Productivity in New Zealand 1988 to 2002

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New Zealand Treasury
03/06

June 2003

THE TREASURY
Kaitohutohu Kaupapa Rawa

Treasury:495502v4

NZ TREASURY WORKING PAPER 03/06

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MONTH/YEAR

June 2003

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ACKNOWLEDGEMENTS

We would like to thank Bob Buckle, Kevin Fox, John Janssen, Denis Lawrence, Peter Mawson and Grant Scobie for helpful discussion and suggestions in the initial stages of this research project. We would also like to thank Ken Fletcher, John Morris and Nick Treadgold from Statistics New Zealand for invaluable discussions and the provision of data. We are grateful to Nargis Bharucha, Mark Blackmore, Bob Buckle, Ken Carlaw, Iris Claus, John Creedy, Paul Dalziel, John Janssen, Struan Little, Peter Mawson, Grant Scobie, Kam Szeto and Bruce White for helpful comments on an earlier draft of this paper. Comments from participants at seminars held at Statistics New Zealand, the New Zealand Treasury and the Reserve Bank of New Zealand are greatly acknowledged.

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Abstract

This paper reports new aggregate and industry productivity series for the New Zealand economy for the period 1988 to 2002. These productivity series are intended for ongoing monitoring of New Zealand's productivity performance and for use in further analyses investigating the evolution, sources and determinants of New Zealand's productivity growth. Productivity series are constructed using index number techniques and industry data sourced from Statistics New Zealand. Throughout, comparisons are made with the productivity estimates reported in Diewert and Lawrence's (1999), *Measuring New Zealand's Productivity.* Industry data are also used to construct productivity series that are comparable with the market sector productivity series published by the Australian Bureau of Statistics. The comparison between Australia and New Zealand shows that market sector multifactor productivity has been similar in both countries over the full sample period. Since 1994 average labour productivity growth has been higher in Australia, which reflects the relatively lower rate of physical capital accumulation in New Zealand after 1993. On the other hand, New Zealand's capital productivity growth has been higher than Australia's capital productivity growth since 1994, reflecting the relatively higher growth in hours worked in New Zealand.

JEL CLASSIFICATION C43 – Index numbers and aggregation; O47 – Measurement of economic growth; aggregate productivity; economic growth and aggregate productivity

KEYWORDS Economic growth; productivity measurement; index numbers; Australia and New Zealand comparison

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Productivity in New Zealand 1988 to 2002

1 Introduction

Productivity growth is inextricably linked to economic growth and increases in welfare. As most of the difference in cross-country per capita GDP growth is due to differences in multifactor productivity growth rather than input accumulation (Easterly and Levine, 2002), understanding the evolution and determinants of New Zealand's productivity is important.

The aims of this paper are to provide aggregate and industry productivity series for the market sector of the New Zealand economy, to give an initial analysis of these series, and to compare the productivity performance of Australia and New Zealand. Furthermore, these series are intended as a basis for ongoing monitoring of New Zealand's productivity performance and for use in further analyses investigating the evolution, sources and determinants of New Zealand's productivity growth.

There are a number of approaches to measuring productivity. This paper produces annual aggregate and industry productivity series for the market sector of the New Zealand economy for the period 1988 to 2002, using index number techniques and industry data sourced from Statistics New Zealand (SNZ). Throughout, this paper draws on the techniques from Diewert and Lawrence (1999); the last major study that examined New Zealand's productivity performance using index number techniques.

The remainder of this paper is structured as follows. Section 2 discusses the index number methodology and the choice of an index number formula. Data sources and construction are discussed in Section 3. Section 4 reports aggregate and industry productivity series and compares these with Diewert and Lawrence (1999) productivity series. Section 4 also discusses some of the limitations of the industry data used in productivity calculations. A comparison of Australia and New Zealand's productivity performance is provided in Section 5. Section 6 summarises key conclusions and suggests several avenues for further work.

2 Index number methodology

This paper uses the index number approach to measure aggregate and industry productivity.[1] Construction of aggregate and industry productivity series using index number techniques is common internationally, especially by statistical agencies. For example, the Australian Bureau of Statistics (ABS) publishes productivity series for the Australian economy using the index number approach. What follows is a brief introduction to productivity measurement using the index number methodology. A more detailed review of the index number approach to productivity measurement is available in McLellan (2003).

