,067	4,834	2,617	511	1,609	1,285	1,407	2,403	6,651	707
1998	2,058	5,162	2,691	507	1,691	1,453	1,654	2,192	7,411	774

Table B36c: TFP Database – Output Values

Year	<i>Investment Goods</i>							<i>Exports</i>		
	<i>Resident Dwelling</i>	<i>Non-Res. Constr'n</i>	<i>Trans. Equipm't</i>	<i>Electric Machin'y</i>	<i>Plant & Other</i>	<i>Agricult. Inventory</i>	<i>Non-Agr. Inventory</i>	<i>Butter</i>	<i>Cheese</i>	<i>Meat</i>
	\$m	\$m	\$m	\$m	\$m	\$m	\$m	\$m	\$m	\$m
1972	306	409	233	55	292	95	-57	189	58	413
1973	416	460	227	54	324	-7	116	171	80	490
1974	562	549	269	75	371	19	393	129	68	573
1975	683	697	424	158	559	-6	-10	116	39	455
1976	769	806	464	177	674	-24	-130	224	72	506
1977	855	920	461	173	744	-7	-332	268	78	737
1978	676	1,037	502	157	802	-33	-209	292	79	787
1979	716	1,105	559	171	786	-80	451	290	72	998
1980	731	1,126	683	225	938	104	-633	380	88	1,149
1981	881	1,418	657	200	1,002	-11	-55	468	136	1,400
1982	1,180	1,816	1,033	327	1,552	-26	-544	575	176	1,551
1983	1,310	2,155	1,052	411	2,353	-107	-469	750	182	1,752
1984	1,518	2,142	937	523	2,689	101	747	566	226	1,873
1985	1,775	2,514	1,364	678	2,768	71	3	711	231	2,007
1986	2,059	3,028	1,599	837	3,373	199	51	658	269	1,927
1987	2,423	3,613	1,281	902	2,692	-110	-434	540	273	2,140
1988	2,746	4,221	1,204	965	3,014	78	-604	582	282	2,059
1989	2,797	3,753	818	1,098	3,166	-177	65	624	290	2,210
1990	3,342	3,717	1,473	1,394	3,041	117	-309	594	320	2,435
1991	3,420	3,292	1,444	1,802	2,854	15	-675	581	362	2,552
1992	2,950	2,905	1,207	1,477	2,171	-63	48	703	390	2,799
1993	3,097	2,527	1,555	1,490	2,530	-4	394	783	505	3,105
1994	3,806	2,837	1,835	1,446	3,548	304	504	849	511	3,017
1995	4,705	3,357	2,222	1,814	4,063	127	516	721	602	2,739
1996	5,035	4,130	2,381	2,022	4,275	-158	-88	845	611	2,697
1997	5,395	4,380	2,637	2,045	4,300	52	-201	881	750	2,753
1998	5,785	4,345	1,984	2,081	4,084	52	-194	942	888	2,936

Table B36d: TFP Database – Output Values

<i>Year</i>	<i>Exports</i>								<i>Subsidies</i>
	<i>Wool \$m</i>	<i>Pastoral and Dairy \$m</i>	<i>Fish and Preps. \$m</i>	<i>Forestry \$m</i>	<i>Aluminium \$m</i>	<i>Transport Equipment \$m</i>	<i>Other Goods \$m</i>	<i>Services \$m</i>	<i>Subsidy Output \$m</i>
1972	199	191	21	82	11	22	77	251	108
1973	364	257	20	87	27	28	103	301	129
1974	400	303	20	109	32	37	143	380	163
1975	278	286	21	130	38	52	140	472	238
1976	348	294	28	148	66	67	177	604	392
1977	653	441	43	219	87	83	322	718	243
1978	585	497	54	245	124	101	405	779	281
1979	662	537	64	276	132	130	491	867	428
1980	893	731	123	416	160	160	614	1,077	352
1981	899	736	158	534	172	212	829	1,288	348
1982	904	968	206	562	236	250	953	1,625	578
1983	964	1,167	279	508	281	240	1,103	1,905	756
1984	1,107	1,337	317	595	420	278	1,368	2,268	660
1985	1,397	1,782	508	771	495	398	1,867	2,939	598
1986	1,297	2,052	537	711	449	436	2,143	3,178	362
1987	1,511	2,303	698	765	480	420	1,982	3,593	292
1988	1,604	2,665	659	917	601	531	2,088	3,912	271
1989	1,819	2,894	732	1,155	762	613	2,375	4,067	180
1990	1,472	3,055	789	1,378	805	678	2,822	4,120	206
1991	977	3,236	766	1,547	764	696	3,245	4,274	205
1992	1,079	3,337	1,044	1,760	658	744	3,580	4,651	241
1993	971	3,692	1,175	2,093	649	938	3,942	5,096	316
1994	973	3,614	1,175	2,570	619	1,117	4,337	5,642	310
1995	1,313	3,822	1,178	2,572	762	1,266	5,006	6,430	325
1996	1,090	3,689	1,205	2,661	780	1,344	4,632	7,118	317
1997	958	4,160	1,136	2,377	723	1,410	4,875	6,808	318
1998	913	4,338	1,062	2,292	857	1,316	5,338	6,531	319

Table B37a: TFP Database – Output Prices

<i>Consumer Commodities</i>										
<i>Year</i>	<i>Food & Beverage Index</i>	<i>Alcohol Index</i>	<i>Clothing & footw'r Index</i>	<i>Fuel & power Index</i>	<i>Furniture etc Index</i>	<i>Textiles etc Index</i>	<i>Other goods Index</i>	<i>Health services Index</i>	<i>Motor vehicles Index</i>	<i>Vehicle operation Index</i>
1972	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1973	1.049	1.010	1.056	1.054	1.059	1.068	1.059	1.178	1.041	1.053
1974	1.188	1.211	1.139	1.103	1.116	1.100	1.078	1.340	1.000	1.122
1975	1.305	1.341	1.289	1.177	1.247	1.256	1.171	1.587	1.251	1.341
1976	1.476	1.706	1.478	1.278	1.378	1.307	1.244	1.857	1.578	1.580
1977	1.742	1.918	1.698	1.758	1.602	1.501	1.474	2.172	1.843	1.900
1978	2.019	2.375	1.998	2.374	1.847	1.721	1.652	2.598	2.097	2.120
1979	2.225	2.787	2.270	2.507	2.022	1.817	1.812	2.952	2.401	2.287
1980	2.667	3.407	2.538	3.404	2.145	1.663	1.888	3.467	2.895	2.785
1981	3.165	4.316	2.868	3.875	2.388	1.787	2.126	4.299	3.459	3.474
1982	3.658	5.059	3.194	4.327	2.534	1.595	2.225	5.270	4.039	4.065
1983	4.033	5.832	3.577	4.951	2.821	1.815	2.570	6.145	4.539	4.594
1984	4.206	5.964	3.831	4.969	2.914	1.927	2.706	6.486	4.885	4.872
1985	4.517	6.638	4.034	5.091	3.003	1.948	2.790	7.122	5.805	5.506
1986	5.150	7.823	4.555	6.202	3.628	2.963	3.299	8.419	6.583	6.800
1987	5.562	8.405	4.981	7.036	4.424	4.581	4.203	9.354	6.865	6.351
1988	5.764	8.943	5.324	7.516	5.113	6.713	4.905	10.095	6.911	5.570
1989	5.935	9.411	5.403	7.940	4.910	6.494	5.149	10.384	6.035	5.446
1990	6.517	9.938	5.458	8.027	5.002	6.416	5.395	11.212	5.845	5.784
1991	6.820	10.647	5.642	8.294	4.987	6.545	5.681	12.130	6.078	6.192
1992	6.818	10.896	5.841	8.832	4.960	6.811	5.803	13.826	6.097	6.336
1993	6.897	11.030	5.886	9.546	4.951	6.984	5.760	14.291	6.313	6.411
1994	6.832	11.266	5.894	10.374	4.948	6.906	5.823	15.047	6.866	6.129
1995	6.897	11.964	5.919	11.332	5.043	6.948	5.895	15.686	7.237	6.178
1996	7.204	12.609	5.706	12.501	5.069	7.538	6.060	16.013	7.004	6.417
1997	7.311	13.030	5.656	13.068	4.903	7.613	6.084	16.397	6.732	6.595
1998	7.451	12.488	5.732	14.159	4.937	7.607	6.509	17.770	6.095	6.532

Table B37b: TFP Database – Output Prices

Year	<i>Consumer Commodities</i>							<i>Govt.</i>		<i>Govt.</i>
	<i>Public transport Index</i>	<i>Recreation Index</i>	<i>Hotels Index</i>	<i>Tobacco Index</i>	<i>Personal Index</i>	<i>Post & telephone Index</i>	<i>Other services Index</i>	<i>Non-res. Expend. Index</i>	<i>Intermediates Index</i>	<i>Investment Index</i>
1972	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1973	1.066	1.063	1.138	1.052	1.057	1.054	1.027	1.058	1.007	1.089
1974	1.121	1.161	1.228	1.071	1.193	1.199	1.094	1.153	1.016	1.233
1975	1.292	1.302	1.421	1.109	1.423	1.420	1.338	1.311	1.159	1.507
1976	1.602	1.492	1.706	1.357	1.632	1.661	1.589	1.509	1.415	1.776
1977	1.901	1.727	2.043	1.602	1.912	1.952	1.844	1.752	1.543	1.896
1978	2.147	1.974	2.484	1.772	2.220	2.270	2.175	2.003	1.532	1.993
1979	2.408	2.178	2.570	1.994	2.480	2.563	2.510	2.220	1.886	2.075
1980	2.841	2.485	2.631	2.637	2.829	3.030	2.970	2.586	2.225	2.178
1981	3.437	2.892	2.786	3.377	3.326	3.589	3.445	3.029	3.025	2.393
1982	4.012	3.304	3.025	4.006	3.719	4.137	3.828	3.489	3.570	2.986
1983	4.579	3.817	3.008	4.741	4.316	4.785	4.576	3.984	4.244	3.357
1984	4.471	4.029	3.078	5.492	4.435	5.018	4.816	4.155	4.446	3.523
1985	4.698	4.417	3.437	5.967	4.632	5.099	5.084	4.554	4.982	3.874
1986	5.296	4.892	3.964	7.275	5.466	5.251	5.982	5.323	5.612	4.310
1987	5.646	5.360	4.287	10.189	6.179	6.084	6.728	5.849	6.168	4.819
1988	4.987	5.711	4.366	6.331	7.208	5.983	7.544	5.738	6.529	5.025
1989	4.966	5.736	4.414	7.124	7.773	6.160	9.725	5.828	7.046	5.371
1990	5.310	6.052	4.517	8.423	7.918	6.505	10.495	6.136	7.659	5.394
1991	5.654	6.310	4.662	9.269	8.117	6.732	11.272	6.483	8.012	5.531
1992	5.851	6.406	4.841	10.792	8.218	7.016	11.421	6.714	8.187	5.604
1993	5.776	6.610	4.857	11.050	8.232	7.111	11.036	6.664	8.206	5.650
1994	5.903	6.730	4.840	11.379	8.190	7.040	11.066	6.703	8.382	5.737
1995	6.112	6.870	4.991	10.985	8.312	7.115	11.335	6.966	8.490	5.854
1996	6.229	7.188	4.751	13.425	8.820	7.395	12.206	7.266	8.588	5.974
1997	6.168	7.043	4.747	16.095	8.775	7.444	12.275	7.312	8.605	6.019
1998	6.139	7.522	4.887	15.948	9.224	8.419	14.434	6.670	8.644	5.995

Table B37c: TFP Database – Output Prices

Year	<i>Investment Goods</i>							<i>Exports</i>		
	<i>Resident Dwelling Index</i>	<i>Non-Res. Constr'n Index</i>	<i>Trans. Equipm't Index</i>	<i>Electric Machin'y Index</i>	<i>Plant & Other Index</i>	<i>Agricult. Inventory Index</i>	<i>Non-Agr. Inventory Index</i>	<i>Butter Index</i>	<i>Cheese Index</i>	<i>Meat Index</i>
1972	1.000	1.000	1.000	1.000	1.000	1.203	0.937	1.000	1.000	1.000
1973	1.095	1.092	0.905	0.930	0.902	1.161	0.985	0.903	1.241	1.176
1974	1.284	1.294	0.934	1.004	0.970	0.636	1.017	0.727	1.256	1.518
1975	1.605	1.591	1.544	1.445	1.406	0.995	1.255	0.780	1.054	1.238
1976	1.777	1.720	1.830	1.824	1.881	1.331	1.609	1.037	1.333	1.242
1977	1.944	1.848	2.142	1.884	2.173	1.332	1.959	1.233	1.497	1.634
1978	2.171	1.846	2.539	1.983	2.533	2.171	2.195	1.405	1.514	1.745
1979	2.351	1.921	2.605	2.095	2.592	2.443	2.541	1.537	1.625	2.165
1980	2.549	2.036	3.009	2.415	2.993	2.376	3.090	1.678	1.943	2.779
1981	2.920	2.364	3.080	2.329	2.924	2.096	3.184	2.066	2.339	3.030
1982	3.531	2.874	3.742	2.695	3.577	2.513	3.960	2.997	2.911	3.331
1983	4.061	3.299	4.362	3.187	4.385	3.046	4.662	3.224	3.548	3.433
1984	4.194	3.204	4.399	3.182	4.674	3.868	4.544	3.370	3.491	3.655
1985	4.559	3.660	5.207	3.273	5.104	3.424	5.332	3.326	3.884	4.263
1986	5.233	4.066	5.995	3.430	5.581	3.592	5.625	3.046	4.040	4.133
1987	5.060	4.622	6.430	3.077	5.602	3.531	6.329	2.804	3.825	3.879
1988	7.154	5.156	6.091	2.905	5.607	3.828	6.630	2.583	3.748	3.839
1989	6.941	5.240	6.137	2.935	5.945	5.093	7.199	2.833	4.538	4.077
1990	7.538	5.450	6.337	2.905	5.936	4.635	7.572	3.671	5.418	4.878
1991	7.857	5.652	6.942	3.085	6.178	4.955	7.844	3.512	5.036	5.215
1992	7.968	5.439	7.220	3.216	5.995	5.690	7.714	3.545	5.175	5.173
1993	8.029	5.401	7.413	3.190	5.927	5.362	7.728	4.103	5.956	5.514
1994	8.435	5.495	7.469	2.952	6.106	4.215	7.775	3.854	5.696	5.494
1995	9.184	5.723	7.599	2.886	6.352	3.743	7.963	3.469	5.156	4.885
1996	9.802	5.935	7.703	2.880	6.498	4.399	8.206	3.878	5.225	4.413
1997	10.222	6.022	7.614	2.878	6.618	4.713	8.390	3.306	5.070	4.593
1998	10.309	5.955	7.350	2.737	6.521	4.721	8.254	3.413	5.261	4.585

Table B37d: TFP Database – Output Prices

<i>Year</i>	<i>Exports</i>							<i>Subsidies</i>	
	<i>Wool Index</i>	<i>Pastoral and Dairy Index</i>	<i>Fish and Preps. Index</i>	<i>Forestry Index</i>	<i>Aluminium Index</i>	<i>Transport Equipment Index</i>	<i>Other Goods Index</i>	<i>Services Index</i>	<i>Subsidy Output Index</i>
1972	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1973	1.731	1.212	1.077	1.011	0.986	1.023	1.551	1.066	1.176
1974	2.604	1.341	1.125	1.240	0.977	1.124	1.629	1.122	1.606
1975	1.975	1.465	1.160	1.531	1.188	1.279	1.856	1.290	2.456
1976	1.988	1.507	1.437	1.778	1.772	1.603	2.169	1.604	4.580
1977	3.354	1.745	1.950	1.994	2.325	1.937	2.491	1.901	2.580
1978	3.571	1.967	2.273	2.059	2.434	2.085	2.715	2.148	3.297
1979	3.536	2.173	2.375	2.143	2.699	2.217	2.957	2.410	4.938
1980	4.435	2.620	2.581	2.748	3.256	2.641	3.783	2.843	3.913
1981	4.454	3.011	2.722	3.423	3.765	3.000	4.101	3.440	3.909
1982	4.558	3.210	3.106	3.895	4.140	3.467	5.074	4.013	6.385
1983	4.402	3.621	3.858	4.026	4.312	3.816	5.808	4.581	8.021
1984	4.938	3.723	4.346	4.327	5.318	4.271	6.260	4.813	7.005
1985	6.140	4.258	5.881	5.630	5.742	4.951	7.297	5.205	6.036
1986	6.396	4.439	6.427	5.580	5.395	5.427	7.475	5.756	3.484
1987	6.746	4.612	7.518	5.858	5.706	5.671	7.329	6.386	2.670
1988	7.928	5.001	7.022	6.175	6.300	6.081	7.725	6.784	2.527
1989	8.570	5.086	6.639	6.936	8.188	6.926	9.030	7.080	1.638
1990	8.424	5.885	7.250	7.224	7.603	7.378	9.743	7.378	1.876
1991	6.707	5.246	6.801	7.112	7.188	7.452	9.884	7.731	1.966
1992	5.500	5.370	8.000	7.019	6.033	7.350	9.657	7.940	2.308
1993	5.969	6.024	9.104	7.511	6.229	7.396	10.547	7.945	2.976
1994	5.449	5.786	8.626	9.218	5.511	6.906	10.083	7.900	2.679
1995	6.522	5.521	8.758	8.618	6.844	6.453	10.359	7.994	2.601
1996	6.818	5.377	8.209	8.853	6.942	6.261	9.674	8.184	2.346
1997	6.116	5.306	7.960	7.566	5.846	6.471	9.427	8.233	2.225
1998	5.863	5.253	7.776	7.427	6.620	6.040	9.584	8.381	2.142

Table B38a: TFP Database – Output Quantities

<i>Consumer Commodities</i>										
<i>Year</i>	<i>Food & Beverage</i> \$1972m	<i>Alcohol</i> \$1972m	<i>Clothing & footw'r</i> \$1972m	<i>Fuel & power</i> \$1972m	<i>Furniture etc</i> \$1972m	<i>Textiles etc</i> \$1972m	<i>Other goods</i> \$1972m	<i>Health services</i> \$1972m	<i>Motor vehicles</i> \$1972m	<i>Vehicle operation</i> \$1972m
1972	594	191	376	89	143	52	67	157	254	303
1973	625	203	409	91	169	62	82	149	255	316
1974	623	204	445	96	213	78	99	152	259	342
1975	648	212	415	96	248	90	100	154	235	372
1976	646	203	398	98	266	97	98	151	197	329
1977	623	207	380	98	255	93	88	138	174	330
1978	597	207	365	95	237	86	85	130	156	320
1979	598	204	357	94	231	84	86	135	190	305
1980	584	203	352	86	225	82	95	135	239	301
1981	578	198	351	86	230	84	92	135	247	308
1982	596	199	376	83	234	86	103	136	255	286
1983	624	178	381	91	245	89	108	141	222	290
1984	648	185	360	94	267	91	124	147	223	307
1985	675	189	373	95	302	95	142	152	244	305
1986	689	189	364	95	312	90	157	159	225	326
1987	727	198	372	99	341	95	171	175	216	325
1988	768	188	352	101	331	89	176	182	225	332
1989	759	184	321	101	322	88	180	192	254	358
1990	733	182	338	104	321	90	173	188	350	373
1991	741	183	324	107	304	86	172	192	373	361
1992	744	175	307	109	303	83	181	193	260	341
1993	749	175	307	106	332	86	187	197	235	332
1994	758	175	319	102	393	95	196	201	264	340
1995	811	175	339	100	426	104	211	207	322	366
1996	817	175	353	97	427	108	216	228	388	384
1997	833	175	357	98	445	105	215	239	449	395
1998	853	190	357	98	445	105	215	239	369	395

Table B38b: TFP Database – Output Quantities

Year	<i>Consumer Commodities</i>							<i>Govt.</i>		<i>Govt.</i>
	<i>Public transport</i> \$1972m	<i>Recreation</i> \$1972m	<i>Hotels</i> \$1972m	<i>Tobacco</i> \$1972m	<i>Personal</i> \$1972m	<i>Post & telephone</i> \$1972m	<i>Other services</i> \$1972m	<i>Non-res. Expend.</i> \$1972m	<i>Intermediates</i> \$1972m	<i>Investment</i> \$1972m
1972	152	435	96	58	149	69	102	38	298	132
1973	153	460	115	59	166	75	113	45	353	168
1974	167	480	126	61	158	77	108	56	385	146
1975	170	479	121	66	133	73	91	69	425	158
1976	153	485	120	65	125	69	86	79	425	184
1977	150	468	134	63	128	66	88	77	440	174
1978	151	447	123	62	106	68	72	67	561	181
1979	163	450	132	61	111	72	76	63	536	195
1980	156	438	157	59	108	68	74	64	503	182
1981	152	431	187	58	113	68	77	67	455	188
1982	145	410	209	60	123	65	84	72	471	175
1983	145	399	262	59	119	65	82	70	460	187
1984	161	406	299	60	130	69	88	92	487	195
1985	168	414	331	60	142	74	96	142	505	184
1986	175	434	356	55	151	79	87	160	517	223
1987	185	469	379	50	166	85	87	181	593	184
1988	234	471	378	51	161	104	104	198	624	163
1989	251	487	354	49	153	111	108	187	623	153
1990	247	484	358	45	155	130	109	193	641	157
1991	248	489	355	45	159	131	113	184	703	166
1992	240	485	346	39	163	135	104	203	693	93
1993	253	495	362	35	162	137	109	222	726	90
1994	250	539	394	36	165	140	106	243	706	80
1995	276	605	457	35	177	151	108	283	695	105
1996	321	636	528	34	183	168	113	354	736	97
1997	335	686	551	32	183	173	115	329	773	117
1998	335	686	551	32	183	173	115	329	857	129