In general, a productivity index is defined as the ratio of an output index to an input index, that is:

$$A^t = \frac{Q^t}{I^t};\ t = 0,...,T \qquad (1)$$

where A^t is a productivity index, Q^t is an output index and I^t is an input index. Each index represents accumulated growth from period 0 to period t.

When I^t is comprised of a single type of input, say labour or capital, A^t is a partial productivity index. The two most common partial productivity measures are labour productivity and capital productivity. Labour and capital productivity indexes measure changes in the ability of the labour and capital inputs, respectively, to produce output over time. Caution should be exercised when using partial productivity measures as changes in the mix of inputs can influence these measures. For example, substitution of physical capital for labour, owing to a relative change in the price of labour to physical capital, may raise labour productivity. In this case, "…labour productivity statistics do not always represent true changes in the underlying productivity of labour…" (Dixon, 1990, p. 6).

When I^t is a composite index of two or more inputs, A^t is a multifactor productivity index. Most often I^t is formed using labour and capital inputs, although researchers have also included other inputs, such as land, in addition to labour and physical capital inputs.[2] This paper presents a suite of productivity measures, including labour and capital productivity. However, owing to limitations with the partial productivity measures, more emphasis is given to multifactor productivity series throughout this paper.

Calculating productivity at the aggregate and industry level requires the construction of both output and input indices. Because outputs and inputs are heterogenous it is not possible to simply add all the outputs to get an output index and, likewise, to add all the inputs to get an input index. Both outputs and inputs need to be weighted to form aggregate and sub-aggregate output and input indices. Output prices and input costs are often used as respective weights to form output and input indices.

[1] Alternative approaches to measuring productivity include the growth accounting, econometric, and other non-parametric methods (eg, the distance function based approach). A survey of alternative approaches to productivity measurement is provided in Mawson, Carlaw and McLellan(2003).

[2] Multifactor productivity and total factor productivity are often used interchangeably. Strictly speaking, total factor productivity is measured by dividing an output index by a composite input index that is formed using *all* inputs in the production process. Rarely is this the case, hence the preference for the terminology multifactor productivity.

When constructing productivity indices, it is not immediately apparent which weighting procedure should be used to form output and input series and on what basis this weighting procedure should be chosen. There is a multiplicity of index number formulae available to users when constructing output and input indices. Some of the better known indexes include the Laspeyres, Paasche, Fisher and Törnqvist.

Suppose information on the price and quantity of I outputs is available for period $t = 0,...,T$. Denoting the price and quantity vectors in period t as $p^t \equiv (p_1^t,...,p_I^t)$ and $q^t \equiv (q_1^t,...,q_I^t)$, the Laspeyres (L^t), Paasche (P^t), Fisher (F^t) and Törnqvist (T^t) quantity indexes are defined as follows:

$$L^t = \frac{\sum_i p_i^0 q_i^t}{\sum_i p_i^0 q_i^0} \qquad (2)$$

$$P^t = \frac{\sum_i p_i^t q_i^t}{\sum_i p_i^t q_i^0} \qquad (3)$$

$$F^t = (L^t P^t)^{\frac{1}{2}} \qquad (4)$$

$$T^t = \prod_i \left(\frac{q_i^t}{q_i^0}\right)^{\frac{1}{2}(w_i^0 + w_i^t)} \qquad (5)$$

for $t = 0,...,T$ and $i = 1,...,I$, and where $w_i^t = \frac{p_i^t q_i^t}{\sum_i p_i^t q_i^t}$.

There are two approaches to choosing an index number formula: the economic approach and the axiomatic approach. The economic approach bases the choice of an index number formula on an assumed underlying aggregator function (ie, production, cost, revenue or profit function). This approach assumes competitive optimising behaviour and embodies production technology. For example, firms are assumed to maximise profit for a given production technology. The axiomatic (or test) approach bases the choice of an index number formula on properties the index should exhibit, with these properties being embodied in axioms. One of the appealing features of this approach is that it does not make any assumptions about competitive optimising behaviour. A strong case can be made in favour of using the Törnqvist and Fisher index formulae as both possess properties that are desired under the economic and axiomatic approaches.[3]

[3] The United Nations' System of National Accounts (United Nations Inter-Secretariat Working Group on National Accounts, 1993, paragraphs 16.51 and 16.52) has recommended the use of the Fisher or Törnqvist indexes. However, they also noted that the choice of index formula becomes less important when chaining is employed, as the spread between series constructed using the various index formula is reduced (a point discussed in more detail later in this section), and that the data requirements are greater for the Fisher and Törnqvist indexes than the Paasche and Laspeyres indexes. Diewert (1992) concluded there were strong economic justifications for using the Törnqvist or Fisher indexes in productivity analysis, but that the Törnqvist index does not pass all the axiomatic tests the Fisher index passes.

In addition to deciding on an index formula, a decision needs to be made whether to construct direct or chained productivity indices. A direct quantity index compares quantities in period t relative to some fixed base period (which is why a direct index is also known as fixed-weight index or a fixed-base index). Information on price movements and therefore weighting changes in the intervening period is ignored. In contrast, a chained quantity index compares quantities between two periods taking into account information on weighting changes in the intervening period. Put another way, a chained index uses price information that is more representative of that faced by economic agents in each period than does a direct index.

When relative prices change, relative quantities also tend to change. For example, if the price of a particular good rises relative to all other goods in the economy due to a demand increase, then price taking producers will tend to produce more of this good relative to other goods. Using a direct quantity index to measure quantity changes in the face of relative price changes will introduce substitution bias into the quantity index. Biases arise because changes in producer behaviour in response to relative price changes are not taken into account when using direct indexes. Moreover, the substitution bias usually becomes cumulatively larger with the passage of time, as historical fixed-weights become increasingly unrepresentative. Chaining direct indexes usually reduces substitution bias.

The chained quantity index is formed by linking direct quantity indexes. Generally, a chained index is constructed as follows:

$$C^{0,t} = 1 \times D^{0,1} \times D^{1,2} \times \ldots \times D^{t-1,t}\,; \quad t = 0,...,T \qquad (6)$$

where $C^{0,t}$ denotes the chained index between time 0 and time t and $D^{t-1,t}$ the direct index. Chaining can be applied to any of the index number formulae outlined in equations (2) to (5). One of the consequences of chaining is that it usually reduces the index number spread (the range between the Laspeyres and Paasche indices).[4] The one situation where it is inappropriate to adopt chaining is when price and quantities exhibit large fluctuations. In this situation, the chained index and counterpart direct index will diverge and the index number spread will be accentuated.

As discussed, under either the axiomatic or economic approaches, a strong case can be made for using either the Fisher or Törnqvist indexes. This paper uses the Fisher index to construct market sector and industry productivity series to provide methodological continuity with Diewert and Lawrence (1999), who also used the Fisher index when constructing productivity series for New Zealand. Furthermore, chaining is also employed throughout. Nonetheless, the paper also constructs productivity series using alternative indexes to test the sensitivity of New Zealand productivity series to different index number formulae.

[4] This is why the United Nations' System of National Accounts (United Nations Inter-Secretariat Working Group on National Accounts, 1993, paragraphs 16.48 and 16.51) has recommended the adoption of chaining where practically possible, because the index number spread is reduced and therefore the choice of index formula becomes less important.

3 Data

To form aggregate and industry productivity series for the market sector of the New Zealand economy, data are needed on the values and volumes of output, labour and capital. Appendix 1 documents the data sources and describes how data have been transformed for use in constructing productivity series. Appendix Table 1 shows which industries are included in the markets sector of the New Zealand economy. What follows is a brief discussion of the data used in producing productivity series for the New Zealand economy.

In 2000, Statistics New Zealand introduced an upgraded set of National Accounts based on the System of National Accounts 1993 (SNA93) accounting standards; re-benchmarked using the 1995/96 Inter-Industry Study; introduced the Australia and New Zealand System of Industrial Classification (ANZSIC); and introduced productive capital stock series intended for use in New Zealand productivity studies. Changes in the upgraded national accounts were backdated to 1987. The introduction of upgraded national accounts has aided considerably in constructing productivity series for the New Zealand economy, especially with the introduction of official productive capital stock series and improvements in the accuracy of the GDP accounts.

Data on the values and volumes of output, labour and capital were sourced from Statistics New Zealand. Annual industry nominal and volume GDP were drawn from the industry income and production GDP accounts. Annual industry hours worked data were obtained from Statistics New Zealand's Household Labour Force Survey (HLFS), and industry capital stock data were sourced from Statistics New Zealand's productive capital stock series. Industry labour and capital cost series were constructed using industry compensation of employees and operating surplus data taken from Statistics New Zealand's income GDP accounts. Industry compensation of employees data were also adjusted to account for sole proprietors' labour income being classified as operating surplus in the System of National Accounts.