Table B38c: TFP Database – Output Quantities

Year	<i>Investment Goods</i>						<i>Exports</i>			
	<i>Resident Dwelling</i> \$1972m	<i>Non-Res. Constr'n</i> \$1972m	<i>Trans. Equipm't</i> \$1972m	<i>Electric Machin'y</i> \$1972m	<i>Plant & Other</i> \$1972m	<i>Agricult. Inventory</i> \$1972m	<i>Non-Agr. Inventory</i> \$1972m	<i>Butter</i> \$1972m	<i>Cheese</i> \$1972m	<i>Meat</i> \$1972m
1972	306	409	233	55	292	79	-61	189	58	413
1973	380	421	251	58	359	-6	117	189	64	416
1974	438	425	288	75	383	29	386	178	54	377
1975	425	438	275	109	398	-6	-8	149	37	367
1976	433	469	253	97	359	-18	-81	216	54	408
1977	440	498	215	92	342	-5	-169	218	52	451
1978	311	562	198	79	316	-15	-95	208	52	451
1979	305	575	215	82	303	-33	177	189	44	461
1980	287	553	227	93	313	44	-205	226	45	413
1981	302	600	213	86	343	-5	-17	227	58	462
1982	334	632	276	121	434	-10	-137	192	60	466
1983	323	653	241	129	537	-35	-101	233	51	510
1984	362	668	213	164	575	26	164	168	65	512
1985	389	687	262	207	542	21	0	214	59	471
1986	393	745	267	244	604	55	9	216	67	466
1987	479	782	199	293	481	-31	-69	193	71	552
1988	384	819	198	332	537	20	-91	225	75	536
1989	403	716	133	374	532	-35	9	220	64	542
1990	443	682	232	480	512	25	-41	162	59	499
1991	435	582	208	584	462	3	-86	166	72	489
1992	370	534	167	459	362	-11	6	198	75	541
1993	386	468	210	467	427	-1	51	191	85	563
1994	451	516	246	490	581	72	65	220	90	549
1995	512	587	292	629	640	34	65	208	117	561
1996	514	696	309	702	658	-36	-11	218	117	611
1997	528	727	346	710	650	11	-24	266	148	599
1998	561	730	270	760	626	11	-24	276	169	640

Table B38d: TFP Database – Output Quantities

Year	<i>Exports</i>								<i>Subsidies</i>
	<i>Wool</i> \$1972m	<i>Pastoral and Dairy</i> \$1972m	<i>Fish and Preps.</i> \$1972m	<i>Forestry</i> \$1972m	<i>Aluminium</i> \$1972m	<i>Transport Equipment</i> \$1972m	<i>Other Goods</i> \$1972m	<i>Services</i> \$1972m	<i>Subsidy Output</i> \$1972m
1972	199	191	21	82	11	22	77	251	108
1973	210	212	18	86	27	28	66	282	110
1974	154	226	17	88	33	33	88	339	101
1975	141	195	18	85	32	41	76	366	97
1976	175	195	20	83	37	42	82	376	85
1977	195	253	22	110	37	43	129	378	94
1978	164	253	24	119	51	49	149	363	85
1979	187	247	27	129	49	59	166	360	87
1980	201	279	48	151	49	61	162	379	90
1981	202	244	58	156	46	71	202	374	89
1982	198	301	66	144	57	72	188	405	91
1983	219	322	72	126	65	63	190	416	94
1984	224	359	73	138	79	65	219	471	94
1985	228	419	86	137	86	80	256	565	99
1986	203	462	84	127	83	80	287	552	104
1987	224	499	93	131	84	74	270	563	109
1988	202	533	94	148	95	87	270	577	107
1989	212	569	110	167	93	88	263	574	110
1990	175	519	109	191	106	92	290	558	110
1991	146	617	113	218	106	93	328	553	104
1992	196	621	130	251	109	101	371	586	104
1993	163	613	129	279	104	127	374	641	106
1994	178	625	136	279	112	162	430	714	116
1995	201	692	134	298	111	196	483	804	125
1996	160	686	147	301	112	215	479	870	135
1997	157	784	143	314	124	218	517	827	143
1998	156	826	137	309	129	218	557	779	149

Table B39a: TFP Database – Input Values

<i>Year</i>	<i>Imports</i>							
	<i>Food & Beverages</i>	<i>Petroleum Products</i>	<i>Non-fuel Crude Mat</i>	<i>Textiles, Iron & Steel Clothing</i>	<i>Non-elect. Machinery</i>	<i>Electrical Machinery</i>	<i>Transport Equipment</i>	
	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>
1972	84	100	88	117	61	181	72	247
1973	96	113	96	119	71	200	78	253
1974	125	154	128	177	102	239	100	306
1975	168	361	192	223	201	388	160	400
1976	194	436	169	166	149	402	184	476
1977	191	516	236	250	194	474	210	525
1978	209	526	248	236	178	497	183	459
1979	208	502	259	263	178	494	197	525
1980	279	935	285	367	238	638	244	699
1981	304	1,266	336	342	229	726	261	756
1982	417	1,335	403	449	310	904	398	1,153
1983	456	1,483	476	494	357	1,146	453	1,067
1984	493	1,381	526	533	361	1,440	604	923
1985	690	1,559	680	782	526	1,687	831	1,483
1986	632	1,684	651	703	442	1,969	976	1,784
1987	760	796	485	766	382	1,736	1,226	1,705
1988	755	872	512	688	414	1,910	1,187	1,977
1989	850	724	580	645	279	1,832	1,264	1,708
1990	1,035	1,043	645	750	362	2,084	1,601	2,971
1991	1,040	1,353	651	704	264	2,290	1,891	2,666
1992	1,052	1,211	642	749	268	2,087	1,523	2,393
1993	1,188	1,216	726	860	313	2,403	1,668	2,638
1994	1,300	1,233	732	853	365	2,828	1,757	2,821
1995	1,427	1,251	751	918	395	3,257	2,097	3,803
1996	1,481	1,467	769	849	389	3,489	2,246	3,688
1997	1,513	1,610	723	821	401	3,418	2,224	3,672
1998	1,660	1,646	757	843	378	3,494	2,338	3,748

Table B39b: TFP Database – Input Values

<i>Year</i>	<i>Imports</i>		<i>Labour</i>			<i>Fuel Tax</i>	<i>Resources</i>	
	<i>Other Merch.</i>	<i>Services</i>	<i>Managers</i>	<i>Clerical</i>	<i>Production</i>	<i>Fuel Tax Input</i>	<i>Oil & Gas</i>	<i>Forestry</i>
	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>	<i>\$m</i>
1972	360	290	531	975	1,892	57	4	19
1973	404	348	636	1,104	2,086	68	3	27
1974	559	453	785	1,301	2,441	75	5	38
1975	866	555	949	1,515	2,830	77	21	23
1976	776	642	1,099	1,695	3,156	119	35	19
1977	986	746	1,302	1,939	3,616	134	29	44
1978	1,023	922	1,600	2,476	4,597	159	42	46
1979	1,094	1,107	1,771	2,842	5,235	202	1	56
1980	1,543	1,350	2,091	3,331	6,052	200	19	97
1981	1,586	1,696	2,504	3,976	7,167	203	13	170
1982	2,121	2,082	3,118	4,797	8,442	220	56	188
1983	2,340	2,431	3,480	5,261	9,061	269	170	205
1984	2,715	2,459	3,598	5,290	8,920	297	172	284
1985	4,011	2,861	4,013	5,767	9,479	345	173	533
1986	3,803	3,365	4,816	6,626	10,795	390	544	689
1987	4,095	3,842	5,938	7,724	11,718	542	262	887
1988	4,280	3,659	6,753	8,404	12,115	855	291	1,105
1989	4,421	4,000	7,343	8,725	12,031	825	290	1,294
1990	5,542	4,067	7,768	8,916	11,801	701	468	1,401
1991	5,498	4,204	8,430	9,335	11,799	609	642	1,424
1992	5,703	4,622	8,546	9,312	11,772	579	621	1,453
1993	6,595	5,176	8,803	9,459	11,970	598	510	1,733
1994	6,890	4,780	9,242	9,739	12,413	615	379	2,687
1995	7,599	5,107	9,924	10,270	13,117	637	289	2,798
1996	7,936	5,326	10,717	10,880	13,926	635	277	2,862
1997	7,902	5,473	11,269	11,228	14,434	606	377	2,538
1998	8,502	5,707	11,498	11,222	14,491	639	383	2,688

Table B39c: TFP Database – Input Values

Year	<i>Capital</i>						
	<i>Non-Residential Construction</i>	<i>Transport Equipment</i>	<i>Electrical Machinery</i>	<i>Plant & Other Machinery</i>	<i>Livestock Inventories</i>	<i>Non-Agricultural Inventories</i>	<i>Business and Agricultural Land</i>
	\$m	\$m	\$m	\$m	\$m	\$m	\$m
1972	754	251	78	298	-224	133	342
1973	809	496	101	629	299	159	-253
1974	833	369	95	511	1,033	353	-708
1975	1,200	-40	48	77	-221	142	315
1976	2,047	495	93	81	-190	-239	164
1977	1,522	340	215	546	237	-253	80
1978	2,154	262	178	363	-922	-109	79
1979	1,278	976	181	1,074	-121	-292	-70
1980	1,458	574	152	572	392	-552	-896
1981	-496	1,123	333	1,788	691	423	-1,296
1982	1,979	1,182	347	1,383	159	80	-2,668
1983	1,632	979	290	950	-145	-65	829
1984	3,866	1,299	430	1,455	-848	460	1,697
1985	1,373	1,319	672	2,823	1,272	-187	1,643
1986	2,202	1,333	729	2,968	351	646	2,646
1987	1,378	2,509	1,290	4,815	719	76	1,237
1988	259	3,749	1,095	4,242	37	441	3,762
1989	7,981	2,645	1,023	3,440	-1,176	111	917
1990	5,681	2,433	1,257	4,610	1,149	365	-120
1991	5,700	1,504	1,168	3,682	64	476	3,301
1992	9,704	1,635	1,227	4,363	-650	687	-929
1993	10,305	2,243	1,848	4,699	1,076	902	-4,075
1994	10,459	2,864	2,444	4,601	2,280	1,169	-3,749
1995	9,607	3,055	2,292	5,016	1,366	1,147	950
1996	9,041	3,090	2,253	5,429	-354	951	4,925
1997	8,970	3,239	2,202	5,120	54	724	6,848
1998	9,948	3,255	2,542	5,613	386	978	4,393

Table B40a: TFP Database – Input Prices

<i>Year</i>	<i>Imports</i>							
	<i>Food & Beverages Index</i>	<i>Petroleum Products Index</i>	<i>Non-fuel Crude Mat Index</i>	<i>Textiles, Iron & Steel Clothing Index</i>	<i>Non-elect. Machinery Index</i>	<i>Electrical Machinery Index</i>	<i>Transport Equipment Index</i>	
1972	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1973	1.096	0.998	1.011	1.059	1.025	1.089	1.024	1.103
1974	1.235	1.252	1.088	1.141	1.148	1.056	1.028	1.115
1975	1.381	2.806	1.566	1.339	1.658	1.184	1.126	1.307
1976	1.823	3.451	2.112	1.613	2.101	1.573	1.458	1.763
1977	2.119	4.453	2.467	1.851	2.383	2.007	1.759	1.975
1978	2.515	4.691	2.454	1.975	2.310	2.217	1.759	2.287
1979	2.362	4.618	2.420	2.012	2.640	2.576	1.846	2.667
1980	2.395	7.700	2.784	2.230	3.089	2.680	1.990	2.707
1981	2.962	11.849	3.536	2.556	3.576	3.125	2.320	3.089
1982	3.005	14.668	4.253	2.870	4.036	3.470	2.529	3.496
1983	3.346	16.171	4.730	3.126	4.283	3.919	2.688	4.028
1984	3.727	15.898	5.143	3.356	4.500	4.303	2.831	4.980
1985	4.465	18.694	6.039	4.223	5.545	5.051	3.111	6.065
1986	4.511	18.563	6.067	4.465	5.464	5.407	3.093	6.203
1987	4.161	12.394	5.468	4.393	5.424	5.937	3.224	7.659
1988	3.753	11.153	5.222	4.316	5.176	5.706	2.768	7.446
1989	4.022	9.648	5.923	4.474	6.595	5.751	2.638	7.643
1990	4.273	12.218	5.969	4.653	7.858	6.010	2.613	7.518
1991	4.361	14.612	6.253	4.747	7.371	5.951	2.532	7.629
1992	4.382	13.372	6.210	5.031	7.858	5.823	2.601	8.457
1993	4.491	13.799	6.287	5.353	7.657	6.469	2.806	9.796
1994	4.297	12.234	5.784	4.971	7.059	6.254	2.841	10.593
1995	4.289	11.533	5.933	5.081	6.870	6.199	2.641	10.717
1996	4.191	11.939	5.935	5.036	7.402	5.990	2.536	10.681
1997	4.303	13.000	5.764	4.992	6.945	5.758	2.472	10.466
1998	4.392	12.368	5.911	5.111	7.031	5.597	2.425	10.814

Table B40b: TFP Database – Input Prices

<i>Year</i>	<i>Imports</i>	<i>Labour</i>				<i>Fuel Tax</i>	<i>Resources</i>	
	<i>Other Merch. Index</i>	<i>Services Index</i>	<i>Managers Index</i>	<i>Clerical Index</i>	<i>Production Index</i>	<i>Fuel Tax Input Index</i>	<i>Oil & Gas Index</i>	<i>Forestry Index</i>
1972	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1973	1.015	1.066	1.137	1.122	1.099	1.133	0.744	1.373
1974	1.104	1.122	1.306	1.283	1.257	1.334	0.980	1.848
1975	1.440	1.290	1.476	1.452	1.425	1.276	3.641	1.128
1976	1.826	1.604	1.648	1.621	1.588	1.906	3.798	0.969
1977	2.172	1.901	1.923	1.820	1.809	2.136	1.426	1.874
1978	2.278	2.148	2.340	2.296	2.300	2.528	1.576	2.095
1979	2.268	2.410	2.624	2.649	2.657	3.319	0.035	2.598
1980	2.769	2.843	3.062	3.065	3.072	3.402	1.238	4.087
1981	3.273	3.440	3.646	3.636	3.667	3.554	0.808	6.965
1982	3.618	4.013	4.339	4.322	4.351	3.909	2.515	7.914
1983	3.922	4.581	4.637	4.680	4.719	4.874	5.137	8.919
1984	4.278	5.127	4.642	4.682	4.724	5.398	4.648	12.773
1985	5.147	5.865	4.813	4.893	4.938	6.172	3.587	23.206
1986	5.333	6.357	5.443	5.438	5.568	7.008	8.724	28.331
1987	5.106	6.468	6.425	6.318	6.284	9.572	3.702	38.677
1988	4.857	6.194	6.949	6.809	6.744	15.175	4.024	47.821
1989	5.250	6.423	7.480	7.252	7.184	14.479	3.770	51.090
1990	5.474	7.135	7.752	7.509	7.474	12.095	5.820	51.139
1991	5.386	7.711	8.087	7.803	7.773	10.555	7.799	44.376
1992	5.363	8.220	8.234	7.947	7.908	10.122	7.114	43.817
1993	5.508	8.745	8.278	8.020	8.001	9.880	5.747	49.461
1994	5.289	8.529	8.378	8.092	8.129	9.849	4.348	75.767
1995	5.180	8.339	8.485	8.189	8.257	9.382	3.556	72.494
1996	5.234	8.029	8.630	8.311	8.419	9.014	3.481	71.885
1997	4.923	7.862	8.812	8.455	8.591	8.581	4.013	66.192
1998	4.971	8.087	9.025	8.606	8.760	8.978	4.018	68.716

Table B40c: TFP Database – Input Prices

<i>Year</i>	<i>Capital</i>						
	<i>Non-Residential Construction Index</i>	<i>Transport Equipment Index</i>	<i>Electrical Machinery Index</i>	<i>Plant & Other Machinery Index</i>	<i>Livestock Inventories Index</i>	<i>Non-Agricultural Inventories Index</i>	<i>Business and Agricultural Land Index</i>
1972	1.000	1.000	1.000	1.000	-0.185	0.080	1.000
1973	1.043	1.802	1.221	1.909	0.233	0.100	-0.741
1974	1.043	1.213	1.040	1.413	0.807	0.207	-2.072
1975	1.463	-0.123	0.440	0.197	-0.169	0.068	0.920
1976	2.427	1.448	0.772	0.197	-0.146	-0.115	0.481
1977	1.753	0.985	1.681	1.283	0.184	-0.127	0.233
1978	2.405	0.760	1.377	0.840	-0.720	-0.059	0.232
1979	1.377	2.798	1.379	2.469	-0.096	-0.168	-0.206
1980	1.517	1.620	1.116	1.300	0.318	-0.288	-2.621
1981	-0.500	3.150	2.410	3.977	0.541	0.247	-3.792
1982	1.930	3.173	2.286	2.905	0.125	0.047	-7.802
1983	1.537	2.587	1.754	1.830	-0.115	-0.042	2.425
1984	3.517	3.443	2.291	2.578	-0.692	0.316	4.962
1985	1.208	3.406	3.048	4.727	1.016	-0.116	4.804
1986	1.872	3.357	2.813	4.654	0.276	0.398	7.737
1987	1.130	6.428	4.204	7.420	0.541	0.047	3.618
1988	0.205	9.757	3.059	6.334	0.028	0.283	11.003
1989	6.076	7.260	2.474	5.008	-0.893	0.076	2.681
1990	4.203	6.587	2.548	6.606	0.896	0.247	-0.351
1991	4.113	4.085	1.970	5.279	0.049	0.331	9.654
1992	6.881	4.564	1.949	6.438	-0.496	0.508	-2.716
1993	7.206	6.251	2.790	6.980	0.828	0.664	-11.917
1994	7.245	7.790	3.512	6.578	1.755	0.830	-10.966
1995	6.576	7.919	2.977	6.836	0.997	0.778	2.779
1996	6.091	7.623	2.638	7.078	-0.252	0.618	14.404
1997	5.912	7.519	2.383	6.444	0.039	0.474	20.027
1998	6.410	7.472	2.549	6.898	0.280	0.650	12.849

Table B41a: TFP Database – Input Quantities

Year	<i>Imports</i>							
	<i>Food & Beverages</i> \$1972m	<i>Petroleum Products</i> \$1972m	<i>Non-fuel Crude Mat</i> \$1972m	<i>Textiles, Iron & Steel Clothing</i> \$1972m	<i>Non-elect. Machinery</i> \$1972m	<i>Electrical Machinery</i> \$1972m	<i>Transport Equipment</i> \$1972m	
1972	84	100	88	117	61	181	72	247
1973	88	114	95	113	69	183	76	230
1974	101	123	118	155	89	226	97	274
1975	121	129	123	167	121	328	142	306
1976	107	126	80	103	71	256	126	270
1977	90	116	96	135	81	236	120	266
1978	83	112	101	120	77	224	104	201
1979	88	109	107	131	67	192	107	197
1980	117	121	102	165	77	238	123	258
1981	103	107	95	134	64	232	113	245
1982	139	91	95	156	77	261	157	330
1983	136	92	101	158	83	293	169	265
1984	132	87	102	159	80	335	213	185
1985	155	83	113	185	95	334	267	245
1986	140	91	107	157	81	364	316	288
1987	183	64	89	174	70	292	380	223
1988	201	78	98	159	80	335	429	266
1989	211	75	98	144	42	319	479	223
1990	242	85	108	161	46	347	613	395
1991	238	93	104	148	36	385	747	350
1992	240	91	103	149	34	358	586	283
1993	265	88	115	161	41	372	594	269
1994	303	101	127	172	52	452	618	266
1995	333	108	127	181	58	525	794	355
1996	353	123	130	169	53	582	886	345
1997	352	124	125	164	58	594	899	351
1998	378	133	128	165	54	624	964	347

Table B41b: TFP Database – Input Quantities

<i>Year</i>	<i>Imports</i>	<i>Labour</i>			<i>Fuel Tax</i>	<i>Resources</i>		
	<i>Other Merch.</i> \$1972m	<i>Services</i> \$1972m	<i>Managers</i> \$1972m	<i>Clerical</i> \$1972m	<i>Production</i> \$1972m	<i>Fuel Tax Input</i> \$1972m	<i>Oil & Gas</i> \$1972m	<i>Forestry</i> \$1972m
1972	360	290	531	975	1,892	57	4	19
1973	398	326	560	984	1,898	60	4	20
1974	506	404	601	1,014	1,942	56	5	20
1975	601	430	643	1,043	1,986	61	6	20
1976	425	400	667	1,046	1,988	62	9	20
1977	454	392	677	1,065	1,999	63	20	23
1978	449	429	684	1,078	1,998	63	27	22
1979	482	459	675	1,073	1,971	61	23	21
1980	557	475	683	1,087	1,970	59	15	24
1981	485	493	687	1,094	1,954	57	15	24
1982	586	519	719	1,110	1,940	56	22	24
1983	597	531	750	1,124	1,920	55	33	23
1984	635	480	775	1,130	1,888	55	37	22
1985	779	488	834	1,179	1,920	56	48	23
1986	713	529	885	1,218	1,939	56	62	24
1987	802	594	924	1,223	1,865	57	71	23
1988	881	591	972	1,234	1,797	56	72	23
1989	842	623	982	1,203	1,675	57	77	25
1990	1,012	570	1,002	1,187	1,579	58	80	27
1991	1,021	545	1,042	1,196	1,518	58	82	32
1992	1,063	562	1,038	1,172	1,489	57	87	33
1993	1,197	592	1,063	1,179	1,496	60	89	35
1994	1,303	560	1,103	1,204	1,527	62	87	35
1995	1,467	612	1,170	1,254	1,589	68	81	39
1996	1,516	663	1,242	1,309	1,654	70	79	40
1997	1,605	696	1,279	1,328	1,680	71	94	38
1998	1,710	706	1,274	1,304	1,654	71	95	39