This paper measures productivity in the market sector of the New Zealand economy (which was around 85% of GDP in the year to March 2002). Industries excluded from the market sector are: Central government administration and defence; Local government services; and Ownership of owner occupied dwellings. The level of industry disaggregation for which market sector productivity series can be constructed is determined by the industry hours worked data.[5] Compared with the production and income GDP accounts and the capital stock data, ANZSIC industry hours worked data are constructed at a more aggregate level. Therefore, even though data on production and income GDP (compensation of employees and operating surplus) and the capital stock are available for 31 industries (ie, at the two digit industry level), hours worked data are only available for a more aggregated nine industries (ie, at the one digit industry level). This made it necessary to form one digit industry level aggregate industry output and capital series using data on production and income GDP and the capital stock at the two digit level in order to approximate the ANZSIC industry hours worked level of industry disaggregation as closely as possible.

[5] The hours worked data do not include a market/non-market split so the Personal and community services sector includes some non-market areas.

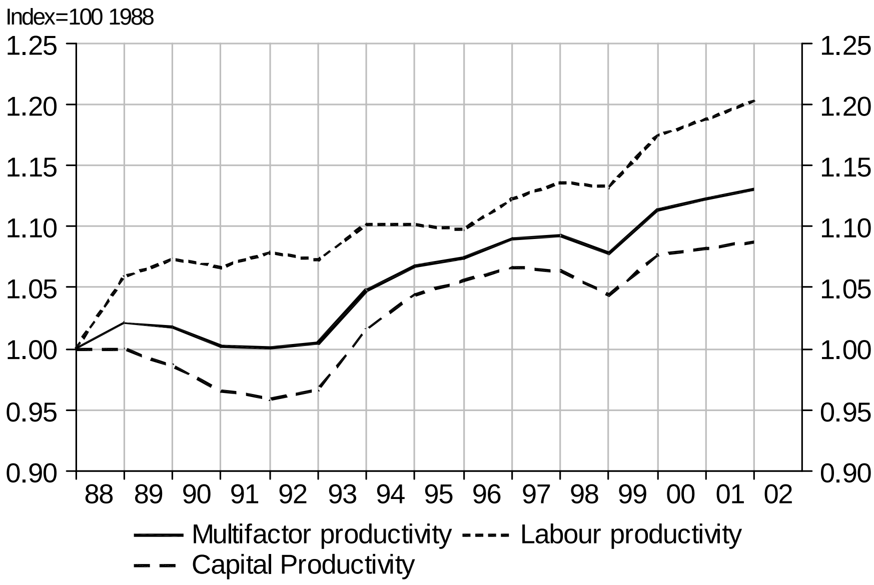
4 New Zealand's productivity performance

4.1 Aggregate productivity

Figure 1 presents partial and multifactor productivity estimates for the market sector of the New Zealand economy. The productivity series used in Figure 1 are also reported in Appendix 2. The output index used in forming each of the productivity series is a chained Fisher output index that has been constructed using industry volume GDP and implicit prices as elemental series. The input index used in forming the multifactor productivity series is a chained Fisher input index that has been constructed using industry hours worked, capital stock, and labour and capital cost data as elemental series. The corresponding chained Fisher input index for the labour productivity series was constructed using industry hours worked and labour cost data. The chained Fisher input index for the capital productivity series was formed using industry capital stock and capital cost data.

The productivity series shown in Figure 1 represent accumulated growth from 1988. The percentage difference in productivity between two years is found by taking the ratio of the index value at the last year to the index value at the first year and then subtracting 1.[6]

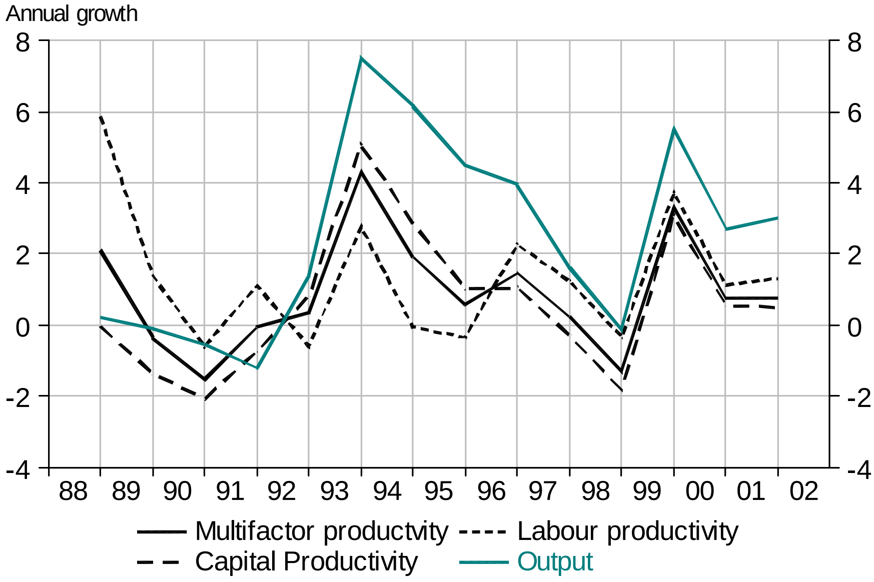
Figure 1 – Multifactor and partial productivity estimates