Table B41c: TFP Database – Input Quantities

<i>Year</i>	<i>Capital</i>						
	<i>Non-Residential Construction</i> \$1972m	<i>Transport Equipment</i> \$1972m	<i>Electrical Machinery</i> \$1972m	<i>Plant & Other Machinery</i> \$1972m	<i>Livestock Inventories</i> \$1972m	<i>Non-Agricultural Inventories</i> \$1972m	<i>Business and Agricultural Land</i> \$1972m
1972	754	251	78	298	1,207	1,649	342
1973	776	275	82	330	1,286	1,588	342
1974	798	304	91	362	1,281	1,705	342
1975	820	327	110	392	1,310	2,092	342
1976	843	342	121	412	1,304	2,084	342
1977	868	346	128	425	1,286	2,003	342
1978	896	345	129	432	1,281	1,834	342
1979	928	349	131	435	1,266	1,738	342
1980	961	355	136	440	1,233	1,916	342
1981	992	357	138	450	1,277	1,711	342
1982	1,026	372	152	476	1,271	1,694	342
1983	1,062	378	165	519	1,261	1,556	342
1984	1,099	377	188	564	1,226	1,456	342
1985	1,137	387	220	597	1,252	1,620	342
1986	1,176	397	259	638	1,273	1,621	342
1987	1,220	390	307	649	1,328	1,630	342
1988	1,265	384	358	670	1,297	1,561	342
1989	1,314	364	413	687	1,317	1,470	342
1990	1,352	369	493	698	1,282	1,479	342
1991	1,386	368	593	698	1,308	1,438	342
1992	1,410	358	630	678	1,311	1,352	342
1993	1,430	359	662	673	1,299	1,359	342
1994	1,443	368	696	699	1,299	1,410	342
1995	1,461	386	770	734	1,371	1,474	342
1996	1,484	405	854	767	1,405	1,539	342
1997	1,517	431	924	795	1,369	1,528	342
1998	1,552	436	997	814	1,380	1,505	342

APPENDIX C: THE 'OFFICIAL' DATABASE

The Treasury, the Reserve Bank and the Department of Labour have supplied an 'official' database consisting of detailed information on GDP, labour and capital to facilitate productivity analysis using generally available information. GDP information covers real and nominal series for production, expenditure and income based GDP covering varying time periods and varying levels of disaggregation. Of particular interest are a detailed set of Annual Production Accounts which present a breakup of income based GDP for 27 two digit sectors. Labour information covers one and two digit level series from three sources: the Household Labour Force Survey (HLFS), the Quarterly Employment Survey (QES) and the Economic Survey of Manufacturing (ESM). Also included is a composite series for two digit industries drawing on all three sources plus additional work by the NZIER and Bryan Philpott. Capital information covers nominal and real investment in Buildings and construction and Plant and equipment at the two digit level from 1950 onwards.

To maximise comparability with other TFP estimates including those of the OECD and those derived from the Diewert–Lawrence database and to minimise the influence of measurement problems, we form output and input series only for the market sector of the New Zealand economy. Ownership of dwellings is excluded due to measurement problems and difficulties in interpreting its contribution to productivity. Sufficient information was available for us to proceed at the level of the 20 separate market sector industries listed in table 4.1 for production GDP, labour and capital.

Official database series are available for varying time periods and a mixture of quarterly and yearly bases. The information we needed was available for most relevant variables in March year format for the period 1978 to 1998 and all results are presented on this basis. This has the added advantage of maximising comparability with the Diewert–Lawrence database results which cover the March years from 1972 to 1998. For some of the detailed nominal series information was only available up to 1995. These series have been updated to 1998 by pro-rating the relevant aggregates as outlined below.

The contents of the official database are described in detail in Keegan (1998). In this appendix we provide a summary of the database drawing heavily in parts on the Keegan paper and list the data series we have actually used in the productivity analyses reported in chapters 4 and 5.

C1 Production and Expenditure Based GDP

The official database provides information on real production GDP at the two digit level. To obtain information for the 20 industries we use in this report we aggregated information for Primary food and Other food, beverages and tobacco to form our industry Food and tobacco. We also aggregated the Wholesale, Restaurants and Hotels industries which were only available separately for part of the time period to form our industry Trade, restaurants and hotels. The 20 industry real production GDPs are presented in table C1.

The database contains information on nominal production GDPs by industry covering the period 1978 to 1995. To update the nominal production GDPs to 1998 we formed implicit prices for the period from 1978 to 1998 by dividing the nominal series by the real series. We then assumed that all 20 industry production GDPs had the same proportional price changes in 1996 and 1998 as the expenditure based GDP deflator provided in the database. Nominal values for 1996, 1997 and 1998 are then recovered by multiplying the real GDPs for those years by the estimated implicit prices. The resulting nominal production GDPs are presented in table C2.

Expenditure based GDP is only provided at the aggregate economy level in the official database. To ensure that we are comparing like with like we need to derive an expenditure based measure relating to market sector outputs. To do this we subtract from total expenditure based GDP the value of *nonmarket* compensation of employees (covering government, nonprofit and domestic services obtained from the database's Annual Production Accounts) and the value of imputed rent (which relates to owner occupied housing which is excluded from our definition of the market sector). The value and price of imputed rent are obtained from the detailed time series of household consumption expenditures supplied to us by SNZ to facilitate formation of the Diewert–Lawrence database. The price of nonmarket labour is formed as a composite of detailed National Accounts information supplied by Treasury for the period from 1983 onwards and the government wage rate series used in the Diewert–Lawrence database for years prior to 1983. The expenditure based GDP deflator is formed as a composite of that in the official database from 1983 onwards and the OECD's GDP deflator for earlier years.

Having information on the value and price of total expenditure based GDP and for each of the two components we wish to exclude, we form a price index for the residual market sector expenditure–based GDP using formula (1) in appendix B. The official database's total economy expenditure GDP series are presented in table C3 while the series used in the construction of our market sector expenditure GDP series are listed in table C4.

C2 Labour Inputs

There are several alternative SNZ survey based sources of hours worked classified by different industries. The official database contains information on hours worked obtained from the HLFS, QES and ESM.

There are a number of differences between the HLFS and QES in terms of industry coverage (eg the QES excludes agriculture, hunting and fishing), definitions (eg the QES measures filled jobs whereas the HLFS measures employed persons) and timing (eg the HLFS takes average results for a quarter whereas the QES takes one pay period in a quarter). Brief details of the three sources are presented below drawing on Keegan's (1998) documentation of the official database.

HLFS

The HLFS was designed using International Labour Organisation (ILO) standards and definitions. Households are sampled on a statistically representative random basis from rural and urban areas throughout the North and South Islands of New Zealand. It covers the civilian usually resident noninstitutionalised population aged 15 and over in the survey population. Where practicable, the information is obtained from each household member personally. Otherwise a proxy interview (ie, obtaining details for one individual from another adult) is conducted.

HLFS data is available for full-time, part-time and hours worked by gender. No distinction is made in these categories between the private and public sectors, therefore those working for the government are simply included in the relevant industry in which they work. Full-time workers are those who usually worked 30 hours or more, even if they did not in fact do so in the survey reference week because of sickness, holiday, etc. Part-time workers are those who usually work fewer than 30 hours per week. Hours worked data are based on the actual hours worked in all jobs. Excluded from the hours data are those normally employed but who worked zero hours in the reference week due to sickness, holiday, etc. Approximately 32,000 people or 16,000 private households in New Zealand are interviewed each quarter. Each person is interviewed for eight quarters (2 years) so that changes in the labour market can be measured. Interviews are carried out each week of the quarter so that the data is an average for that quarter.

The hours worked data includes working proprietors. The official HLFS series starts in 1985. A backdated series estimated by Gorbey, Briggs and Chapple (1993) has been added to take the series back to 1971.

QES

The QES section of the official database presents hours worked information for 9 industries: Forestry and mining; Manufacturing; Electricity, gas and water; Building and construction; Trade, restaurants and hotels; Transport and communication; Business and financial services; Public administration and defence; Other community, social and personal services.

Total hours worked data was calculated by multiplying information on surveyed employment and average hours paid together. In order to be consistent with the GDP data available the Transport and Communication Industry was separated into two parts; Transport and Storage, and Communication. More recent data (post 1987) was provided by SNZ and backdates were located in the 'Supplementary Tables to the Employment and Labour Gazette'. These tables only provided data for February so the data was interpolated to form a quarterly series. Fishing and Hunting data was extracted from Philpott (1994).

All series in the database begin at 1971Q1 and end at 1998Q2. The official SNZ data begins in 1989Q1 after SNZ took the survey over from the Department of Labour (DOL). It was backdated using the DOL QES and Half Yearly Employment Survey (HYS) (collected from 1971Q1-1988Q4). The backdated data was obtained from NZIER spreadsheets for the period 1971Q1-1988Q4. Some elements of the survey were changed at the time it was taken over by SNZ.

Comparing the HLFS and QES

The two surveys should paint a similar picture of the labour market, and so one survey's results provides confirmation of the other's. However, because there are several differences between the surveys, the results are usually not precisely the same. In recent years the growth patterns of the HLFS and the QES have been quite different. Reasons for this difference have yet to be fully explored.

There are several factors to keep in mind when comparing HLFS and QES employment tracks.

Filled Jobs Versus Number Employed

QES results measure the number of filled jobs, whereas HLFS estimates are of the number of employed persons. In the QES, individuals with more than one job are counted at each workplace, whereas they are counted once in the HLFS.

Industry Exclusions

There are several industries excluded from QES coverage. These are:

- Agriculture and hunting
- Fishing
- Ocean and coastal water transport
- Residential property leasing and rental
- National accounts code for those who own their own home
- Commercial property leasing and rental
- Central government defence services (although civilian staff are included in the survey).
- Domestic services

Out of Scope

QES total filled jobs results in May, August, and November comprise survey estimates of full-time and part-time employees in business locations employing more than two full-time equivalent employees, plus a projection for out of scope employment. This projection consists of full-time and part-time employees out of scope of the survey (ie, in business locations with two or fewer full-time equivalent employees) and all working proprietors. The out of scope component comprises a growing proportion of total filled jobs. Provisionally carrying forward the out of scope component unchanged tends to dampen the quarterly movements evident in provisional QES surveyed employment.

Timing Differences

The two surveys have different reference periods. QES collects information relating to the pay period ending on or immediately before the mid points of quarters, while HLFS figures are quarterly averages based on responses collected throughout the quarter.

Age Differences

Only those aged 15 years and over are included in the coverage of the HLFS, whereas there is no such age distinction in the QES.

Family Businesses

The HLFS has four categories for status in employment: working for wages or salary, employer of others, self employed and not employing others, and working without pay in a family business. The QES, on the other hand, does not specifically include the last category. It has two categories only: working proprietors and paid employees.

Part-time/Full-time

Part-time/full-time figures will differ between the two surveys, eg, a person who works in two jobs for a total of more than 30 hours will be counted as two part-timers in the QES, but as one full-timer in the HLFS.

Coding

QES industry figures are generally more accurate, because they are based on the Business Directory and on administrative records, whereas HLFS coding depends on the adequacy of respondent's recollections about their employment status and hours worked. In addition, some HLFS hours worked is based on proxy reporting of one respondent on behalf of other household members, which is also likely to be measured with greater error than self reporting.

Industry

The HLFS only collects industry information for main job. Therefore, if there are industries in which many people work 'second' jobs, this is not recorded, whereas it would be in the QES.

Casuals

Because the QES is based on the Business Directory, any 'casual' type of employment (eg, cash jobs, cottage industries), that is done outside the framework of a business, will not be picked up. Such people would be counted as employed in the HLFS.

Economic Survey of Manufacturing

The ESM presents data on hours worked for 10 manufacturing industries: Meat and dairy products; Other food, beverage and tobacco; Textiles, apparel and leather goods; Wood processing and products; Paper products, printing and publishing; Chemicals, petroleum, coal, rubber and plastic products; Nonmetallic minerals; Basic metal industries; Fabricated metals (machinery); Other manufacturing. Data runs from 1977Q2 - 1998Q2.

Keegan (1998, p.21) makes the following statement about comparability of the QES and ESM data:

'QES (*Quarterly Employment Survey*) and ESM (*Economic Survey of Manufacturing*) hours worked data, for the manufacturing sector, were compared over the period 1987Q1-1997Q3. This was then graphed and the correlation was found to be 0.92. The ESM data appears to be approximately 10x the value of the QES data. In order to obtain QES data comparable to the ESM 'hours worked by paid employees' I multiplied the QES 'total average hours paid for' by 'total paid employees'.'

Composite Labour Data for Two Digit Industries

The official database contains a composite estimate of hours worked to allow productivity calculations at a two digit level. It was not possible to employ a consistent set of sources. The manufacturing sector hours worked series are likely to be the most robust, since they come from one consistent official data series throughout the period under consideration (the ESM). The next most robust series are those where the two digit industry corresponds exactly with its one digit equivalent. Since, however, in these cases three different data sets were used to obtain the figures (the Department of Labour's HYS and QES and Statistics New Zealand's QES), the data possesses less than the desired degree of reliability. Least reliable is the data for the sectors which has had to be constructed from a variety of sources, eg, Agriculture and Fishing and hunting.

Keegan describes the sources for the 20 industries are as follows:

Agriculture: HLFS data on Agriculture, hunting, forestry and fishing employment was used. Given the small size of the nonagricultural sectors relative to agriculture, hours worked for agriculture were taken as the combined sectors.

Fishing and hunting: This was the most difficult sector to estimate hours worked and the consequent estimates are the least reliable. The hours worked series should be used with extreme caution. Data from 1985Q4 on hours worked were obtained from the HLFS. Due to the small size of the sector, the error bounds are likely to be large. Philpott's numbers for full-time equivalents on a March year basis were obtained for the period up until 1994. These were interpolated. The logged ratio of the HLFS numbers to full-time equivalents were regressed on a constant and three seasonal dummies and the resulting equation used to back cast the HLFS numbers. Note that this method assumes that hours worked by each full-time equivalent were constant prior to 1985.

Forestry and logging: The NZIER has backdated Department of Labour and Statistics NZ QES hours data for Forestry and logging and Mining and quarrying. The share of Forestry and logging was calculated. There appeared to be no break in the share contingent on the shift in the survey to Statistics New Zealand in 1989. The share was therefore applied to the aggregate backdated Forestry and Mining series to obtain the eventual series.

Mining and quarrying: As for Forestry and logging.

Food, beverages and tobacco: The ESM Meat and dairy products and Other food, beverage and tobacco hours data was summed. An observation for 1977Q3 for the latter sector was missing and was linearly interpolated.

Textiles, apparel and leather: ESM.

Wood and wood products: ESM.

Paper, printing and publishing: ESM.

Chemicals, plastics, petroleum, rubber: ESM.

Nonmetallic mineral products: ESM.

Basic metal industries: ESM.

Fabricated metal products: ESM.

Other manufacturing: ESM.

Electricity, gas and water: QES.

Construction: QES.

Trade, restaurants, hotels: QES.

Transport and storage: For the post 1989 period, the QES data for Transport and Storage hours was obtained from Statistics New Zealand. The share of Transport and Storage in the combined Transport, Storage and Communications pre 1989 was calculated and forecast forward one quarter into 1989 as a polynomial function of time. The pre 1989 share was then adjusted using this one quarter of overlap to the post 1989 share. The adjusted share was then used to split out Transport and storage from the consistent one digit industry data pre 1989.

Communications: The Transport and storage series was subtracted from the one digit industry combined Transport, storage and communications sector.

Finance, insurance, business services and real estate: QES data.

Community, social and personal services: QES data.

Industry Labour Costs

To use the industry labour information to form measures of total input we also need to have estimates of labour costs by industry. This was obtained from the compensation of employees component of the market sector Annual Production Accounts. As noted earlier, this series only runs from 1978 to 1995. A similar technique to that outlined for production GDP was used. We derived an implicit price for labour for the period 1978 to 1995 by dividing the compensation value by hours worked for each industry. This was updated to 1996, 1997 and 1998 assuming the same proportion change in price occurred for all industries. The price change for these years was estimated by dividing the total compensation of employees value obtained from the income based GDP accounts by total hours worked. Industry labour costs for 1996, 1997 and 1998 were then obtained by multiplying the estimated implicit price of labour by the industry hours worked for those years.

We present the composite hours worked series for the 20 industries in table C5 and industry labour costs in table C6. The one digit HLFS series are presented in table C7, the one digit QES series in table C8 and the ESM series in table C9.

C3 Capital Inputs

The theory behind our approach to measuring capital inputs is developed in appendix D while the basic equations used to form our real gross and net capital stock estimates and the corresponding user costs are presented in chapter 4.

To form gross capital stock estimates for long-lived assets we need a long time series of real investment. In the official database we have estimates of real investment for each of the 20 industries back to 1950. For some of the manufacturing industries real investment is provided for a longer period. We also have estimated gross capital stocks for 1950 for each industry and the two asset types considered by Bryan Philpott (1992). As noted in chapter 4, in the interests of having as consistent a set of estimates as possible, we have formed estimates of pre 1950 real investment by taking Philpott's 1950 stock estimates by industry and asset type and distributing them equally across 1950 and preceding years back as far as the assumed asset life. This procedure leads to our gross capital stock estimates for 1950 coinciding with Philpott's. We have furthermore assumed that the gross and net capital stock estimates were equal in 1950. This is equivalent to assuming that the economy was in a 'steady state' in 1950 where retirements under the gross and net capital stock models are equal. This provides consistent starting values for the net capital stock formula (2) in chapter 4 of the Philpott estimates in 1950. We then assume that the depreciation rate used in the net model is the reciprocal of the equivalent asset life assumed in the gross model. The Philpott estimated stocks for 1950 (expressed in 1992 prices) and Philpott's estimated asset life for each of the 20 industries and two asset types were listed in table 4.2.

In tables C10 and C11 we list the nominal investment series and deflators for Plant and equipment and Buildings and construction, respectively, for each of the 20 industries back to 1950. We then list the real gross capital stock estimates for Plant and equipment and Buildings and construction for 1978 to 1998 based on Philpott's estimated asset lives and implied depreciation rates in tables C12 and C13, respectively. Corresponding series for real net capital stocks are then presented in tables C14 and C15. User costs for the gross and net capital stocks using a common market sector wide real interest rate are presented in tables C16 to C19. Finally, in tables C20 and C21 we present the user costs for net capital stocks using industry specific real interest rates.

In the interests of conserving space we do not present the analogous tables for the other three capital models reported in chapter 4 which use longer, shorter and average lengths of asset life compared to the Philpott based model reported here. However, these can be readily derived from the information presented here.

Table C1: Real Production GDPs by Industry, \$1992 millions

<i>March Year</i>	<i>Agriculture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>
1978	2,677	85	439	574	3,631	1,001	726	1,488	1,250	432
1979	2,502	87	456	505	3,810	972	723	1,451	1,293	411
1980	2,845	100	503	366	3,693	1,118	809	1,578	1,387	414
1981	3,198	114	560	330	3,941	1,030	793	1,602	1,271	409
1982	3,172	122	576	361	4,024	1,097	891	1,637	1,364	498
1983	3,324	126	572	529	4,337	1,113	806	1,577	1,308	512
1984	3,065	139	585	416	4,436	1,083	851	1,712	1,411	519
1985	3,191	148	607	556	4,710	1,142	952	1,895	1,601	549
1986	3,863	171	627	803	4,439	1,071	934	1,879	1,586	546
1987	3,848	196	615	833	4,953	1,103	870	1,947	1,642	524
1988	4,434	177	547	754	4,629	1,013	813	2,099	1,546	478
1989	4,154	230	668	887	4,610	935	745	1,993	1,573	451
1990	3,832	220	732	999	4,334	918	722	2,024	1,575	424
1991	4,514	230	825	970	4,392	794	706	1,982	1,502	409
1992	4,517	229	850	1,082	4,442	813	722	1,934	1,481	381
1993	3,820	243	865	1,098	4,582	807	799	1,923	1,558	424
1994	4,616	221	894	1,167	4,756	849	894	2,058	1,713	456
1995	4,555	223	940	1,052	4,960	873	994	2,154	1,890	516
1996	4,685	233	953	1,066	5,214	803	992	2,215	1,934	536
1997	5,104	218	921	1,187	5,202	789	1,009	2,174	1,867	562
1998	5,259	229	937	1,159	5,548	711	1,039	2,137	1,830	598

Table C1: Real Production GDPs by Industry, \$1992 millions (continued)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	390	2,967	110	1,353	3,304	10,281	2,716	1,079	6,729	3,213
1979	400	2,832	111	1,449	3,033	10,323	2,786	1,110	7,015	3,356
1980	413	3,012	104	1,585	2,780	10,209	2,852	1,146	7,196	3,388
1981	373	2,890	95	1,629	2,749	10,053	2,741	1,236	7,418	3,429
1982	416	3,361	120	1,669	2,966	10,596	2,781	1,304	7,690	3,572
1983	436	3,364	116	1,677	3,062	10,339	2,762	1,355	7,681	3,549
1984	438	3,400	123	1,853	3,324	10,664	3,027	1,432	8,409	3,651
1985	521	3,754	157	1,875	3,498	10,818	3,238	1,560	9,040	3,738
1986	469	3,520	162	1,939	3,595	10,396	3,022	1,687	9,690	3,875
1987	483	3,276	146	1,978	3,456	10,747	3,217	1,878	10,531	3,699
1988	446	3,302	139	2,027	3,337	10,560	3,367	1,973	11,057	3,790
1989	480	3,057	144	1,980	3,206	10,694	3,625	2,094	11,100	3,821
1990	511	3,156	140	2,052	3,331	10,976	3,529	2,356	10,952	3,846
1991	486	2,766	132	2,129	2,822	10,735	3,504	2,511	10,693	3,869
1992	477	2,535	122	2,107	2,389	10,248	3,632	2,676	10,641	3,974
1993	578	2,654	129	2,030	2,302	10,708	3,805	2,869	10,699	4,080
1994	661	2,865	132	2,148	2,509	11,313	4,144	3,122	11,035	4,409
1995	666	3,182	137	2,224	2,814	12,182	4,539	3,486	11,334	4,872
1996	686	3,191	126	2,306	3,160	12,550	4,915	3,925	11,745	5,131
1997	700	3,411	130	2,290	3,379	12,654	5,131	4,292	12,174	5,435
1998	707	3,521	148	2,276	3,418	12,967	5,166	4,622	12,713	5,506

Table C2: Nominal Production GDPs by Industry, \$ millions

<i>March Year</i>	<i>Agriculture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>
1978	1,352	37	121	183	822	385	194	402	265	168
1979	1,440	40	142	165	1,060	403	248	418	364	174
1980	2,159	59	197	153	1,069	525	306	524	492	196
1981	2,180	60	220	188	1,394	560	367	606	470	227
1982	2,274	77	216	227	1,647	716	472	724	595	337
1983	2,168	89	197	369	2,057	756	442	803	719	373
1984	2,512	104	215	280	2,349	704	514	844	778	396
1985	3,138	130	300	422	2,650	763	621	1,124	998	402
1986	3,060	177	398	582	2,570	856	718	1,206	1,318	401
1987	3,012	221	461	621	3,294	982	749	1,356	1,752	418
1988	3,708	230	333	597	3,592	922	700	1,661	1,504	405
1989	4,074	260	557	644	3,910	800	716	1,671	1,604	427
1990	4,491	249	615	836	4,015	864	752	1,827	1,776	413
1991	3,989	233	701	1,005	4,260	817	720	1,965	1,490	424
1992	4,511	236	850	1,082	4,441	813	723	1,934	1,481	381
1993	4,344	270	1,052	1,107	4,389	803	866	1,886	1,574	417
1994	4,956	272	1,494	1,126	4,607	840	970	1,979	1,800	496
1995	4,852	285	1,306	1,080	4,853	873	1,197	2,215	2,178	579
1996	5,111	305	1,356	1,121	5,224	822	1,223	2,333	2,282	616
1997	5,663	290	1,333	1,269	5,301	822	1,266	2,328	2,241	657
1998	5,856	306	1,361	1,244	5,674	743	1,308	2,297	2,204	701

Table C2: Nominal Production GDPs by Industry, \$ millions (continued)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	124	878	43	380	944	2,850	872	370	1,532	560
1979	127	932	45	439	977	3,246	987	442	1,789	649
1980	167	1,118	45	654	1,006	3,465	1,119	516	2,020	742
1981	173	1,229	56	715	1,187	4,400	1,232	622	2,332	863
1982	217	1,726	83	828	1,556	5,334	1,442	703	2,985	1,035
1983	298	1,850	71	962	1,772	6,145	1,616	884	3,451	1,189
1984	317	1,913	80	1,077	1,942	7,033	1,934	982	4,077	1,294
1985	359	2,179	102	1,116	2,222	7,274	2,143	1,034	4,817	1,486
1986	350	2,368	134	1,442	2,551	8,494	2,372	1,156	5,981	1,766
1987	342	2,670	122	1,723	2,806	9,650	2,815	1,758	7,741	1,906
1988	257	2,792	128	1,757	2,942	9,698	3,110	2,100	9,498	2,325
1989	255	2,693	144	1,992	2,997	10,524	3,470	2,148	10,298	2,584
1990	460	2,840	151	2,134	3,216	10,292	3,687	2,183	10,771	2,720
1991	424	2,605	142	2,086	2,803	11,411	3,653	2,349	10,681	2,839
1992	477	2,534	122	2,107	2,389	10,244	3,633	2,677	10,641	3,121
1993	671	2,653	136	2,126	2,325	11,102	3,745	2,507	10,693	3,418
1994	650	3,032	156	2,282	2,600	12,539	4,057	2,475	11,573	3,730
1995	613	3,356	165	2,327	3,048	13,853	4,480	2,631	12,746	4,034
1996	647	3,447	155	2,471	3,505	14,615	4,968	3,034	13,526	4,351
1997	671	3,747	163	2,496	3,812	14,987	5,275	3,374	14,259	4,687
1998	680	3,882	186	2,489	3,870	15,413	5,330	3,646	14,944	4,765

Table C3: Total Economy Expenditure GDP Components, \$ millions

<i>March</i>	<i>Final Consumption</i>		<i>Increase</i>	<i>Gross Fixed</i>	<i>Gross Nat.</i>	<i>Exports</i>	<i>less Imports</i>	<i>Expenditure</i>
<i>Year</i>	<i>Govt</i>	<i>Private</i>	<i>in Stocks</i>	<i>Capital Exp.</i>	<i>Expenditure</i>			<i>on GDP</i>
1978	2,363	9,149	133	3,545	15,189	4,125	4,378	14,936
1979	2,882	10,324	-246	3,880	16,840	4,687	4,647	16,880
1980	3,314	12,053	470	4,067	19,905	5,996	6,256	19,645
1981	4,134	14,169	-33	4,754	23,024	7,003	7,272	22,755
1982	4,989	16,633	165	6,597	28,384	8,249	9,168	27,465
1983	5,566	19,019	247	7,775	32,607	9,266	10,319	31,554
1984	5,858	20,718	377	8,611	35,560	10,507	11,064	35,007
1985	6,334	23,582	1,111	9,994	41,021	13,228	14,541	39,708
1986	7,347	27,870	-156	11,977	47,038	13,946	15,311	45,673
1987	8,930	32,959	587	12,363	54,838	15,123	15,240	54,719
1988	10,128	37,432	-380	13,382	60,560	16,663	15,635	61,591
1989	11,023	40,524	-61	12,893	64,380	18,061	15,583	66,858
1990	11,742	43,456	1,406	14,304	70,907	19,152	18,938	71,121
1991	12,293	45,758	-118	13,794	71,727	19,961	19,440	72,248
1992	12,266	45,806	85	11,538	69,698	21,683	19,103	72,278
1993	12,682	46,680	757	12,280	72,396	23,890	21,708	74,577
1994	12,579	48,992	1,729	14,769	78,068	25,314	22,588	80,794
1995	12,535	52,938	1,438	17,601	84,513	27,172	25,140	86,545
1996	13,197	56,467	1,117	19,174	89,955	27,421	26,169	91,207
1997	13,830	59,766	627	20,087	94,310	27,546	26,714	95,142
1998	14,954	62,420	894	19,807	98,075	28,172	27,715	98,532

Table C4: Construction of Market Sector Expenditure GDP

<i>March Year</i>	<i>Total Expenditure on GDP</i>		<i>Nonmarket Comp. of Employees</i>			<i>Imputed Rent</i>			<i>Market Expenditure on GDP</i>		
	<i>\$m</i>	<i>Price</i>	<i>\$m</i>	<i>Price</i>	<i>\$1972m</i>	<i>\$m</i>	<i>Price</i>	<i>\$1972m</i>	<i>\$m</i>	<i>Price</i>	<i>\$1972m</i>
1978	14,936	1.000	1,850	1.000	1,850	1,037	1.000	1,037	12,049	1.000	12,049
1979	16,880	1.154	2,284	1.139	2,006	1,126	1.064	1,058	13,470	1.164	11,572
1980	19,645	1.336	2,659	1.320	2,015	1,221	1.135	1,076	15,766	1.356	11,628
1981	22,755	1.549	3,320	1.569	2,116	1,368	1.253	1,092	18,067	1.572	11,491
1982	27,465	1.787	3,976	1.862	2,136	1,652	1.497	1,103	21,837	1.799	12,138
1983	31,554	1.966	4,355	2.004	2,173	2,015	1.786	1,128	25,184	1.974	12,761
1984	35,007	2.062	4,461	2.039	2,187	2,282	1.982	1,151	28,264	2.071	13,647
1985	39,708	2.222	4,671	2.116	2,208	2,711	2.308	1,174	32,326	2.231	14,489
1986	45,673	2.562	5,455	2.428	2,246	3,614	3.008	1,202	36,604	2.545	14,380
1987	54,719	2.976	6,743	3.065	2,200	4,375	3.567	1,227	43,601	2.913	14,969
1988	61,591	3.318	7,649	3.541	2,160	5,159	4.139	1,246	48,783	3.216	15,168
1989	66,858	3.562	8,270	3.809	2,171	6,216	4.913	1,265	52,372	3.412	15,348
1990	71,121	3.794	8,713	3.865	2,254	6,745	5.250	1,285	55,663	3.661	15,206
1991	72,248	3.886	8,960	4.011	2,234	7,325	5.606	1,307	55,963	3.723	15,032
1992	72,278	3.931	8,938	3.954	2,260	7,554	5.695	1,326	55,786	3.778	14,765
1993	74,577	4.024	9,112	3.970	2,295	7,513	5.594	1,343	57,952	3.902	14,853
1994	80,794	4.104	9,303	3.940	2,361	7,702	5.665	1,360	63,789	3.999	15,950
1995	86,545	4.176	9,450	3.947	2,394	8,065	5.853	1,378	69,030	4.071	16,957
1996	91,207	4.276	9,949	4.058	2,451	8,887	6.351	1,399	72,371	4.138	17,491
1997	95,142	4.349	10,426	4.222	2,470	9,475	6.675	1,420	75,241	4.178	18,010
1998	98,532	4.365	11,274	4.330	2,604	9,919	6.889	1,440	77,339	4.165	18,569

Table C5: Composite Hours Worked by Industry

<i>March Year</i>	<i>Agriculture hours</i>	<i>Fishing and hunting hours</i>	<i>Forestry hours</i>	<i>Mining hours</i>	<i>Food, beverage and tobacco '00 hrs</i>	<i>Textiles '00 hrs</i>	<i>Wood & wood products '00 hrs</i>	<i>Paper & paper products '00 hrs</i>	<i>Chemical '00 hrs</i>	<i>Non- metallic minerals '00 hrs</i>
1978	25,988,017	524,254	2,156,576	1,106,107	129,709	74,484	44,005	57,938	48,503	22,204
1979	26,566,259	547,093	2,181,516	1,108,160	137,191	72,314	41,696	56,298	50,146	21,379
1980	27,074,834	566,039	2,414,607	1,006,956	133,021	75,830	44,978	56,867	52,638	21,480
1981	27,487,366	579,967	2,016,337	956,904	134,431	70,793	44,308	56,937	49,526	18,828
1982	27,782,073	593,896	2,078,364	987,022	133,318	72,978	47,218	57,709	49,401	19,391
1983	27,972,737	607,824	2,003,208	1,016,357	136,299	74,040	43,536	56,374	48,232	19,007
1984	28,098,688	630,662	2,019,047	1,054,986	131,121	71,191	40,308	57,355	47,885	17,152
1985	28,200,642	649,608	2,067,667	1,060,391	140,140	77,226	42,671	60,420	49,242	18,026
1986	28,241,210	521,065	1,872,167	1,140,558	133,928	83,419	43,823	64,688	51,456	19,130
1987	27,922,586	324,644	1,711,274	1,142,019	141,485	76,816	39,700	66,719	50,284	18,951
1988	26,777,966	322,231	909,597	970,333	124,943	70,107	38,588	67,582	44,449	19,316
1989	26,438,451	416,792	873,467	1,050,555	129,911	60,042	35,888	60,463	40,863	17,016
1990	26,185,923	446,964	598,526	1,148,014	128,777	60,312	34,097	56,402	38,904	13,874
1991	25,150,456	542,692	544,402	1,142,309	121,072	56,656	33,953	55,835	39,511	12,278
1992	25,241,018	653,496	553,946	1,299,047	119,161	52,317	33,013	51,499	38,482	10,546
1993	24,956,368	544,330	544,120	1,449,042	122,883	50,402	37,083	50,979	40,090	11,100
1994	25,638,711	410,271	649,208	1,562,164	123,253	52,393	41,766	50,859	41,576	11,378
1995	26,544,242	676,974	776,171	1,732,153	124,708	52,126	46,975	53,018	44,030	11,967
1996	26,319,812	624,534	758,930	1,837,793	128,735	49,894	47,195	57,399	45,505	12,985
1997	25,444,892	573,440	700,846	1,725,587	128,175	42,848	46,460	57,811	45,471	13,173
1998	24,509,881	603,798	652,577	1,606,742	127,664	38,522	46,880	56,439	46,078	14,074

Table C5: Composite Hours Worked by Industry (continued)

<i>March Year</i>	<i>Basic Machin metals -ery</i>	<i>Other man- uf'g</i>	<i>Elect. gas, water</i>	<i>Const- ruction</i>	<i>Trade, rest'rant hotels</i>	<i>Trans- port & storage</i>	<i>Com- muni- cations</i>	<i>Finance services</i>	<i>Com- munity services</i>	
	'00 hrs	'00 hrs	'00 hrs	hours	hours	hours	hours	hours	hours	
1978	13,201	140,427	6,926	2,190,427	21,399,161	46,452,963	9,205,441	10,421,205	13,881,109	35,435,763
1979	12,689	141,311	7,080	2,291,858	20,459,557	46,302,588	9,139,078	10,502,251	14,151,536	36,743,040
1980	13,388	142,074	7,429	2,134,181	18,380,210	47,308,612	8,960,065	10,339,336	14,390,352	37,368,155
1981	12,765	135,215	7,264	2,102,577	16,705,409	47,170,610	8,533,255	9,953,180	14,629,217	37,281,052
1982	13,096	140,389	7,916	2,248,942	16,495,756	47,399,860	8,387,493	9,962,948	15,148,103	37,071,532
1983	13,474	137,697	7,332	2,274,640	16,795,679	47,772,899	8,229,730	9,896,898	15,455,148	37,236,194
1984	14,015	130,614	7,157	2,332,783	16,410,519	47,408,675	8,217,901	9,882,465	15,751,792	37,782,163
1985	15,056	141,276	7,965	2,331,555	17,525,091	50,161,048	8,238,587	9,966,451	16,584,968	38,466,600
1986	14,382	143,866	8,506	2,371,153	17,602,666	51,433,348	8,253,161	10,274,791	17,785,302	38,558,328
1987	13,407	137,965	8,269	2,493,801	17,354,677	51,576,596	8,236,923	10,415,227	20,083,572	40,075,341
1988	13,169	136,978	7,563	2,685,800	16,408,190	49,686,570	7,873,480	9,695,260	21,427,560	39,685,800
1989	13,868	115,829	6,080	2,610,990	15,298,411	47,439,942	7,206,897	8,987,488	22,687,965	40,500,736
1990	14,223	110,946	6,164	2,329,846	15,324,668	48,556,933	6,856,210	8,695,113	23,371,036	42,466,766
1991	14,111	103,848	5,152	2,246,436	14,531,708	47,837,413	6,812,683	8,236,747	23,076,822	43,384,540
1992	12,591	96,529	4,956	2,139,751	13,240,132	47,086,130	6,549,442	7,986,301	22,797,487	44,592,136
1993	12,437	103,452	5,134	1,875,882	12,995,554	48,637,239	6,360,642	7,623,734	23,167,867	45,306,589
1994	12,805	121,657	5,545	1,791,334	13,824,340	51,499,432	6,395,152	7,679,979	24,433,715	47,974,324
1995	13,945	130,726	5,208	1,742,097	15,113,599	55,651,634	6,842,898	7,895,320	26,629,485	50,364,185
1996	14,472	136,812	5,213	1,663,934	16,224,747	57,957,560	7,323,899	8,057,801	28,427,502	51,923,005
1997	14,766	140,452	5,116	1,641,936	17,078,900	60,041,884	7,566,484	8,747,216	30,293,485	54,574,715
1998	13,337	141,333	5,297	1,496,176	17,385,965	61,827,304	7,828,686	9,050,334	31,408,355	56,213,888

Table C6: Labour Costs by Industry, \$ millions

<i>March Year</i>	<i>Agricul- ture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non- metallic minerals</i>
1978	240	7	66	49	536	281	158	230	212	84
1979	259	8	79	51	674	302	167	260	242	89
1980	325	17	90	43	763	372	204	318	294	110
1981	373	18	110	55	916	407	246	387	326	121
1982	446	19	135	66	1,091	494	314	470	385	151
1983	476	21	126	78	1,225	514	325	509	405	173
1984	488	25	132	88	1,191	492	315	540	405	160
1985	561	25	143	100	1,326	544	359	589	455	173
1986	603	28	149	111	1,370	626	435	717	566	207
1987	611	34	161	182	1,710	661	479	851	644	236
1988	678	37	98	174	1,757	653	500	951	707	245
1989	773	37	91	166	1,786	596	489	998	694	240
1990	897	39	101	158	1,789	600	503	1,018	751	227
1991	905	36	110	170	1,926	528	502	1,102	755	231
1992	926	39	101	155	2,037	535	483	1,037	767	206
1993	986	45	118	191	2,022	539	531	1,053	779	229
1994	1,012	52	144	181	1,996	536	620	1,128	835	242
1995	1,013	56	168	199	2,088	607	715	1,201	905	268
1996	1,029	53	168	216	2,208	595	736	1,332	958	298
1997	1,022	50	160	209	2,258	525	744	1,378	983	310
1998	1,011	54	153	200	2,311	485	772	1,383	1,024	341

Table C6: Labour Costs by Industry, \$ millions (continued)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	67	599	24	120	587	1,319	580	277	545	272
1979	77	668	27	146	644	1,487	671	320	649	311
1980	91	769	31	181	691	1,738	780	372	762	366
1981	104	880	35	213	785	2,041	910	445	930	445
1982	129	1,105	45	263	940	2,435	1,061	523	1,155	554
1983	146	1,220	44	277	1,066	2,630	1,148	553	1,325	631
1984	150	1,169	44	294	1,118	2,682	1,192	548	1,424	671
1985	171	1,305	49	305	1,236	3,010	1,263	579	1,625	761
1986	201	1,515	58	389	1,434	3,658	1,457	691	2,114	890
1987	220	1,692	61	479	1,535	4,417	1,688	846	2,831	1,014
1988	239	1,822	69	557	1,614	4,883	1,972	1,058	3,650	1,145
1989	288	1,697	70	564	1,656	5,008	2,086	1,166	3,960	1,235
1990	313	1,696	79	549	1,705	5,252	2,112	1,145	4,018	1,293
1991	336	1,628	71	543	1,591	5,459	2,130	1,107	3,951	1,327
1992	325	1,536	64	510	1,559	5,429	1,878	1,115	3,900	1,462
1993	302	1,536	68	500	1,469	5,791	1,923	1,053	4,004	1,534
1994	296	1,700	83	529	1,547	6,167	1,964	1,026	4,189	1,713
1995	346	1,869	83	490	1,765	6,796	2,103	957	4,605	1,840
1996	368	2,004	85	479	1,941	7,249	2,305	1,000	5,035	1,943
1997	386	2,113	86	486	2,099	7,716	2,447	1,116	5,513	2,098
1998	358	2,185	91	455	2,196	8,165	2,602	1,186	5,873	2,221