Changes in input utilisation arising from business cycle fluctuations are reflected in productivity estimates. Although during slack periods some labour is usually shed, workers that are retained or do not have their hours reduced are often underutilised. Underutilisation of the capital stock tends to be relatively greater, because the capital stock cannot be shed as easily as labour. For this reason, annual productivity growth is usually strongly positively correlated with annual output growth (see Figure 2).

[6] For example, the percentage difference in multifactor productivity between 1988 and 2002 is equal to 13.09% ((1.1309/1)-1=0.1309); and the percentage difference in labour productivity between 1993 and 2002 is equal to 12.57% (1.1825/1.0519-1=0.1257) (see Appendix 2 for multifactor productivity series).

Figure 2 – Annual output and productivity growth



One way of accounting for changes in input utilisation arising from business cycle fluctuations is to calculate average productivity growth between two consecutive cyclical peaks or troughs in the level of activity. Providing input utilisation rates are the same at consecutive cyclical peaks or troughs, this is a valid method to account for changes in input utilisation and gives a measure of trend productivity growth over the *classical cycle*. Alternatively, trend productivity growth can be measured over the *growth cycle*. This is done by measuring average growth rates between three consecutive points at which the economy is deemed to be on trend. On-trend points can be identified in one of two ways. First, a variety of survey based measures of input utilisation can be used to judge when the economy is on-trend. Second, statistical filters can be used to measure the economy's trend level of output and on-trend points identified where the trend level of output and actual output are equal.

The period covered by these productivity series is relatively short and consequently there are few business cycles over which to compare trend productivity growth. The annual output series for the market sector suggests that peaks in the level of economic activity occur in 1989 and 1997 and troughs in the level of economic activity occur in 1990 and 1998. McLellan (2001) also argued that cyclical peaks and troughs in the level of economic activity in New Zealand occurred in these years based on the Haugh (2001) aggregate production GDP series. In addition, Downing, Janssen, McLellan and Szeto (2002), who used the Quarterly Survey of Business Opinion (QSBO) to identify growth cycles for the New Zealand economy, suggested a growth cycle between 1993 and 1999.

Table 1 panel I reports trend productivity growth over the classical cycles identified by McLellan (2001) and the growth cycles identified by Downing et al (2002). The geometric average growth rate has been used to calculate trend productivity growth.

Table 1 – Trend annual productivity growth

Time period	Multifactor productivity	Labour productivity	Capital productivity
I. Business Cycles			
Classical cycles			
Peak to peak: 1989 to 1997	0.82%	0.73%	0.81%
Trough to trough: 1990 to 1998	0.90%	0.72%	0.95%
Growth cycles			
1993 to 1999	1.19%	0.91%	1.29%
II. Growth pre- and post-1993			
1988 to 1993	0.09%	1.41%	-0.68%
1993 to 2002	1.32%	1.29%	1.32%
1988 to 2002	0.88%	1.33%	0.60%

Between 1989 and 1997 trend growth in multifactor productivity was 0.82% per annum. Trend capital productivity growth was almost identical to trend multifactor productivity growth, and labour productivity growth was somewhat weaker at 0.73% per annum. Trend multifactor and capital productivity growth measured from the trough in 1990 to the trough in 1998 were slightly higher than trend growth measured from the peak in 1989 to the peak in 1997. Trend labour productivity growth was essentially the same whether measured from peak to peak or from trough to trough.

The trend growth estimates for multifactor productivity, labour productivity and capital productivity measured over the growth cycle identified by Downing et al (2002) are 1.19% per annum, 0.91% per annum, and 1.29% per annum, respectively. These trend productivity growth estimates are higher than those obtained for the classical cycle, whether measured from consecutive cyclical peaks or consecutive cyclical troughs.