Table C7: One Digit HLFS Labour Hours Worked

<i>March Year</i>	<i>Agric. fishing forestry</i>	<i>Mining quarrying</i>	<i>Manufac-turing</i>	<i>Elect. gas, water</i>	<i>Const- ruction</i>	<i>Trade, rest'rant hotels</i>	<i>Trans- port & comms.</i>	<i>Finance services</i>	<i>Com- munity services</i>	<i>Not spec'd</i>
1978	25,988,017	869,185	46,217,377	2,173,499	16,870,387	32,984,044	15,711,162	13,169,895	38,940,750	0
1979	26,566,259	878,103	45,414,325	2,211,059	16,489,523	33,572,717	15,804,546	13,438,112	40,556,572	0
1980	27,074,834	817,695	46,310,908	2,214,273	15,381,170	34,724,341	15,879,405	13,674,067	41,745,432	0
1981	27,487,366	789,456	45,656,687	2,234,180	14,466,301	35,355,104	15,927,633	13,911,486	42,471,581	0
1982	27,782,073	818,346	45,700,223	2,279,773	14,475,455	36,178,681	16,013,832	14,427,317	43,121,967	0
1983	27,972,737	847,303	45,905,184	2,308,516	14,826,886	37,094,863	16,095,366	14,735,544	44,051,583	0
1984	28,098,688	881,307	44,922,121	2,342,051	14,733,364	37,646,803	16,188,562	15,026,853	45,280,036	0
1985	28,200,642	890,398	46,469,254	2,367,877	15,619,344	39,822,430	16,290,138	15,857,767	46,636,281	0
1986	28,241,211	993,810	46,533,172	2,363,501	16,002,197	41,859,184	16,053,464	17,111,058	47,313,428	490,066
1987	27,922,587	951,230	45,854,116	2,412,354	15,706,586	42,237,028	16,536,244	19,125,062	49,240,894	769,073
1988	26,775,479	742,442	43,372,262	2,550,607	14,892,241	43,073,028	16,823,501	20,471,425	50,390,916	504,429
1989	26,438,453	678,843	38,709,787	2,166,795	14,481,488	40,409,077	15,816,773	20,892,815	49,069,719	307,263
1990	26,173,930	870,120	37,452,654	1,811,591	14,376,003	40,457,344	14,626,038	20,468,244	50,753,554	369,737
1991	25,150,456	816,503	37,319,143	2,137,622	13,137,274	42,461,210	14,369,425	20,874,221	49,910,946	731,369
1992	25,241,016	582,087	35,081,366	1,944,966	11,073,169	41,333,155	13,921,654	21,836,835	50,694,256	361,927
1993	24,956,367	590,658	35,458,377	1,611,819	11,836,418	42,937,222	13,665,754	22,294,200	51,692,375	176,665
1994	25,638,713	701,240	39,057,884	1,588,984	12,715,216	43,838,270	14,007,119	21,673,334	53,821,904	205,601
1995	26,544,241	789,772	43,588,107	1,610,054	14,891,004	45,710,823	14,499,801	23,440,947	53,348,256	204,406
1996	26,319,809	946,285	44,000,253	2,018,872	15,958,299	47,538,297	15,233,478	25,530,648	55,468,621	207,711
1997	25,444,893	871,316	42,981,408	1,968,533	17,210,005	47,568,259	15,667,252	27,051,751	57,048,221	871,673
1998	24,509,881	845,674	41,625,866	1,601,912	17,387,921	48,186,817	15,978,596	29,150,691	56,621,201	622,401

Table C8: One Digit QES Labour Hours Worked

<i>March Year</i>	<i>Forestry & mining</i>	<i>Manufacturing</i>	<i>Electricity gas, water</i>	<i>Construction</i>	<i>Trade, restaurants hotels</i>	<i>Transport & comms.</i>	<i>Finance services</i>	<i>Community services</i>
1978	3,262,683	50,159,845	2,190,427	21,399,161	46,452,963	19,626,646	13,881,109	35,435,763
1979	3,289,676	48,686,446	2,291,858	20,459,557	46,302,588	19,641,328	14,151,536	36,743,040
1980	3,421,563	50,432,537	2,134,181	18,380,210	47,308,612	19,299,401	14,390,352	37,368,155
1981	2,973,240	49,096,022	2,102,577	16,705,409	47,170,610	18,486,436	14,629,217	37,281,052
1982	3,065,387	49,191,476	2,248,942	16,495,756	47,399,860	18,350,441	15,148,103	37,071,532
1983	3,019,566	49,561,217	2,274,640	16,795,679	47,772,899	18,126,628	15,455,148	37,236,194
1984	3,074,033	47,766,740	2,332,783	16,410,519	47,408,675	18,100,366	15,751,792	37,782,163
1985	3,128,058	50,753,519	2,331,555	17,525,091	50,161,048	18,205,039	16,584,968	38,466,600
1986	3,012,725	50,769,195	2,371,153	17,602,666	51,433,348	18,527,952	17,785,302	38,558,328
1987	2,837,293	44,438,989	2,493,801	17,354,677	51,576,596	18,652,150	20,083,572	40,075,341
1988	1,816,870	46,861,130	2,685,800	16,408,190	49,686,570	17,568,740	21,427,560	39,685,800
1989	1,849,507	44,269,197	2,610,990	15,298,411	47,439,942	16,194,385	22,687,965	40,500,736
1990	1,651,322	41,848,207	2,329,846	15,324,668	48,556,933	15,551,323	23,371,036	42,466,766
1991	1,586,997	40,170,448	2,246,436	14,531,708	47,837,413	15,049,430	23,076,822	43,384,540
1992	1,714,287	37,871,130	2,139,751	13,240,132	47,086,130	14,535,743	22,797,487	44,592,136
1993	1,829,926	38,698,412	1,875,882	12,995,554	48,637,239	13,984,376	23,167,867	45,306,589
1994	2,022,841	40,899,542	1,791,334	13,824,340	51,499,432	14,075,131	24,433,715	47,974,324
1995	2,294,306	43,652,067	1,742,097	15,113,599	55,651,634	14,738,218	26,629,485	50,364,185
1996	2,395,248	44,256,697	1,663,934	16,224,747	57,957,560	15,381,700	28,427,502	51,923,005
1997	2,241,062	43,893,496	1,641,936	17,078,900	60,041,884	16,313,700	30,293,485	54,574,715
1998	2,086,715	42,603,808	1,496,176	17,385,965	61,827,304	16,879,020	31,408,355	56,213,888

Table C9: Economic Survey of Manufacturing – '00 Hours Worked

<i>March Year</i>	<i>Meat & dairy products</i>	<i>Other food, beverage</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>	<i>Basic metals</i>	<i>Machinery</i>	<i>Other manufacturing</i>
1978	82,144	47,369	74,484	44,005	57,938	48,503	22,204	13,201	140,427	6,926
1979	90,094	47,098	72,314	41,696	56,298	50,146	21,379	12,689	141,311	7,080
1980	84,391	48,630	75,830	44,978	56,867	52,638	21,480	13,388	142,074	7,429
1981	85,304	49,127	70,793	44,308	56,937	49,526	18,828	12,765	135,215	7,264
1982	84,341	48,976	72,978	47,218	57,709	49,401	19,391	13,096	140,389	7,916
1983	86,657	49,641	74,040	43,536	56,374	48,232	19,007	13,474	137,697	7,332
1984	81,320	49,801	71,191	40,308	57,355	47,885	17,152	14,015	130,614	7,157
1985	87,650	52,490	77,226	42,671	60,420	49,242	18,026	15,056	141,276	7,965
1986	80,226	53,702	83,419	43,823	64,688	51,456	19,130	14,382	143,866	8,506
1987	89,870	51,615	76,816	39,700	66,719	50,284	18,951	13,407	137,965	8,269
1988	73,315	51,629	70,107	38,588	67,582	44,449	19,316	13,169	136,978	7,563
1989	76,812	53,100	60,042	35,888	60,463	40,863	17,016	13,868	115,829	6,080
1990	74,566	54,210	60,312	34,097	56,402	38,904	13,874	14,223	110,946	6,164
1991	67,245	53,826	56,656	33,953	55,835	39,511	12,278	14,111	103,848	5,152
1992	67,687	51,474	52,317	33,013	51,499	38,482	10,546	12,591	96,529	4,956
1993	68,657	54,226	50,402	37,083	50,979	40,090	11,100	12,437	103,452	5,134
1994	67,003	56,250	52,393	41,766	50,859	41,576	11,378	12,805	121,657	5,545
1995	65,664	59,044	52,126	46,975	53,018	44,030	11,967	13,945	130,726	5,208
1996	68,372	60,363	49,894	47,195	57,399	45,505	12,985	14,472	136,812	5,213
1997	67,262	60,913	42,848	46,460	57,811	45,471	13,173	14,766	140,452	5,116
1998	67,456	60,207	38,522	46,880	56,439	46,078	14,074	13,337	141,333	5,297

Table C10: Nominal Investment in Plant and Equipment by Industry, \$ millions

<i>March Year</i>	<i>Price Index</i>	<i>Agricul- ture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, b'rage tobacco</i>	<i>Textiles</i>	<i>Wood & Paper & wood paper product product</i>	<i>Chem- icals</i>	<i>Non- metallic minerals</i>
1950	0.0690	17.5	0.2	4.2	1.4	4.6	2.0	1.5 2.1	2.0	0.4
1951	0.0734	24.3	0.2	3.7	1.4	5.2	3.0	1.5 2.6	2.1	0.8
1952	0.0853	25.7	0.2	3.4	1.4	8.9	2.4	2.6 2.7	2.1	1.4
1953	0.0912	24.2	0.4	4.2	1.6	10.1	2.4	1.9 11.6	2.1	1.1
1954	0.0927	26.1	0.6	4.6	1.6	9.0	3.2	2.1 3.1	3.8	1.5
1955	0.0986	26.1	0.6	4.2	1.8	8.5	3.1	7.0 35.6	3.8	0.7
1956	0.1001	21.7	0.6	3.7	2.0	10.8	2.5	2.1 6.5	4.0	0.6
1957	0.1023	24.2	0.5	3.5	2.2	12.0	3.1	1.8 4.3	3.0	1.3
1958	0.1045	21.7	0.5	3.7	2.4	11.3	4.0	2.0 5.3	6.8	1.4
1959	0.1082	18.6	0.5	4.3	2.7	10.8	4.1	2.5 7.3	5.9	3.3
1960	0.1105	23.1	0.7	2.6	3.0	12.5	6.7	3.2 11.3	8.3	2.2
1961	0.1134	25.6	0.9	2.7	3.3	13.2	5.2	2.8 11.4	7.2	4.9
1962	0.1171	24.3	1.1	2.8	3.6	13.2	5.5	3.6 32.3	8.9	2.1
1963	0.1171	26.6	1.3	2.7	4.0	12.4	6.5	3.1 10.2	7.2	2.9
1964	0.1201	26.5	1.5	3.3	0.2	16.8	6.7	3.6 9.7	8.6	7.3
1965	0.1238	35.8	1.7	3.5	4.4	24.0	7.9	4.2 17.5	9.8	9.0
1966	0.1268	34.8	2.1	4.7	4.7	21.9	6.6	5.3 15.3	13.5	5.4
1967	0.1283	32.0	2.6	4.8	5.0	19.6	6.6	3.5 12.1	9.3	3.7
1968	0.1364	31.8	3.1	5.0	10.2	28.3	7.2	3.5 12.2	5.9	4.1
1969	0.1483	32.6	3.6	6.2	12.2	29.6	11.5	5.3 22.5	9.8	4.3
1970	0.1527	40.6	4.3	7.1	7.7	36.5	14.5	5.8 15.7	9.6	7.1
1971	0.1683	69.0	5.0	8.0	5.0	42.0	12.0	6.0 24.0	11.0	7.0
1972	0.1854	98.0	3.0	8.0	7.0	47.0	11.0	10.0 63.0	16.0	6.0
1973	0.1987	94.0	4.0	8.0	7.0	50.0	14.0	13.0 61.0	24.0	11.0

Table C10: Nominal Investment in Plant and Equipment by Industry, \$ mil (cont'd)

<i>March Year</i>	<i>Price Index</i>	<i>Agricul- ture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, b'rage tobacco</i>	<i>Textiles</i>	<i>Wood & Paper & wood paper product product</i>	<i>Chem- icals</i>	<i>Non- metallic minerals</i>	
1974	0.2098	77.0	4.0	10.0	10.0	82.0	20.0	20.0	72.0	24.0	13.0
1975	0.2373	116.0	4.0	13.0	14.0	83.0	24.0	20.0	41.0	34.0	17.0
1976	0.2921	156.0	7.0	12.0	13.0	99.0	21.0	25.0	72.0	44.0	30.0
1977	0.3507	132.0	15.0	13.0	13.0	83.0	29.0	35.0	33.0	37.0	10.0
1978	0.3952	193.0	9.0	15.0	6.0	114.0	33.0	19.0	62.0	54.0	12.0
1979	0.4500	237.0	21.0	14.0	18.0	155.0	34.0	23.0	64.0	39.0	14.0
1980	0.5049	269.0	9.0	19.0	19.0	245.0	28.0	26.0	75.0	37.0	17.0
1981	0.6013	355.0	7.0	23.0	24.0	279.0	36.0	19.0	102.0	225.0	48.0
1982	0.6776	351.0	13.0	10.0	30.0	283.0	61.0	37.0	126.0	922.0	54.0
1983	0.7221	392.0	22.0	12.0	47.0	282.0	57.0	36.0	118.0	844.0	29.0
1984	0.7646	474.0	22.0	15.0	64.0	343.0	72.0	98.0	172.0	618.0	38.0
1985	0.8523	236.0	31.0	11.0	99.0	303.0	86.0	125.0	171.0	555.0	37.0
1986	0.9515	254.0	26.0	19.0	101.0	356.0	54.0	88.0	294.0	250.0	42.0
1987	0.9913	251.6	26.9	18.2	50.6	369.1	53.5	86.5	292.0	223.3	42.0
1988	0.9762	216.6	63.9	24.3	45.9	463.5	64.9	62.5	205.5	166.5	29.2
1989	0.9590	271.3	43.7	15.3	32.5	325.3	51.4	53.2	312.2	132.5	37.0
1990	0.9759	349.4	71.0	19.4	71.6	598.3	46.7	63.3	411.2	153.6	39.2
1991	0.9839	265.2	71.7	37.6	176.6	322.4	46.6	54.5	159.6	110.2	60.2
1992	1.0000	319.8	48.6	53.7	183.4	365.6	37.0	72.1	348.9	157.1	35.2
1993	1.0438	45.1	73.1	38.9	49.5	547.4	50.0	125.2	133.0	668.0	41.2
1994	1.0440	69.1	96.2	68.4	44.6	575.4	68.1	250.3	241.0	195.6	37.1
1995	1.0143	80.7	82.3	88.2	17.2	592.6	84.6	199.1	249.7	389.7	60.8
1996	0.9657	78.6	113.8	107.0	78.1	540.9	73.6	140.3	378.5	270.9	59.5
1997	0.9026	78.6	113.8	107.0	78.1	540.9	73.6	140.3	378.5	270.9	59.5
1998	0.8146	78.6	113.8	107.0	78.1	540.9	73.6	140.3	378.5	270.9	59.5

Table C10: Nominal Investment in Plant and Equipment by Industry, \$ mil (cont'd)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1950	0.1	1.9	0.6	8.3	3.0	4.0	10.1	4.6	0.6	2.2
1951	0.2	2.4	0.6	9.7	5.2	5.9	15.2	5.2	0.7	2.3
1952	0.2	3.0	0.0	13.4	7.4	7.2	21.8	5.9	0.8	2.6
1953	-0.2	3.0	0.6	15.8	10.1	9.8	20.0	5.5	0.7	3.5
1954	0.6	4.6	0.6	15.9	12.8	14.2	23.5	6.2	0.6	4.4
1955	0.2	5.2	0.0	16.7	16.7	16.0	23.4	7.3	0.7	4.7
1956	0.2	3.6	0.6	21.7	20.5	17.6	30.6	8.9	0.9	5.0
1957	0.6	4.0	0.6	29.0	24.3	19.8	28.4	9.1	1.2	5.3
1958	0.4	4.7	0.6	28.2	28.2	21.7	31.0	9.2	1.6	5.6
1959	0.2	5.6	0.6	31.5	26.2	23.6	30.5	8.9	2.0	5.9
1960	0.3	7.8	1.0	29.9	36.4	23.2	31.9	9.0	2.5	7.3
1961	0.6	11.3	1.3	28.3	33.5	33.2	38.0	10.5	3.1	8.8
1962	1.0	9.7	1.8	25.1	27.7	31.6	31.8	13.6	3.8	10.6
1963	1.7	11.4	1.9	24.4	29.9	31.1	34.1	14.0	4.7	12.8
1964	1.6	15.0	1.9	27.3	28.4	33.1	33.7	14.2	5.7	15.4
1965	1.7	17.4	2.4	30.5	28.2	6.0	51.7	14.9	7.0	18.5
1966	1.3	5.6	2.1	37.8	34.6	49.4	38.1	15.6	9.9	21.6
1967	9.9	6.0	1.9	34.6	34.6	34.9	56.5	15.7	13.4	25.3
1968	18.1	2.1	1.9	33.3	33.3	45.9	54.8	14.9	18.1	29.6
1969	36.0	1.0	2.3	32.3	36.5	60.8	51.8	19.9	24.3	34.6
1970	1.8	12.6	1.1	32.1	40.2	83.2	67.4	24.9	32.7	40.5
1971	31.0	19.0	1.0	34.0	46.0	112.0	113.0	26.0	45.0	17.0
1972	17.0	29.0	2.0	53.0	46.0	137.0	129.0	24.0	57.0	21.0
1973	2.0	38.0	1.0	40.0	62.0	154.0	156.0	34.0	66.0	28.0

Table C10: Nominal Investment in Plant and Equipment by Industry, \$ mil (cont'd)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1974	6.0	42.0	2.0	51.0	64.0	176.0	206.0	44.0	76.0	33.0
1975	9.0	46.0	2.0	114.0	71.0	175.0	290.0	65.0	87.0	51.0
1976	26.0	50.0	3.0	156.0	82.0	168.0	255.0	53.0	89.0	38.0
1977	17.0	59.0	2.0	172.0	87.0	164.0	321.0	56.0	92.0	49.0
1978	17.0	50.0	3.0	150.0	66.0	240.0	387.0	69.0	106.0	38.0
1979	16.0	72.0	3.0	153.0	106.0	384.0	210.0	48.0	138.0	49.0
1980	23.0	74.0	3.0	156.0	138.0	388.0	280.0	85.0	146.0	56.0
1981	92.0	112.0	3.0	131.0	192.0	516.0	543.0	103.0	202.0	69.0
1982	187.0	135.0	3.0	88.0	151.0	539.0	454.0	105.0	173.0	65.0
1983	200.0	144.0	7.0	171.0	154.0	647.0	350.0	170.0	402.0	84.0
1984	154.0	193.0	6.0	143.0	158.0	994.0	442.0	180.0	753.0	168.0
1985	332.0	223.0	6.0	113.0	191.0	1,130.0	782.0	253.0	1,090.0	229.0
1986	257.0	203.0	9.0	168.0	193.0	1,041.0	650.0	319.0	872.0	234.0
1987	23.7	192.5	8.7	2.5	202.9	1,001.7	432.0	2.3	888.3	193.5
1988	65.3	228.6	8.4	1.5	211.9	1,356.1	402.5	8.1	824.5	222.0
1989	79.1	128.1	14.1	2.0	158.0	1,313.8	89.6	5.9	1,211.2	171.9
1990	61.0	149.1	4.3	7.7	122.9	1,575.0	676.6	16.3	731.8	222.2
1991	52.7	129.9	6.7	15.7	154.7	1,004.7	460.5	240.3	1,517.8	222.0
1992	37.6	78.3	6.2	22.1	115.6	505.1	441.4	360.2	813.2	200.6
1993	-78.2	116.9	7.9	14.6	118.6	728.2	1,061.0	317.3	904.3	223.6
1994	64.7	217.6	6.0	31.6	230.5	849.9	1,234.6	-304.3	2,483.5	341.3
1995	96.3	323.1	16.3	17.8	284.3	972.8	1,136.9	142.0	2,673.8	456.2
1996	114.5	279.7	14.7	44.7	367.3	1,042.4	1,433.8	861.2	2,032.0	439.2
1997	114.5	279.7	14.7	44.7	367.3	1,042.4	1,688.2	861.2	1,788.6	439.2
1998	114.5	279.7	14.7	44.7	367.3	1,042.4	1,049.6	861.2	1,830.8	439.2

Table C11: Nominal Investment in Buildings and Construction by Industry, \$ millions

<i>March Year</i>	<i>Price Index</i>	<i>Agricul- ture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, b'rage tobacco</i>	<i>Textiles</i>	<i>Wood & Paper & wood paper product product</i>	<i>Chem- icals</i>	<i>Non- metallic minerals</i>	
1950	0.0394	18.7	0.0	0.5	1.4	1.6	1.9	0.9	0.2	0.4	0.2
1951	0.0435	21.6	0.0	0.7	1.4	1.7	3.0	1.2	0.7	0.3	0.5
1952	0.0488	28.5	0.0	0.6	1.4	1.8	2.8	1.7	1.1	0.4	0.5
1953	0.0517	34.3	0.0	0.6	1.4	2.9	1.5	1.5	1.5	0.5	1.1
1954	0.0547	33.2	0.0	0.5	1.0	4.1	1.2	0.9	2.9	0.3	0.2
1955	0.0570	39.2	0.0	0.4	0.8	6.6	1.8	1.5	3.4	0.9	0.8
1956	0.0594	44.4	0.0	0.5	0.9	5.1	1.7	5.2	1.3	0.9	0.8
1957	0.0605	42.1	0.0	0.6	1.1	3.9	1.1	1.2	7.3	1.6	1.1
1958	0.0623	45.0	0.0	0.7	1.4	3.7	2.2	1.4	2.8	0.9	1.7
1959	0.0641	43.5	0.0	0.9	1.7	3.8	3.3	2.3	3.6	1.4	1.1
1960	0.0635	43.5	0.0	1.3	2.0	7.7	2.1	1.5	4.8	1.6	1.2
1961	0.0647	48.3	0.0	1.0	1.6	6.8	2.5	2.3	5.5	2.2	1.1
1962	0.0658	51.9	0.0	1.1	1.2	7.6	2.7	2.0	11.7	3.3	1.4
1963	0.0670	55.8	0.0	1.3	0.8	6.4	2.6	1.8	14.0	3.3	1.0
1964	0.0676	54.1	0.0	1.4	0.4	7.2	2.5	1.8	3.4	2.7	1.4
1965	0.0711	60.7	0.0	2.0	0.4	11.3	2.9	1.7	2.8	3.5	2.1
1966	0.0735	66.1	0.0	2.3	0.4	16.8	2.9	2.8	6.9	5.3	2.6
1967	0.0758	69.5	0.0	2.7	0.1	13.4	3.4	3.1	9.5	5.5	2.5
1968	0.0782	61.5	0.0	2.4	0.5	12.1	1.6	2.6	2.3	3.4	2.0
1969	0.0835	63.1	0.0	2.3	1.5	21.2	3.4	2.3	2.9	4.1	1.9
1970	0.0887	59.2	0.0	2.6	2.3	20.5	4.8	4.1	9.4	4.8	1.6
1971	0.1029	60.9	0.0	2.6	1.4	20.1	4.2	3.4	3.3	6.5	3.9
1972	0.1166	56.0	0.0	4.0	1.0	19.0	3.0	2.0	3.0	5.0	2.0
1973	0.1252	79.0	0.0	5.0	2.0	20.0	1.0	3.0	11.0	5.0	2.0

Table C11: Nominal Investment in Buildings and Construction by Industry, \$m (cont.)

<i>March Year</i>	<i>Price Index</i>	<i>Agricul- ture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, b'rage tobacco</i>	<i>Textiles</i>	<i>Wood & Paper & wood paper product product</i>	<i>Chem- icals</i>	<i>Non- metallic minerals</i>	
1974	0.1389	103.0	0.0	6.0	5.0	25.0	2.0	4.0	14.0	7.0	2.0
1975	0.1604	95.0	0.0	6.0	26.0	37.0	5.0	5.0	10.0	5.0	6.0
1976	0.1897	105.0	0.0	8.0	129.0	41.0	3.0	12.0	9.0	5.0	2.0
1977	0.2227	131.0	0.0	6.0	164.0	45.0	2.0	9.0	14.0	8.0	4.0
1978	0.2575	145.0	0.0	11.0	194.0	37.0	4.0	7.0	4.0	5.0	2.0
1979	0.2908	178.0	0.0	11.0	114.0	52.0	6.0	3.0	9.0	9.0	4.0
1980	0.3393	247.0	0.0	11.0	63.0	67.0	5.0	4.0	8.0	23.0	4.0
1981	0.4182	325.0	0.0	16.0	50.0	102.0	3.0	6.0	12.0	59.0	3.0
1982	0.4988	414.0	1.0	19.0	28.0	115.0	-1.0	8.0	14.0	157.0	5.0
1983	0.5568	390.0	1.0	16.0	35.0	111.0	7.0	6.0	23.0	144.0	10.0
1984	0.5727	392.0	2.0	19.0	68.0	110.0	9.0	4.0	36.0	165.0	9.0
1985	0.6163	391.0	3.0	18.0	62.0	57.0	18.0	23.0	49.0	161.0	11.0
1986	0.7003	320.0	5.0	17.0	81.0	55.0	21.0	33.0	50.0	94.0	8.0
1987	0.8145	189.6	2.8	3.8	81.8	121.7	3.6	19.4	49.3	45.2	4.9
1988	0.8948	190.8	0.0	-1.0	47.5	72.2	1.1	1.9	34.2	-14.4	2.5
1989	0.9232	239.4	0.0	1.9	85.5	18.6	8.2	7.2	28.9	18.2	14.5
1990	0.9617	311.7	0.0	0.6	43.9	118.8	8.9	18.2	9.8	7.5	-0.2
1991	0.9861	297.9	0.9	3.1	146.3	146.3	2.9	8.7	12.5	40.8	3.0
1992	1.0000	276.1	3.3	3.2	302.7	66.6	4.3	16.7	21.0	17.9	-3.5
1993	1.0106	140.6	3.2	11.7	3.1	85.5	5.1	6.1	13.5	13.1	-0.4
1994	1.0458	174.5	2.9	27.9	67.1	102.6	1.4	56.6	17.9	26.1	4.7
1995	1.1162	158.7	3.8	25.9	68.1	166.9	2.6	12.7	15.6	25.5	2.8
1996	1.1662	193.9	2.9	13.6	84.1	152.8	24.1	37.1	12.7	36.6	2.7
1997	1.2119	222.1	2.9	14.7	93.5	161.1	24.1	37.1	12.7	36.6	2.7
1998	1.2219	211.2	2.9	4.8	3.9	81.8	24.1	37.1	12.7	36.6	2.7

Table C11: Nominal Investment in Buildings and Construction by Industry, \$m (cont.)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1950	0.1	0.7	0.1	9.2	0.0	2.7	3.8	2.2	8.5	2.2
1951	0.1	1.5	0.1	11.9	0.0	3.6	4.8	2.1	9.0	2.3
1952	0.3	1.7	0.1	14.0	0.0	5.3	6.9	2.4	9.5	2.4
1953	0.1	3.1	0.1	19.3	0.0	6.5	10.2	2.7	10.0	2.6
1954	-0.2	3.8	0.1	21.8	0.0	9.2	9.1	2.5	10.0	3.5
1955	0.2	4.3	0.3	20.3	0.0	15.0	11.0	2.8	10.0	4.4
1956	0.1	6.1	0.1	20.3	0.3	16.9	10.8	3.4	10.6	4.6
1957	0.1	3.6	0.3	26.5	0.9	17.2	15.8	4.1	11.4	4.9
1958	0.1	5.0	0.1	34.0	1.6	19.3	12.8	4.2	12.4	5.2
1959	0.2	4.5	0.3	33.2	2.5	19.2	15.3	4.2	13.4	5.5
1960	0.1	4.5	0.4	36.5	2.9	19.0	15.5	4.1	14.4	5.9
1961	0.2	7.4	0.5	36.7	4.0	20.7	16.6	4.2	15.3	7.2
1962	0.3	8.3	1.1	37.6	4.1	17.8	20.2	5.0	16.1	8.6
1963	0.3	7.2	0.6	36.1	3.4	20.9	16.7	6.5	17.0	10.3
1964	0.6	7.5	1.4	39.7	4.1	24.6	16.2	6.9	17.9	12.4
1965	0.5	8.5	0.7	48.7	3.9	24.6	15.1	7.0	18.9	14.9
1966	0.5	14.2	1.4	61.9	3.9	24.3	19.8	7.5	20.2	18.0
1967	0.3	13.4	1.1	76.7	4.3	26.8	14.4	7.3	24.9	18.6
1968	2.8	6.2	0.9	73.5	3.9	26.8	21.0	6.7	30.7	19.2
1969	4.3	4.4	0.6	74.2	3.3	26.0	20.1	5.7	37.8	19.8
1970	16.0	5.4	1.5	75.1	3.2	35.9	18.7	7.0	46.5	20.4
1971	5.1	9.8	1.1	78.5	3.0	43.8	23.7	8.3	57.3	7.9
1972	28.0	7.0	1.0	86.0	3.0	27.0	38.0	7.0	71.0	5.0
1973	2.0	13.0	1.0	105.0	3.0	33.0	33.0	7.0	89.0	6.0

Table C11: Nominal Investment in Buildings and Construction by Industry, \$m (cont.)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1974	3.0	14.0	1.0	105.0	6.0	43.0	38.0	9.0	122.0	7.0
1975	1.0	17.0	1.0	165.0	6.0	51.0	45.0	12.0	202.0	9.0
1976	0.0	13.0	-1.0	191.0	7.0	49.0	49.0	13.0	252.0	6.0
1977	10.0	15.0	1.0	173.0	8.0	58.0	56.0	13.0	227.0	9.0
1978	5.0	17.0	1.0	213.0	9.0	58.0	78.0	11.0	268.0	18.0
1979	4.0	12.0	1.0	261.0	9.0	62.0	68.0	15.0	254.0	12.0
1980	4.0	15.0	1.0	223.0	9.0	70.0	49.0	16.0	237.0	14.0
1981	5.0	12.0	0.0	250.0	13.0	77.0	47.0	13.0	219.0	15.0
1982	79.0	13.0	0.0	378.0	21.0	112.0	63.0	17.0	248.0	21.0
1983	114.0	14.0	1.0	490.0	20.0	139.0	81.0	90.0	329.0	31.0
1984	142.0	16.0	2.0	423.0	23.0	182.0	78.0	107.0	350.0	36.0
1985	114.0	29.0	3.0	404.0	19.0	201.0	99.0	118.0	556.0	45.0
1986	196.0	48.0	4.0	428.0	11.0	239.0	200.0	191.0	933.0	63.0
1987	1.8	31.1	3.9	0.0	25.3	198.1	13.6	0.2	1,248.4	71.8
1988	3.1	48.9	-0.2	0.0	42.5	107.2	28.6	1.1	2,014.9	92.4
1989	8.3	34.7	1.7	18.2	36.1	132.7	29.6	0.5	1,645.7	125.6
1990	2.3	22.4	1.0	16.9	3.5	200.0	28.0	0.3	1,275.3	103.7
1991	-5.9	20.4	1.1	15.8	23.4	285.9	15.0	172.2	525.0	149.7
1992	-0.4	24.2	0.9	7.0	8.6	184.1	49.7	387.6	320.5	133.6
1993	1.9	11.5	1.9	0.1	10.0	171.5	15.2	263.5	321.8	418.0
1994	2.2	11.8	-0.1	15.5	30.5	227.4	62.9	-35.2	618.9	171.4
1995	7.8	27.6	1.2	20.6	28.9	294.9	65.7	263.7	1,020.0	175.3
1996	5.1	27.4	0.6	25.0	34.2	164.7	56.8	345.0	1,819.9	89.2
1997	5.1	27.4	0.6	28.0	34.8	175.1	57.2	380.7	1,885.9	91.3
1998	5.1	27.4	0.6	-0.3	28.9	75.9	53.2	40.4	1,509.0	71.5

Table C12: Real Gross Plant and Equipment Capital Stocks by Industry, \$1992 mil

<i>March Year</i>	<i>Agriculture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>
1978	5,646	369	549	661	4,213	1,331	934	3,217	1,755	871
1979	5,946	411	543	667	4,457	1,369	962	3,292	1,788	872
1980	6,258	423	543	703	4,829	1,363	985	3,338	1,786	886
1981	6,559	426	545	707	5,177	1,377	992	3,407	2,096	922
1982	6,803	436	518	714	5,482	1,420	1,016	3,317	3,381	984
1983	7,096	455	488	740	5,767	1,444	1,039	3,394	4,488	999
1984	7,483	472	460	749	6,075	1,482	1,137	3,538	5,225	988
1985	7,540	494	430	783	6,237	1,519	1,250	3,597	5,797	959
1986	7,541	505	409	839	6,438	1,524	1,301	3,786	5,953	961
1987	7,385	512	380	860	6,658	1,527	1,361	3,986	6,106	974
1988	7,078	555	350	870	6,925	1,540	1,399	4,107	6,233	974
1989	6,888	576	325	868	7,065	1,516	1,419	4,281	6,305	984
1990	6,879	621	308	894	7,439	1,469	1,446	4,599	6,400	977
1991	6,659	664	308	1,015	7,517	1,445	1,465	4,619	6,447	997
1992	6,445	696	331	1,153	7,629	1,423	1,483	4,628	6,517	1,000
1993	6,112	746	330	1,164	7,902	1,400	1,538	4,448	7,037	984
1994	5,690	819	357	1,191	8,062	1,370	1,682	4,336	7,110	957
1995	5,243	884	430	1,168	8,297	1,353	1,794	4,409	7,350	946
1996	4,791	977	524	1,211	8,518	1,357	1,854	4,555	7,480	904
1997	4,288	1,061	623	1,258	8,880	1,356	1,910	4,880	7,675	942
1998	3,866	1,178	741	1,310	9,256	1,363	2,034	5,188	7,871	985

Table C12: Real Gross Plant Capital Stocks by Industry, \$1992 million (continued)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	1,068	2,184	224	6,875	3,658	7,949	9,756	2,673	3,268	2,563
1979	1,101	2,292	225	7,044	3,665	8,536	9,942	2,687	3,528	2,563
1980	1,144	2,368	222	7,183	3,666	9,029	10,079	2,739	3,760	2,546
1981	1,292	2,455	216	7,184	3,715	9,839	10,681	2,791	4,018	2,511
1982	1,559	2,571	205	7,031	3,694	10,245	10,911	2,828	4,169	2,437
1983	1,822	2,673	198	6,998	3,661	10,869	10,994	2,943	4,593	2,356
1984	2,010	2,801	190	6,894	3,605	11,832	11,223	3,055	5,414	2,358
1985	2,386	2,922	178	6,756	3,555	12,748	11,699	3,230	6,479	2,394
1986	2,646	3,091	171	6,683	3,510	13,297	11,710	3,456	7,128	2,375
1987	2,592	3,238	165	6,471	3,403	13,642	11,450	3,324	7,716	2,469
1988	2,526	3,457	159	6,264	3,315	14,292	11,077	3,169	8,229	2,583
1989	2,366	3,584	159	6,039	3,180	14,887	10,189	3,021	9,130	2,621
1990	2,417	3,654	156	5,801	3,025	15,662	9,660	2,908	9,513	2,692
1991	2,286	3,673	157	5,518	2,935	15,946	9,255	2,981	10,751	2,702
1992	2,232	3,595	152	5,271	2,883	15,876	8,781	3,132	11,302	2,773
1993	2,147	3,516	155	5,041	2,761	16,106	8,818	3,162	11,900	2,847
1994	2,181	3,524	151	4,853	2,709	16,313	9,534	2,689	13,972	3,078
1995	2,238	3,649	158	4,661	2,670	16,418	10,101	2,669	16,319	3,419
1996	2,267	3,767	163	4,505	2,827	16,729	10,682	3,386	18,087	3,763
1997	2,346	3,909	174	4,269	3,021	17,026	11,883	4,234	19,814	4,135
1998	2,443	4,126	184	4,122	3,265	17,510	12,687	5,123	21,504	4,578

Table C13: Real Gross Buildings Capital Stocks by Industry, \$1992 mil

<i>March Year</i>	<i>Agriculture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>
1978	28,144	3	773	2,781	4,280	1,134	1,072	2,008	1,079	620
1979	28,357	3	802	3,165	4,435	1,144	1,074	2,032	1,104	631
1980	28,686	2	825	3,341	4,609	1,148	1,078	2,049	1,167	639
1981	29,063	2	855	3,429	4,829	1,144	1,084	2,072	1,302	642
1982	29,494	4	884	3,456	5,036	1,132	1,092	2,093	1,611	649
1983	29,795	6	904	3,492	5,212	1,134	1,095	2,128	1,864	663
1984	30,081	9	928	3,593	5,380	1,139	1,093	2,184	2,147	675
1985	30,316	13	949	3,679	5,449	1,157	1,123	2,258	2,402	690
1986	30,373	20	964	3,780	5,504	1,177	1,162	2,322	2,531	698
1987	30,207	23	960	3,862	5,630	1,171	1,177	2,377	2,581	700
1988	30,021	23	950	3,893	5,687	1,161	1,171	2,408	2,559	699
1989	29,881	23	943	3,959	5,683	1,159	1,171	2,433	2,573	712
1990	29,806	23	935	3,973	5,783	1,158	1,182	2,437	2,575	708
1991	29,709	24	922	4,096	5,908	1,150	1,183	2,443	2,611	707
1992	29,585	27	913	4,381	5,951	1,144	1,191	2,458	2,624	700
1993	29,325	30	913	4,372	6,012	1,139	1,189	2,464	2,631	696
1994	29,093	33	931	4,430	6,086	1,129	1,235	2,475	2,650	697
1995	28,836	36	947	4,486	6,212	1,121	1,239	2,483	2,667	696
1996	28,603	39	950	4,552	6,320	1,131	1,262	2,487	2,693	695
1997	28,387	41	953	4,628	6,429	1,140	1,285	2,491	2,718	694
1998	28,160	44	945	4,625	6,457	1,091	1,288	2,485	2,741	684

Table C13: Real Gross Buildings Capital Stocks by Industry, \$1992 mil (continued)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	736	2,774	224	21,671	967	9,921	6,704	1,954	13,691	3,753
1979	750	2,799	226	22,489	987	10,020	6,931	2,005	14,507	3,770
1980	761	2,827	229	23,066	1,003	10,113	7,070	2,051	15,148	3,786
1981	772	2,840	228	23,584	1,023	10,183	7,176	2,081	15,614	3,796
1982	930	2,850	227	24,262	1,054	10,294	7,296	2,114	16,053	3,813
1983	1,134	2,859	228	25,063	1,090	10,430	7,436	2,275	16,587	3,843
1984	1,381	2,870	231	25,722	1,130	10,634	7,566	2,461	17,140	3,881
1985	1,566	2,901	235	26,297	1,161	10,847	7,721	2,651	17,985	3,929
1986	1,845	2,954	240	26,829	1,177	11,074	8,000	2,923	19,260	3,993
1987	1,846	2,976	244	26,749	1,208	11,204	8,011	2,922	20,735	4,056
1988	1,849	3,014	243	26,669	1,250	11,210	8,037	2,923	22,929	4,134
1989	1,857	3,036	244	26,609	1,274	11,240	8,063	2,922	24,654	4,245
1990	1,859	3,043	244	26,547	1,252	11,334	8,086	2,922	25,923	4,328
1991	1,852	3,047	245	26,484	1,237	11,511	8,095	3,048	26,397	4,454
1992	1,851	3,055	245	26,411	1,200	11,581	8,139	3,387	26,660	4,563
1993	1,853	3,051	246	26,331	1,148	11,637	8,148	3,595	26,921	4,951
1994	1,854	3,046	245	26,266	1,115	11,741	8,202	3,516	27,456	5,090
1995	1,860	3,054	246	26,205	1,090	11,891	8,255	3,703	28,312	5,222
1996	1,864	3,062	245	26,147	1,059	11,919	8,298	3,941	29,815	5,273
1997	1,868	3,068	245	26,090	1,033	11,981	8,339	4,188	31,313	5,323
1998	1,870	3,056	243	26,010	1,003	11,934	8,376	4,153	32,341	5,356

Table C14: Real Net Plant and Equipment Capital Stocks by Industry, \$1992 mil

<i>March Year</i>	<i>Agriculture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>
1978	4,873	293	468	517	3,361	1,036	818	2,474	1,345	650
1979	5,095	325	463	524	3,537	1,059	829	2,493	1,364	649
1980	5,310	327	465	529	3,845	1,062	839	2,517	1,369	650
1981	5,568	322	468	536	4,117	1,069	828	2,560	1,675	698
1982	5,738	325	447	547	4,329	1,105	842	2,618	2,952	742
1983	5,922	339	429	578	4,503	1,129	849	2,651	3,973	745
1984	6,172	351	415	625	4,726	1,167	935	2,743	4,583	758
1985	6,063	370	396	702	4,846	1,209	1,035	2,807	5,005	763
1986	5,951	379	386	765	4,977	1,205	1,076	2,975	5,017	769
1987	5,833	387	375	768	5,101	1,199	1,109	3,121	4,992	773
1988	5,690	433	371	767	5,321	1,206	1,118	3,176	4,913	764
1989	5,618	457	358	753	5,394	1,199	1,117	3,342	4,805	765
1990	5,625	507	350	779	5,737	1,187	1,126	3,597	4,722	767
1991	5,543	555	362	910	5,778	1,175	1,125	3,579	4,598	789
1992	5,516	575	387	1,037	5,855	1,153	1,141	3,749	4,525	785
1993	5,214	617	395	1,019	6,086	1,143	1,204	3,689	4,939	785
1994	4,955	678	430	998	6,333	1,151	1,383	3,735	4,879	782
1995	4,725	725	484	953	6,601	1,177	1,511	3,795	5,020	803
1996	4,511	807	557	974	6,831	1,195	1,580	3,997	5,049	824
1997	4,316	893	633	1,000	7,089	1,217	1,657	4,217	5,097	849
1998	4,143	988	716	1,033	7,398	1,246	1,746	4,470	5,175	879

Table C14: Real Net Plant Capital Stocks by Industry, \$1992 million (continued)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	757	1,694	155	4,771	3,129	6,954	8,163	2,059	2,440	1,916
1979	755	1,770	154	4,872	3,141	7,373	8,085	2,051	2,584	1,905
1980	763	1,828	152	4,937	3,190	7,681	8,101	2,106	2,701	1,897
1981	878	1,922	149	4,908	3,281	8,059	8,464	2,160	2,857	1,893
1982	1,110	2,026	146	4,793	3,270	8,350	8,570	2,195	2,922	1,871
1983	1,331	2,124	149	4,790	3,250	8,724	8,483	2,308	3,284	1,870
1984	1,466	2,270	149	4,737	3,224	9,479	8,496	2,415	4,050	1,973
1985	1,782	2,418	149	4,633	3,218	10,213	8,847	2,578	5,058	2,118
1986	1,963	2,511	151	4,578	3,191	10,668	8,940	2,770	5,638	2,232
1987	1,889	2,579	152	4,352	3,168	11,012	8,780	2,619	6,158	2,288
1988	1,862	2,684	153	4,136	3,158	11,713	8,607	2,481	6,592	2,372
1989	1,851	2,684	160	3,931	3,098	12,351	8,126	2,350	7,416	2,403
1990	1,821	2,702	156	3,742	3,002	13,193	8,278	2,236	7,671	2,481
1991	1,783	2,699	155	3,571	2,945	13,389	8,194	2,356	8,702	2,551
1992	1,732	2,643	154	3,415	2,850	13,058	8,089	2,585	8,935	2,592
1993	1,570	2,622	154	3,258	2,760	12,939	8,566	2,746	9,206	2,645
1994	1,554	2,700	152	3,125	2,784	12,945	9,178	2,302	10,971	2,806
1995	1,571	2,883	160	2,987	2,865	13,095	9,687	2,314	12,876	3,081
1996	1,611	3,029	167	2,884	3,041	13,356	10,526	3,077	14,122	3,343
1997	1,657	3,187	175	2,789	3,231	13,676	11,695	3,860	15,162	3,621
1998	1,715	3,371	185	2,705	3,451	14,101	12,203	4,703	16,399	3,933