Figure 1 indicates there may have been a change in New Zealand's multifactor and capital productivity growth around 1993, with these series showing an upward trend after 1993 in contrast to the period before 1993. This is also evident from Table 1, panel II, which shows an increase in average multifactor and capital productivity growth in the period 1993 to 2002, compared to the period 1988 to 1993. However, it is difficult to conclude that there has been a structural improvement in New Zealand's multifactor productivity growth given the short time period covered by the data. Formal time-series tests for structural breaks in New Zealand's productivity will require productivity data that cover a longer period.[7]

Nonetheless, some recent research using longer time series has suggested the New Zealand economy experienced a structural break in the early 1990s. For example, Razzak (2002) argued that trend labour productivity growth during the 1990s was different than in the previous two decades. Similarly, Buckle, Haugh and Thompson (2002) found evidence of a significant change in New Zealand's GDP growth characteristics dating back to 1993.

[7] Mawson (2002), in the context of measuring economic growth in New Zealand, pointed out that average growth rates can be quite sensitive to the time period chosen. This is also the case for New Zealand productivity series. For example, if average New Zealand market sector multifactor productivity growth is measured from 1994 to 2002 rather than 1993 to 2002, average growth is 0.35% per annum lower. A longer New Zealand productivity time series would allow comparison of productivity growth between different business cycles.

4.1.1 Sensitivity analysis to alternative index number formulae

Section 2 argued there were good justifications on both economic and axiomatic grounds for using the Fisher index to calculate productivity series. However, to give an idea of the sensitivity of New Zealand productivity series to alternative index number formulae, this section presents multifactor productivity series using alternative index number formulae. Alternative multifactor productivity series are also shown in Figure 3. Average growth rates for the alternative productivity series for the period 1988 to 2002 and the sub-periods 1988 to 1993 and 1993 to 2002 are presented in Table 2.[8]

Figure 3 – Comparison of multifactor productivity using alternative index formulae

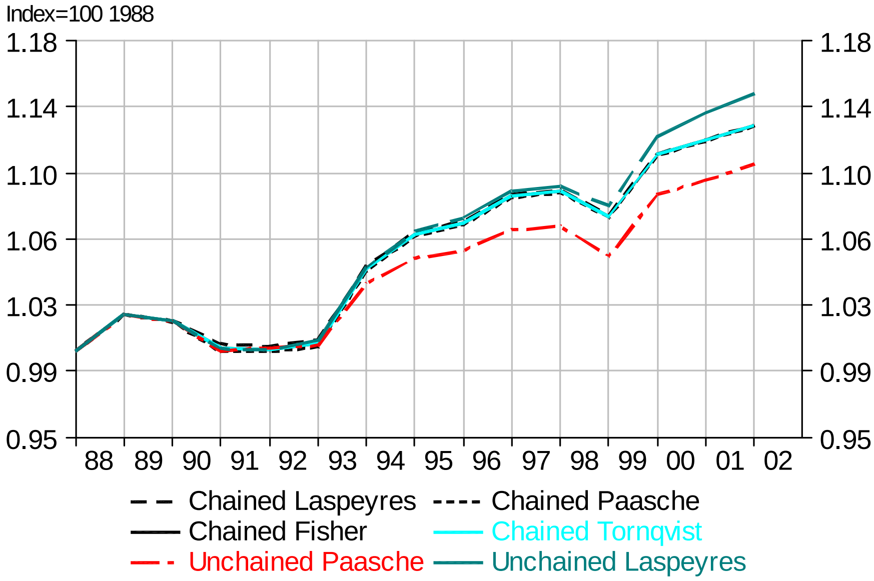


Table 2 – Alternative index formulae multifactor productivity series: average growth rates

March Year	Chained Fisher	Chained Törnqvist	Chained Laspeyres	Chained Paasche	Unchained Laspeyres	Unchained Paasche
1988 to 1993	0.09%	0.09%	0.13%	0.05%	0.12%	0.06%
1993 to 2002	1.32%	1.32%	1.30%	1.34%	1.50%	1.12%
1988 to 2002	0.88%	0.88%	0.88%	0.88%	1.00%	0.74%

Figure 3 shows that the chained Fisher and Törnqvist indices are almost identical. This is consistent with other studies, which have found little difference between Fisher and Törnqvist indices, and illustrates that these two indexes are approximations for each other. In addition, the chained Laspeyres and Paasche multifactor productivity series are also very similar to the Fisher and Törnqvist multifactor productivity series. Overall, New Zealand market sector multifactor productivity series appear to be relatively insensitive to the choice of index number formulae when productivity series are chained.