Table C15: Real Net Buildings Capital Stocks by Industry, \$1992 mil

<i>March Year</i>	<i>Agriculture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>
1978	26,213	5	699	2,602	3,707	954	910	1,600	918	518
1979	26,301	5	720	2,908	3,807	954	901	1,597	929	520
1980	26,503	5	734	2,997	3,924	948	893	1,587	977	521
1981	26,750	4	754	3,016	4,084	935	889	1,582	1,098	517
1982	27,045	6	773	2,972	4,228	913	886	1,576	1,389	516
1983	27,204	8	783	2,936	4,337	907	878	1,584	1,618	523
1984	27,345	11	796	2,956	4,437	903	866	1,613	1,872	528
1985	27,432	16	805	2,959	4,435	913	885	1,658	2,093	534
1986	27,341	23	810	2,976	4,419	924	913	1,694	2,183	534
1987	27,027	25	794	2,977	4,475	908	918	1,719	2,192	529
1988	26,699	25	773	2,931	4,460	890	900	1,721	2,129	521
1989	26,425	24	756	2,926	4,385	880	889	1,715	2,104	525
1990	26,220	24	738	2,874	4,416	871	889	1,689	2,067	514
1991	25,998	24	722	2,926	4,470	855	879	1,666	2,064	506
1992	25,754	27	707	3,132	4,441	841	877	1,651	2,038	492
1993	25,378	29	701	3,030	4,432	828	864	1,629	2,008	481
1994	25,037	31	710	2,993	4,435	812	900	1,612	1,990	475
1995	24,679	34	716	2,955	4,491	797	892	1,592	1,970	467
1996	24,352	36	710	2,928	4,526	801	905	1,569	1,960	460
1997	24,048	37	704	2,908	4,563	804	916	1,546	1,948	452
1998	23,740	38	690	2,814	4,533	806	927	1,523	1,937	445

Table C15: Real Net Buildings Capital Stocks by Industry, \$1992 mil (continued)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	638	2,311	182	19,452	807	8,894	5,354	1,440	12,162	3,236
1979	638	2,303	181	20,072	813	8,914	5,481	1,456	12,777	3,216
1980	636	2,298	180	20,442	814	8,926	5,516	1,467	13,204	3,197
1981	635	2,278	176	20,748	820	8,916	5,518	1,461	13,447	3,172
1982	780	2,255	173	21,209	836	8,947	5,534	1,459	13,658	3,154
1983	968	2,232	171	21,786	846	9,002	5,569	1,584	13,958	3,151
1984	1,195	2,213	171	22,214	860	9,124	5,594	1,731	14,272	3,154
1985	1,355	2,213	172	22,552	864	9,252	5,642	1,879	14,871	3,167
1986	1,606	2,234	174	22,841	852	9,392	5,815	2,105	15,887	3,198
1987	1,574	2,225	175	22,515	857	9,431	5,716	2,053	17,081	3,225
1988	1,544	2,232	171	22,193	878	9,346	5,633	2,003	18,969	3,268
1989	1,520	2,222	169	21,896	889	9,287	5,553	1,953	20,349	3,342
1990	1,490	2,198	167	21,601	865	9,293	5,471	1,905	21,242	3,387
1991	1,452	2,172	164	21,308	862	9,381	5,376	2,032	21,322	3,475
1992	1,421	2,150	162	21,011	844	9,361	5,319	2,368	21,189	3,543
1993	1,393	2,116	160	20,711	827	9,327	5,227	2,570	21,057	3,890
1994	1,365	2,082	157	20,429	830	9,342	5,183	2,472	21,200	3,980
1995	1,343	2,062	154	20,156	830	9,403	5,138	2,646	21,663	4,062
1996	1,319	2,042	152	19,890	834	9,340	5,084	2,876	22,763	4,062
1997	1,295	2,021	149	19,629	836	9,281	5,030	3,118	23,835	4,061
1998	1,272	2,001	146	19,348	834	9,142	4,972	3,074	24,562	4,043

Table C16: Gross Plant and Equipment User Costs by Industry, \$ million

<i>March Year</i>	<i>Agricul- ture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non- metallic minerals</i>
1978	300	18	31	35	210	66	47	161	88	43
1979	346	22	34	39	243	75	52	179	97	48
1980	411	26	39	46	297	84	60	205	110	54
1981	476	29	43	51	348	92	67	229	141	62
1982	566	34	47	59	423	110	78	256	261	76
1983	644	38	48	67	487	122	88	287	379	84
1984	787	47	52	79	603	147	113	351	518	98
1985	894	55	55	93	699	170	140	403	649	107
1986	961	61	56	107	772	183	156	454	713	115
1987	1,013	66	56	118	863	198	176	516	791	126
1988	956	71	51	117	883	196	178	524	795	124
1989	975	78	49	123	953	205	191	577	851	133
1990	1,009	87	48	131	1,042	206	202	644	896	137
1991	968	92	48	147	1,040	200	203	639	892	138
1992	941	97	51	168	1,060	198	206	643	905	139
1993	935	109	54	178	1,150	204	224	648	1,024	143
1994	939	130	62	197	1,278	217	267	688	1,127	152
1995	863	140	74	192	1,315	214	284	699	1,165	150
1996	773	152	89	195	1,327	211	289	710	1,166	141
1997	651	156	99	191	1,303	199	280	716	1,126	138
1998	546	161	109	185	1,267	186	278	710	1,077	135

Table C16: Gross Plant and Equipment User Costs by Industry, \$ million (continued)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	53	109	11	343	203	422	529	137	177	136
1979	60	125	12	384	224	497	593	151	210	149
1980	70	145	14	441	253	593	677	173	253	167
1981	87	165	14	482	285	714	796	194	299	182
1982	120	198	16	542	324	852	931	225	356	203
1983	154	226	17	591	350	987	1,023	257	427	214
1984	199	278	19	684	396	1,244	1,205	311	581	248
1985	267	327	20	757	440	1,511	1,415	371	783	284
1986	317	370	20	801	469	1,695	1,526	425	929	303
1987	336	420	21	839	488	1,872	1,603	441	1,080	339
1988	322	441	20	799	468	1,930	1,526	414	1,134	349
1989	319	483	21	815	468	2,108	1,469	416	1,316	371
1990	338	512	22	812	461	2,297	1,441	415	1,419	395
1991	316	508	22	764	443	2,317	1,369	421	1,590	393
1992	310	499	21	732	438	2,318	1,306	444	1,680	405
1993	313	512	23	734	439	2,464	1,373	470	1,853	436
1994	346	559	24	770	462	2,693	1,598	434	2,342	508
1995	355	578	25	739	453	2,701	1,686	430	2,723	563
1996	353	587	25	702	469	2,698	1,746	535	2,956	607
1997	344	574	26	626	472	2,584	1,827	630	3,047	628
1998	334	565	25	564	473	2,471	1,812	710	3,072	646

Table C17: Gross Buildings and Construction User Costs by Industry, \$ million

<i>March Year</i>	<i>Agriculture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>
1978	838	0	23	85	128	34	32	60	32	18
1979	902	0	26	104	141	36	34	65	35	20
1980	1,071	0	31	128	172	43	40	77	44	24
1981	1,189	0	35	146	198	47	44	85	53	26
1982	1,478	0	45	180	253	57	55	105	81	33
1983	1,733	0	53	210	304	66	64	124	109	39
1984	2,064	1	64	252	369	78	75	150	147	46
1985	2,275	1	71	281	409	87	84	170	180	52
1986	2,452	2	78	312	445	95	94	188	205	56
1987	2,976	2	95	388	555	115	116	234	254	69
1988	3,245	3	103	429	615	126	127	261	277	76
1989	3,657	3	116	491	696	142	143	298	315	87
1990	3,894	3	122	525	756	151	154	318	337	93
1991	3,884	3	121	543	773	150	155	320	342	93
1992	3,861	4	120	580	777	149	156	321	343	91
1993	3,887	4	121	588	797	151	158	327	349	92
1994	4,423	5	142	679	926	172	188	376	403	106
1995	4,836	6	159	758	1,042	188	208	416	447	117
1996	5,202	7	173	833	1,150	206	230	452	490	126
1997	5,412	8	182	887	1,226	217	245	475	518	132
1998	5,618	9	189	927	1,288	218	257	496	547	137

Table C17: Gross Buildings and Construction User Costs by Industry, \$ million (cont.)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	22	83	7	644	29	296	200	59	408	112
1979	24	89	7	713	32	319	220	64	462	120
1980	28	106	9	859	38	378	264	77	566	141
1981	32	116	9	960	43	418	294	86	640	155
1982	47	143	11	1,210	54	517	366	107	806	191
1983	66	167	13	1,452	65	608	432	133	966	223
1984	95	197	16	1,762	79	730	519	170	1,177	266
1985	118	218	18	1,971	88	815	579	200	1,351	295
1986	149	239	19	2,161	97	895	646	237	1,556	322
1987	182	293	24	2,631	121	1,105	789	289	2,044	399
1988	200	326	26	2,878	137	1,213	869	317	2,480	447
1989	227	372	30	3,254	157	1,376	987	359	3,018	519
1990	243	398	32	3,466	165	1,482	1,056	383	3,388	565
1991	242	399	32	3,460	163	1,506	1,058	400	3,453	582
1992	242	399	32	3,444	158	1,513	1,062	443	3,481	595
1993	246	405	33	3,488	154	1,544	1,080	478	3,570	656
1994	282	463	37	3,992	171	1,786	1,247	535	4,175	774
1995	312	512	41	4,394	184	1,995	1,385	622	4,749	876
1996	339	557	45	4,755	193	2,168	1,509	718	5,423	959
1997	356	585	47	4,973	198	2,285	1,590	799	5,971	1,015
1998	373	610	49	5,188	201	2,381	1,671	829	6,453	1,068

Table C18: Net Plant and Equipment User Costs by Industry, \$ million

<i>March Year</i>	<i>Agriculture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>
1978	324	18	33	34	208	64	51	153	83	40
1979	373	22	37	38	241	72	57	170	93	44
1980	441	25	42	44	298	82	65	195	106	50
1981	511	27	47	49	350	91	70	218	142	59
1982	605	32	51	58	423	108	82	256	289	73
1983	686	37	54	67	485	122	92	286	428	80
1984	836	45	60	85	600	148	119	348	582	96
1985	926	53	65	107	695	173	148	403	718	109
1986	978	58	68	126	766	185	165	458	772	118
1987	1,041	65	72	137	855	201	186	523	836	130
1988	1,003	72	70	135	881	200	185	526	813	127
1989	1,046	80	71	140	948	211	196	588	845	134
1990	1,087	93	72	151	1,049	217	206	658	864	140
1991	1,063	100	74	175	1,047	213	204	649	833	143
1992	1,067	105	80	201	1,070	211	208	685	827	143
1993	1,061	119	85	207	1,170	220	231	709	949	151
1994	1,096	143	101	221	1,332	242	291	785	1,026	164
1995	1,047	153	113	211	1,392	248	319	801	1,059	169
1996	983	168	128	212	1,420	248	329	831	1,050	171
1997	894	177	138	207	1,403	241	328	835	1,009	168
1998	801	183	145	200	1,369	231	323	827	958	163

Table C18: Net Plant and Equipment User Costs by Industry, \$ million (continued)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	47	105	10	296	218	462	554	132	166	127
1979	52	121	10	332	241	540	606	145	194	140
1980	59	142	12	382	278	638	688	168	229	158
1981	75	163	13	417	317	739	796	190	269	174
1982	109	198	14	469	363	880	925	222	315	197
1983	143	229	16	516	395	1,010	1,005	257	389	217
1984	186	288	19	602	456	1,284	1,174	316	560	267
1985	256	347	21	665	513	1,560	1,379	381	789	324
1986	302	386	23	704	548	1,753	1,500	439	946	367
1987	317	432	25	729	590	1,964	1,598	451	1,121	408
1988	308	444	25	685	581	2,064	1,547	423	1,185	418
1989	325	472	28	691	599	2,299	1,540	424	1,406	447
1990	333	494	29	684	603	2,550	1,629	419	1,509	479
1991	323	489	28	647	587	2,568	1,600	438	1,700	489
1992	316	483	28	624	573	2,526	1,594	485	1,761	502
1993	302	504	30	626	584	2,632	1,774	541	1,907	538
1994	327	568	32	657	638	2,864	2,064	495	2,467	621
1995	331	608	34	630	656	2,901	2,180	499	2,898	682
1996	335	630	35	600	684	2,910	2,328	653	3,124	728
1997	328	631	35	552	691	2,834	2,459	780	3,188	750
1998	317	624	34	500	688	2,726	2,393	888	3,216	760

Table C19: Net Buildings and Construction User Costs by Industry, \$ million

<i>March Year</i>	<i>Agricul- ture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non- metallic minerals</i>
1978	879	0	24	95	125	32	31	54	31	18
1979	955	0	27	116	139	35	33	59	34	19
1980	1,139	0	33	141	170	41	39	69	42	23
1981	1,277	0	37	159	197	45	43	76	53	25
1982	1,582	0	47	192	250	54	52	93	82	30
1983	1,853	1	55	219	298	62	60	109	111	36
1984	2,189	1	66	257	358	73	70	130	151	43
1985	2,401	1	73	280	391	81	78	146	185	47
1986	2,588	2	79	306	422	88	87	162	208	51
1987	3,143	3	95	374	524	106	108	201	257	62
1988	3,426	3	102	407	577	115	116	222	275	67
1989	3,843	4	113	457	642	129	130	251	308	77
1990	4,078	4	118	478	691	136	139	264	324	80
1991	4,062	4	116	490	703	135	138	262	325	80
1992	4,041	4	114	527	702	133	139	261	322	78
1993	4,061	5	115	520	714	133	139	263	323	77
1994	4,613	6	134	587	822	151	167	299	369	88
1995	5,040	7	150	640	922	164	183	327	405	96
1996	5,411	8	161	688	1,011	179	202	350	438	103
1997	5,672	9	170	724	1,082	191	217	367	462	107
1998	5,882	10	174	735	1,129	201	231	379	482	111

Table C19: Net Buildings and Construction User Costs by Industry, \$ mil (continued)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery manufacturing</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	22	78	6	627	29	302	180	50	412	108
1979	23	84	7	699	32	328	199	55	468	116
1980	28	100	8	843	38	388	237	65	573	136
1981	31	110	9	946	43	432	264	73	649	150
1982	46	133	10	1,186	53	530	324	89	807	183
1983	67	153	12	1,422	62	621	379	112	960	213
1984	96	179	14	1,715	74	738	448	143	1,152	251
1985	120	195	15	1,905	81	819	494	170	1,312	275
1986	153	213	17	2,082	87	899	551	206	1,516	300
1987	184	261	21	2,527	107	1,109	665	246	2,002	373
1988	200	289	22	2,748	120	1,212	723	265	2,453	416
1989	223	325	25	3,085	137	1,364	808	292	2,980	483
1990	233	344	26	3,258	143	1,459	851	304	3,326	524
1991	228	342	26	3,226	143	1,479	840	326	3,354	540
1992	225	340	26	3,193	141	1,483	835	382	3,348	552
1993	224	341	26	3,212	140	1,507	837	422	3,393	619
1994	253	386	29	3,661	161	1,735	955	466	3,930	729
1995	276	424	32	4,009	178	1,936	1,049	553	4,450	825
1996	295	456	34	4,310	194	2,091	1,130	653	5,086	898
1997	307	479	35	4,518	207	2,205	1,186	751	5,652	953
1998	317	498	36	4,684	216	2,281	1,232	777	6,117	997

Table C20: Net Plant User Costs with Industry Specific Real Interest Rate, \$ million

<i>March Year</i>	<i>Agriculture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>
1978	304	30	32	35	181	69	25	129	41	57
1979	341	32	36	30	244	68	52	121	90	58
1980	497	42	57	29	203	101	64	155	139	59
1981	515	42	58	34	310	101	75	166	107	73
1982	527	57	44	40	356	145	95	191	170	127
1983	506	67	38	68	513	157	72	217	258	134
1984	612	77	43	53	716	143	125	228	308	159
1985	756	102	72	91	836	151	170	393	444	157
1986	733	143	107	136	773	158	184	367	600	134
1987	683	178	118	120	972	209	172	373	847	123
1988	748	184	91	109	1,092	173	127	500	606	106
1989	769	212	161	116	1,244	132	141	478	675	120
1990	816	201	174	161	1,322	166	153	581	751	120
1991	718	189	203	214	1,372	180	135	616	544	125
1992	808	189	269	249	1,425	173	149	651	530	115
1993	763	216	346	255	1,450	168	211	613	609	126
1994	816	211	506	254	1,597	191	226	624	723	165
1995	726	218	435	218	1,647	166	307	724	927	197
1996	688	240	471	213	1,744	139	304	711	941	198
1997	676	228	474	233	1,698	170	314	668	869	209
1998	617	239	497	221	1,813	144	313	636	793	212

Table C20: Net Plant User Costs with Industry Specific Real Interest, \$ mil (cont'd)

<i>March Year</i>	<i>Basic metals</i>	<i>Machinery</i>	<i>Other manufacturing</i>	<i>Elect. gas, water</i>	<i>Construction</i>	<i>Trade, rest'rant hotels</i>	<i>Transport & storage</i>	<i>Communications</i>	<i>Finance services</i>	<i>Community services</i>
1978	40	155	11	119	311	872	249	71	259	152
1979	36	152	11	136	292	1,031	271	92	304	178
1980	52	199	9	189	277	1,024	292	108	332	195
1981	51	204	13	204	353	1,398	296	132	378	216
1982	65	355	21	220	530	1,697	346	135	469	241
1983	107	364	16	246	601	2,040	407	233	564	271
1984	115	446	21	272	700	2,613	594	300	810	314
1985	136	544	30	287	839	2,680	710	319	1,127	383
1986	113	538	43	344	948	3,056	744	325	1,388	466
1987	94	597	33	357	1,056	3,210	871	580	1,648	458
1988	34	577	31	319	1,076	2,937	853	624	1,772	567
1989	5	581	38	333	1,068	3,355	970	570	1,923	622
1990	104	662	37	343	1,193	3,148	1,092	588	2,006	655
1991	71	569	36	324	956	3,667	1,058	691	2,168	688
1992	106	578	30	323	662	2,987	1,196	842	2,229	750
1993	218	655	36	327	685	3,310	1,288	795	2,325	830
1994	208	778	38	328	831	3,874	1,483	726	2,793	889
1995	159	860	42	308	993	4,118	1,652	770	3,167	955
1996	161	825	36	297	1,320	4,205	1,838	991	3,176	1,038
1997	160	910	38	269	1,289	3,978	1,950	1,123	3,159	1,094
1998	172	924	45	241	1,247	3,839	1,847	1,283	3,138	1,062

Table C21: Net Buildings User Costs with Industry Specific Real Interest Rate, \$ mil

<i>March Year</i>	<i>Agriculture</i>	<i>Fishing and hunting</i>	<i>Forestry</i>	<i>Mining</i>	<i>Food, beverage tobacco</i>	<i>Textiles</i>	<i>Wood & wood products</i>	<i>Paper & paper products</i>	<i>Chemical</i>	<i>Non-metallic minerals</i>
1978	808	0	23	99	105	35	11	43	12	27
1979	840	0	27	84	142	33	29	37	32	27
1980	1,337	0	50	81	103	52	38	51	59	27
1981	1,292	0	52	99	168	52	46	53	37	33
1982	1,301	1	37	121	200	77	63	63	40	59
1983	1,186	1	33	223	319	85	45	77	56	66
1984	1,412	2	40	139	442	69	74	76	65	77
1985	1,821	3	85	231	488	68	92	142	99	72
1986	1,724	6	142	335	427	72	99	122	152	60
1987	1,718	9	182	319	612	112	98	132	261	59
1988	2,282	9	144	314	743	96	73	210	191	54
1989	2,532	11	305	362	880	72	86	195	235	67
1990	2,778	9	340	517	904	98	96	228	274	66
1991	2,366	8	388	621	962	109	83	247	191	68
1992	2,777	8	480	678	979	105	91	246	184	60
1993	2,595	9	588	661	917	96	124	220	186	62
1994	3,128	9	844	691	1,014	113	124	227	242	89
1995	3,113	11	703	663	1,118	100	175	290	346	114
1996	3,402	12	719	693	1,278	88	184	292	385	121
1997	3,965	12	699	828	1,345	126	207	282	388	137
1998	4,227	13	711	823	1,549	114	223	279	387	149

Table C21: Net Buildings User Costs with Industry Specific Real Interest, \$ mil (cont.)

<i>March Year</i>	<i>Basic metals</i>	<i>Machin- ery</i>	<i>Other manufac- turing</i>	<i>Elect. gas, water</i>	<i>Const- ruction</i>	<i>Trade, rest'rant hotels</i>	<i>Trans- port & storage</i>	<i>Com- muni- cations</i>	<i>Finance services</i>	<i>Com- munity services</i>
1978	17	124	8	141	46	659	43	22	728	136
1979	14	112	7	157	41	728	45	30	836	160
1980	24	150	5	284	38	703	47	36	926	181
1981	18	145	8	298	49	961	26	45	1,024	202
1982	23	266	17	345	86	1,202	35	45	1,361	240
1983	45	266	11	439	105	1,475	61	98	1,562	287
1984	52	298	15	511	124	1,738	148	134	1,843	309
1985	52	330	23	524	147	1,584	170	136	2,065	342
1986	36	315	33	709	169	1,780	171	140	2,479	410
1987	28	381	28	887	215	2,023	256	332	3,262	434
1988	-16	393	28	881	252	1,878	285	418	4,076	613
1989	-38	415	36	1,095	273	2,161	414	412	4,415	727
1990	43	482	35	1,242	318	1,892	483	450	4,747	772
1991	17	408	35	1,219	256	2,285	465	551	4,562	824
1992	46	420	28	1,274	168	1,828	559	720	4,512	909
1993	151	462	32	1,299	171	2,001	534	659	4,364	1,054
1994	146	554	35	1,425	222	2,498	610	723	4,591	1,128
1995	108	627	40	1,529	290	2,939	725	904	4,974	1,239
1996	118	620	35	1,698	414	3,232	829	1,046	5,192	1,374
1997	125	724	39	1,741	424	3,294	878	1,135	5,588	1,495
1998	150	773	50	1,793	427	3,410	881	1,177	5,933	1,483

APPENDIX D: MEASURING CAPITAL INPUTS

D1 The Relationship between Asset Prices, Depreciation and Rental Prices

Consider a new durable input that is purchased at the beginning of a period at the price P_0 . At this same point in time, older vintages of this same input can be purchased at the price P_t for a unit of the asset that is t years old, for $t=1,2,\dots$. Generally speaking, these vintage asset prices decline as the age of the asset increases. This sequence of vintage asset prices at a particular point in time,

$$(1) \quad P_0, P_1, \dots, P_t, \dots$$

is called the *asset price profile* of the durable input.

Depreciation for a unit of a new asset, D_0 , is defined as the difference in the price of a new asset and an asset that is one year old, $P_0 - P_1$. In general, *depreciation* for an asset that is t years old is defined as

$$(2) \quad D_t = P_t - P_{t+1} \quad ; t = 0,1,2,\dots$$

Given the asset price profile, the profile of depreciation allowances, D_t , can be calculated using equations (2). Conversely, given the sequence of depreciation allowances, the asset price profile can be calculated using the following equations:

$$(3) \quad P_t = D_t + D_{t+1} + D_{t+2} + \dots \quad ; t = 0,1,2,\dots$$

In addition to the asset price sequence $\{P_t\}$ and the depreciation sequence $\{D_t\}$, there is a sequence of rental payments to the vintage assets or the sequence of *vintage user costs*, $\{U_t\}$, that an asset of age t can earn during the current period, $t = 0,1,2,\dots$. If the real after tax interest rate in the current period is r , then economic theory suggests that the price of a new asset, P_0 , should be equal to the rental for a new asset, U_0 , plus the discounted stream of rentals or user costs that older vintage assets can earn. In general, the price of an age t asset, P_t , should be approximately equal to:

$$(4) \quad P_t = U_t + (1+r)^{-1}U_{t+1} + (1+r)^{-2}U_{t+2} + \dots \quad ; t = 0,1,2,\dots$$

Equations (4) can be manipulated (use the equations for t and $t+1$) to give us a formula for U_t in terms of the asset prices:

$$(5) \quad P_t = U_t + (1+r)^{-1}P_{t+1} \quad ; t = 0,1,2,\dots$$

Equations (5) then yield the following formula for the user cost of a t year old asset:

$$(6) \quad U_t = P_t - (1+r)^{-1}P_{t+1} \quad ; t = 0,1,2,\dots$$

The interpretation of (6) is clear: the net cost of buying an asset that is t years old and using it for one period and then selling it at the end of the period is equal to its purchase price P_t less the discounted end of the period price for the asset when it is one year older, $(1+r)^{-1}P_{t+1}$. User cost formulae similar to (6) date back to the economist Walras (1954, p.269) and the engineer Green (1915). In more recent times, user cost formulae adjusted for income taxes have been derived by Jorgenson (1963; 1989) and by Hall and Jorgenson (1967). A simple method for deriving these tax adjusted user costs may be found in Diewert (1980, p.471; 1992a, p.194).

The above equations show that the sequence of vintage asset prices $\{P_t\}$, the sequence of vintage depreciation allowances $\{D_t\}$, and the sequence of vintage rental prices or user costs $\{U_t\}$, *cannot be specified independently*; given any one of these sequences, the other two sequences are completely determined. This is an important point since capital stock researchers usually specify a pattern of depreciation rates and *these alternative depreciation assumptions completely determine the sequence of vintage specific rental prices which should be used as weights when aggregating across vintages to form an aggregate capital stock component*.

In what follows, we consider three alternative patterns of depreciation: declining balance or exponential depreciation (the amount of depreciation for each vintage is assumed to be a constant fraction of the depreciated asset value at the beginning of the period); 'one hoss shay' depreciation (or 'light bulb' depreciation) where the efficiency of the asset is assumed to be constant until it reaches the end of its life when it completely collapses; and, straight line depreciation where the amount of depreciation is assumed to be a constant amount for each vintage until the asset reaches the end of its life.

D2 The Declining Balance Depreciation Model

In terms of the sequence of vintage asset prices, this model can be specified as follows:

$$(7) \quad P_t = (1-\delta)^t P_0 \quad ; t = 1,2,\dots,$$

where δ is a positive number between 0 and 1 (the constant depreciation rate). Thus from (7), we see that the vintage asset price declines geometrically as the asset ages. If we substitute (7) into (2), we see that:

$$(8) \quad D_t = [1 - (1-\delta)](1-\delta)^t P_0 = \delta(1-\delta)^t P_0 = \delta P_t \quad ; t = 0,1,2, \dots;$$

ie, depreciation for a t year old asset is equal to the constant depreciation rate δ times the vintage asset price at the start of the period, P_t . Note that the second equality in (8) tells us that D_t declines geometrically as t increases.

Substituting (7) into (6) yields the following sequence of vintage rental prices:

$$(9) \quad U_t = (1-\delta)^t P_0 - (1+r)^{-1}(1-\delta)^{t+1}P_0 = (1-\delta)^t(1+r)^{-1}[r + \delta] P_0 \quad ; t = 0,1,2,\dots$$

Thus, the rental price for a new asset is (set $t = 0$ in the above equation):

$$(10) \quad U_0 = (1+r)^{-1}[r + \delta] P_0.$$

Now substitute (10) into (9) and we find that the rental price for a t year old asset is a geometrically declining fraction of the rental price for a new asset:

$$(11) \quad U_t = (1-\delta)^t U_0 \quad ; t = 1,2,\dots$$

The above equations imply that the vintage specific asset rental prices *vary in fixed proportion over time*. This means that we can apply Hicks' (1946, pp.312–313) Aggregation Theorem to aggregate the capital stock components across vintages. (Hicks formulated his aggregation theorem in the context of consumer theory but his arguments can be adapted to the producer context). If I_0 is the new investment in the asset in the current period and I_t is the vintage investment in the asset that occurred t periods ago for $t = 1,2,\dots$, then the current period value of the particular capital stock component under consideration, aggregated over all vintages is:

$$(12) \quad U_0 I_0 + U_1 I_1 + \dots = U_0 [I_0 + (1-\delta) I_1 + (1-\delta)^2 I_2 + \dots].$$

Thus (12) gives us the value of capital services over all vintages of the capital stock component under consideration. It can be seen that this value flow can be decomposed into a price term U_0 which is the user cost for a new unit of the durable input, times an aggregated over vintages capital stock K defined as:

$$(13) \quad K = I_0 + (1-\delta) I_1 + (1-\delta)^2 I_2 + \dots$$

This is the standard *net capital stock model* that has been used extensively by Jorgenson and his associates; see Jorgenson (1963; 1983; 1984) Jorgenson and Griliches (1967; 1972) and Christensen and Jorgenson (1969).

Note that we do not have to use a superlative index number formula to aggregate over vintages in this model since the user costs of the vintages will vary in strict proportion over time and we can apply Hicks' Aggregation Theorem.

D3 The Gross Capital Model

In this model, it is assumed that the efficiency of the asset remains constant over its life of, say, N years and then the asset becomes worthless. This means that the rental price for the asset remains *constant* over its useful life; ie, we make the following assumption:

$$(14) \quad U_t = U_0 \quad \text{for } t = 1,2, \dots, N-1 \quad \text{and} \quad U_t = 0 \quad \text{for } t = N, N+1, N+2, \dots$$

We need a formula for the user cost of a new unit of the asset, U_0 . Substituting (14) into equation (4) when $t = 0$ yields:

$$(15) \quad P_0 = U_0 + (1+r)^{-1}U_0 + (1+r)^{-2}U_0 + \dots + (1+r)^{-N+1}U_0 \\ = U_0(1+r)^{-1} [1 - (1+r)^{-N}].$$

Now use (15) to solve for U_0 in terms of P_0 :

$$(16) \quad U_0 = P_0 r (1+r)^{-1} [1 - (1+r)^{-N}]^{-1}.$$

The capital aggregate in this model is simply the sum of the current period investment I_0 plus the vintage investments going back $N-1$ periods:

$$(17) \quad K = I_0 + I_1 + \dots + I_{N-1}.$$

The corresponding price for this capital aggregate is U_0 defined by (16). Because the rental price is constant across vintages, we can again apply Hicks' Aggregation Theorem to aggregate across vintages; ie, we do not have to use a superlative index number formula to aggregate over vintages in this model since the user costs of the vintages will vary in strict proportion over time. This is the standard *gross capital stock model* that is used by the OECD and many other researchers. The only point that is not generally known is that there is a definite rental price that can be associated with this gross capital stock and the corresponding quantity aggregate is consistent with Hicks' Aggregation Theorem.

For comparison purposes, it may be useful to have explicit formulae for the profile of vintage asset prices P_t and the vintage depreciation amounts D_t . In terms of U_0 , these formulae are:

$$(18) \quad P_t = U_0(1+r)^{-1} [1 - (1+r)^{-(N-t)}] \text{ for } t = 0, 1, 2, \dots, N-1 \text{ and } P_t = 0 \text{ for } t = N, N+1, \dots \text{ and}$$

$$(19) \quad D_t = U_0(1+r)^{1-N+t} \text{ for } t = 0, 1, 2, \dots, N-1 \text{ and } D_t = 0 \text{ for } t = N, N+1, \dots$$

Of course, P_t declines as t increases (for t less than N) but D_t *increases* as t increases (for t less than N), which is quite different from the pattern of depreciation in the declining balance model where depreciation *decreases* as t increases.

In table D1 below, we list the gross capital user costs U_0 for the real interest rates r equal to 0.02, 0.04, 0.06 and 0.08 and for asset lives N equal to 5, 10, 15, 20 and 30 years, assuming that P_0 is 1.

Table D1: Gross Capital Stock User Costs by r And N

	$N=5$	$N=10$	$N=15$	$N=20$	$N=30$
$r = 0.02$	0.2080	0.1091	0.0763	0.0600	0.0438
$r = 0.04$	0.2160	0.1185	0.0865	0.0708	0.0556
$r = 0.06$	0.2240	0.1282	0.0971	0.0823	0.0685
$r = 0.08$	0.2319	0.1380	0.1082	0.0943	0.0822

It is very important to use the above gross capital stock user costs as price weights when aggregating over different components of a gross capital stock in order to form an aggregate flow of services that can be attributed to the capital stock in any period. Many researchers who construct gross capital stocks for productivity measurement purposes use formula (17) above to construct gross capital stock components but then when they construct an overall capital aggregate, *they use the stock prices P_0 as price weights instead of the user costs U_0 defined by (16)*. This will typically lead to an aggregate capital stock which grows too slowly since structures (which usually grow more slowly than machinery and equipment components) are given an inappropriately large weight when stock prices are used in place of user costs as price weights.

D3 The Straight Line Depreciation Model

In this model of depreciation, the depreciation for an asset which is t years old is set equal to a constant fraction of the value of a new asset P_0 over the life of the asset; ie, we have

$$(20) \quad D_t = (1/N) P_0 \quad \text{for } t = 0, 1, 2, \dots, N-1 \quad \text{and } D_t = 0 \quad \text{for } t = N, N+1, N+2, \dots$$

where N is the useful life of a new asset. Using (3) and (20), we can deduce that the sequence of vintage asset prices is:

$$(21) \quad P_t = [1 - t/N]P_0 \quad \text{for } t = 0, 1, 2, \dots, N-1 \quad \text{and } P_t = 0 \quad \text{for } t = N, N+1, N+2, \dots$$

Using (6) and (21), we can calculate the sequence of vintage user costs:

$$(22) \quad U_t = [1 - t/N]P_0 - (1+r)^{-1} [1 - (t+1)/N]P_0 \quad \text{for } t = 0, 1, \dots, N-1 \quad \text{and } U_t = 0 \quad \text{for } t = N, N+1, \dots$$

$$(23) \quad = (1+r)^{-1} [r + N^{-1} - tN^{-1}r]P_0 \quad \text{for } t = 0, 1, \dots, N-1.$$

Recall that in the declining balance model, depreciation *decreased* as the asset aged (see (8) above) and in the gross capital stock model, depreciation *increased* as the asset aged (see (19) above). In the present model, depreciation is *constant* over the useful life of the asset. Also recall that in the declining balance model, the vintage asset prices *decreased* as the asset aged (see (7) above) and in the gross capital stock model, the vintage asset prices also *decreased* as the asset aged (see (18) above). In the present model, the vintage asset prices also *decrease* over the useful life of the asset (see (21) above). Finally, recall that in the declining balance model, the vintage rental prices *decreased* as the asset aged (see (11) above) and in the gross capital stock model, the vintage rental prices *remained constant* as the asset aged (see (14) above). In the present model, the vintage asset prices also *decrease* over the useful life of the asset (see (23) above); ie, U_t decreases from $(1+r)^{-1}[r + (1/N)]P_0$ when $t = 0$ to $(1/N)P_0$ when $t = N-1$.

How can we empirically distinguish between the three depreciation models? We know of only two methods for doing this: (a) engineering studies and (b) regression models which utilise profiles of used asset prices; eg, see Hulten and Wykoff (1981). In practice, it is difficult to distinguish between the declining balance and straight line models of depreciation since their price and depreciation profiles are qualitatively similar.

We now encounter a problem with the straight line depreciation model that we did not encounter with our first two models: the rental prices of the vintage capital stock components *will no longer vary in strict proportion over time unless the real interest rate r is constant over time*. Thus, in order to form a capital services aggregate over the different vintages of capital, we can no longer appeal to Hicks' Aggregation Theorem to form the aggregate using minimal assumptions on the degree of substitutability between the different vintages.

The aggregate value of capital services over vintages is:

$$(24) \quad U_0 I_0 + U_1 I_1 + \dots + U_{N-1} I_{N-1} = (1+r)^{-1} [r + (1/N)] P_0 I_0 + \dots + (1/N) P_0 I_{N-1} .$$

It can be seen that the price of a new unit of the capital stock, P_0 , is a common factor in all of the terms on the right hand side of (24); this follows from the fact that P_0 is a common factor in all of the user costs U_t defined by (23). Thus we could set the price of the aggregate equal to P_0 and define the corresponding capital services aggregate as the right hand side of (24) divided by P_0 . However, to justify this procedure, we have to assume that each vintage of the capital aggregate is a perfect substitute for every other vintage with efficiency weights proportional to the user costs of each vintage. The problem with this assumption is if the real interest rate is not constant, then we are implicitly assuming that efficiency factors are changing over time in accordance with real interest rate changes. This is a standard assumption in capital theory *but it is not necessary to make this restrictive assumption*. Instead, we can use standard index number theory and use a superlative index number formula (see Diewert (1976; 1978)) to aggregate the N vintage capital stock components: in each period, the quantities are I_0, I_1, \dots, I_{N-1} and the corresponding prices are the user costs U_0, U_1, \dots, U_{N-1} defined by (23). If we use the Fisher ideal index, then this formula is consistent with the vintage specific assets being perfect substitutes but the formula is also consistent with more flexible aggregator functions.

In Table D2 below, we list the straight line user costs U_t for the real interest rates r equal to 0.02, 0.04, 0.06 and 0.08 and for asset lives N equal to 5, 10, 15, 20 and 30 years, assuming that P_0 is 1.

We conclude by noting that there was no need to use an index number formula in the first two depreciation models considered above since under the assumptions of these models, the vintage rental prices will vary in strict proportion over time. Thus, if we did use an index

number formula that satisfied the proportionality test, then the resulting aggregates would be the same as the aggregates that were exhibited in sections D2 and D3 above. Most models of depreciation do not have vintage rental prices that vary in strict proportion over time so those two models are rather special. More complicated (but more flexible) models of depreciation are considered in Hulten and Wykoff (1981).

Table D2: Straight Line Depreciation User Costs U_t by r , t and N

Age	$r = 0.02$	$r = 0.04$	$r = 0.06$	$r = 0.08$
Case 1: $N=5$				
0	0.2157	0.2308	0.2453	0.2593
1	0.2118	0.2231	0.2340	0.2444
2	0.2078	0.2154	0.2226	0.2296
3	0.2039	0.2077	0.2113	0.2148
4	0.2000	0.2000	0.2000	0.2000
Case 2: $N=10$				
0	0.1176	0.1346	0.1509	0.1667
1	0.1157	0.1308	0.1453	0.1593
2	0.1137	0.1269	0.1396	0.1519
3	0.1118	0.1231	0.1340	0.1444
4	0.1098	0.1192	0.1283	0.1370
5	0.1078	0.1154	0.1226	0.1296
6	0.1059	0.1115	0.1170	0.1222
7	0.1039	0.1077	0.1113	0.1148
8	0.1020	0.1038	0.1057	0.1074
9	0.1000	0.1000	0.1000	0.1000
Case 3: $N=15$				
0	0.0850	0.1026	0.1195	0.1358
1	0.0837	0.1000	0.1157	0.1309
2	0.0824	0.0974	0.1120	0.1259
3	0.0810	0.0949	0.1082	0.1210
4	0.0797	0.0923	0.1044	0.1160
5	0.0784	0.0897	0.1006	0.1111
6	0.0771	0.0872	0.0969	0.1062
7	0.0758	0.0846	0.0931	0.1012
8	0.0745	0.0821	0.0893	0.0963
9	0.0732	0.0795	0.0855	0.0914
10	0.0719	0.0769	0.0818	0.0864
11	0.0706	0.0744	0.0780	0.0815
12	0.0693	0.0718	0.0742	0.0765
13	0.0680	0.0692	0.0704	0.0716
14	0.0667	0.0667	0.0667	0.0667

Table D2: Straight Line Depreciation User Costs U_t by r , t and N (continued)

Age	$r=0.02$	$r=0.04$	$r=0.06$	$r=0.08$
Case 4: $N=20$				
0	0.0686	0.0865	0.1038	0.1204
1	0.0676	0.0846	0.1009	0.1167
2	0.0667	0.0827	0.0981	0.1130
3	0.0657	0.0808	0.0953	0.1093
4	0.0647	0.0788	0.0925	0.1056
5	0.0637	0.0769	0.0896	0.1019
6	0.0627	0.0750	0.0868	0.0981
7	0.0618	0.0731	0.0840	0.0944
8	0.0608	0.0712	0.0811	0.0907
9	0.0598	0.0692	0.0783	0.0870
10	0.0588	0.0673	0.0755	0.0833
11	0.0578	0.0654	0.0726	0.0796
12	0.0569	0.0635	0.0698	0.0759
13	0.0559	0.0615	0.0670	0.0722
14	0.0549	0.0596	0.0642	0.0685
15	0.0539	0.0577	0.0613	0.0648
16	0.0529	0.0558	0.0585	0.0611
17	0.0520	0.0538	0.0557	0.0574
18	0.0510	0.0519	0.0528	0.0537
19	0.0500	0.0500	0.0500	0.0500
Case 5: $N=30$				
0	0.0523	0.0705	0.0881	0.1049
1	0.0516	0.0692	0.0862	0.1025
2	0.0510	0.0679	0.0843	0.1000
3	0.0503	0.0667	0.0824	0.0975
4	0.0497	0.0654	0.0805	0.0951
5	0.0490	0.0641	0.0786	0.0926
6	0.0484	0.0628	0.0767	0.0901
7	0.0477	0.0615	0.0748	0.0877
8	0.0471	0.0603	0.0730	0.0852
9	0.0464	0.0590	0.0711	0.0827
10	0.0458	0.0577	0.0692	0.0802
11	0.0451	0.0564	0.0673	0.0778
12	0.0444	0.0551	0.0654	0.0753
13	0.0438	0.0538	0.0635	0.0728
14	0.0431	0.0526	0.0616	0.0704
15	0.0425	0.0513	0.0597	0.0679
16	0.0418	0.0500	0.0579	0.0654
17	0.0412	0.0487	0.0560	0.0630
18	0.0405	0.0474	0.0541	0.0605
19	0.0399	0.0462	0.0522	0.0580
20	0.0392	0.0449	0.0503	0.0556
21	0.0386	0.0436	0.0484	0.0531
22	0.0379	0.0423	0.0465	0.0506
23	0.0373	0.0410	0.0447	0.0481
24	0.0366	0.0397	0.0428	0.0457
25	0.0359	0.0385	0.0409	0.0432
26	0.0353	0.0372	0.0390	0.0407
27	0.0346	0.0359	0.0371	0.0383
28	0.0340	0.0346	0.0352	0.0358
29	0.0333	0.0333	0.0333	0.0333

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