Chaining appears to be quite important when measuring market sector productivity in New Zealand. Figure 3 shows a marked increase in the index number spread when comparing unchained Laspeyres and unchained Paasche multifactor productivity series. The unchained Paasche series is similar to the chained Paasche series up to 1993, but diverges thereafter. The unchained Laspeyres series is similar to the Fisher and

[8] Productivity series used in Figure 3 and underlying the average growth rates reported in Table 2 are available in Appendix 2.

Törnqvist series, but appears to diverge from 1999. The range of estimates for average multifactor productivity for the period 1988 to 2002 is 0.74% per annum, using the unchained Paasche series, to 1.00% per annum using the unchained Laspeyres series. For the sub-period 1993 to 2002, the range for average multifactor productivity growth is 1.12% per annum, using the unchained Paasche series, to 1.50% per annum, measured using the unchained Laspeyres series.

4.1.2 Comparison with Diewert and Lawrence productivity estimates

The productivity series constructed by Diewert and Lawrence (1999) used two databases. The first database was one that the authors had previously used for analysing the impact of tax changes in the New Zealand economy. The authors' 'preferred' multifactor productivity series for the market sector of the New Zealand economy for the period 1972 to 1998 was constructed using this database (see Diewert and Lawrence, 1999, Table 1, 'Diewert-Lawrence preferred' series). Further details on this database are available in Appendix B *Diewert-Lawrence Database* (Diewert and Lawrence, 1999). The second database was provided by the Reserve Bank of New Zealand, the New Zealand Treasury, and the Department of Labour, and was designated the name *Official Database* by Diewert and Lawrence. The 'Preferred Base Case' multifactor productivity series for the market sector of the New Zealand economy for the period 1978 to 1998 (see Diewert and Lawrence, 1999, Table 1, 'Preferred Base Case' series) was formed using the Official Database.[9] Further details on the 'Official' Database are provided in Keegan (1998) and in Appendix C *The 'Official' Database* (Diewert and Lawrence, 1999).

The most comparable Diewert and Lawrence multifactor productivity series to the market sector multifactor productivity series presented in Figure 1 is found in Table 4.3 of Diewert and Lawrence (1999, p. 45, 'Philpott' Lives series). The comparable Diewert and Lawrence labour and capital productivity series to the market sector labour and capital productivity series presented in Figure 1 are found in Table 4.12 of Diewert and Lawrence (1999, p. 66, 'Labour' and 'Net capital' series). These series were constructed using the Official Database. The chained Fisher output index was formed using production GDP data for 20 industries comprising the market sector of the New Zealand economy. Chained Fisher input indices were formed using information on industry hours worked (drawn primarily from the HLFS, Quarterly Employment Survey (QES) and the Economic Survey of Manufacturing (ESM)), and industry net capital stocks for plant and equipment and building and construction, weighted by user costs with industry specific depreciation rates and asset lives based on Philpott (1992).

[9] Diewert and Lawrence (1999) refer to both of these series as total factor productivity rather than multifactor productivity.

Figure 4 – Comparison with Diewert and Lawrence market sector productivity series

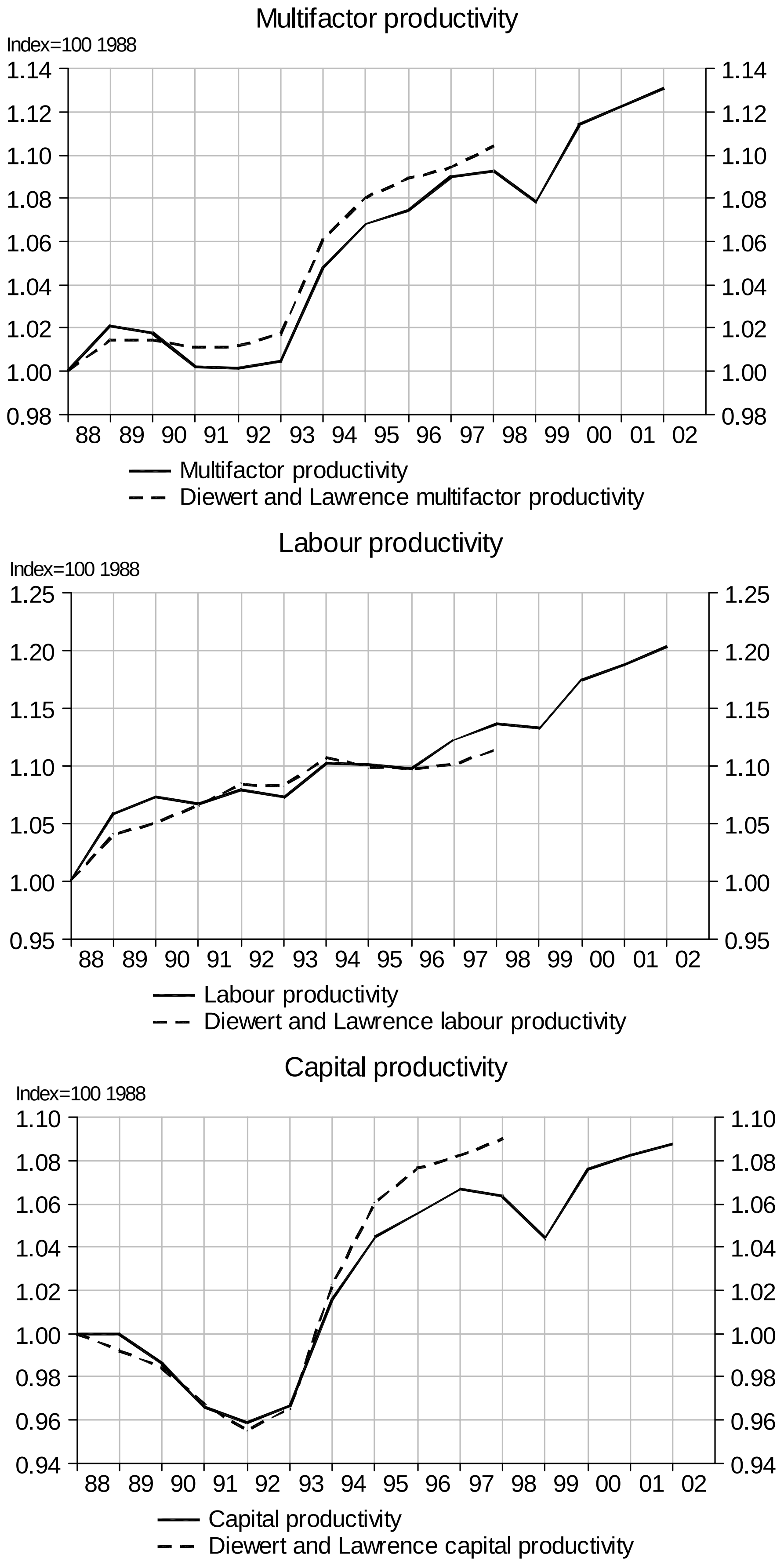


Figure 4 compares the Diewert and Lawrence productivity series constructed using the 'Official' Database with the productivity series presented in Figure 1. Because the Diewert and Lawrence series have a base of 1 in 1978, it was necessary to rebase these series to unity in 1988 to aid comparison with the productivity series shown in Figure 1. Table 3 reports average growth for the Diewert and Lawrence productivity series for the period 1988 to 1998 and for the sub-periods 1988 to 1993 and 1993 to 1998.

Table 3 – Diewert and Lawrence average productivity growth

Time period	Multifactor productivity	Labour productivity	Capital productivity
1988 to 1993	0.34% (0.09%)	1.61%% (1.41%)	-0.70% (-0.68%)
1993 to 1998	1.65% (1.69%)	0.57% (1.16%)	2.46% (1.93%)
1988 to 1998	0.99% (0.89%)	1.08% (1.29%)	0.87% (0.62%)

Source: Diewert and Lawrence (1999)

Note: New Zealand market sector estimates are in parentheses

In general the Diewert and Lawrence productivity series are quite similar to the market sector productivity series presented in Figure 1. Table 3 shows that over the period 1988 to 1998 average growth in the Diewert and Lawrence multifactor productivity series was 0.10% per annum higher than average growth in the multifactor productivity series shown in Figure 1. In contrast, average labour productivity growth was 0.21% per annum higher in the Diewert and Lawrence labour productivity series over the period 1988 to 1998. Average growth in the Diewert and Lawrence capital productivity series over the period 1988 to 1998 displays higher growth than the capital productivity series shown in Figure 1. Moreover, the two series appear to be diverging from the mid-1990s.

Given the improvements in the National Accounts data since Diewert and Lawrence (1999) undertook their study, especially the introduction of productive capital stocks estimates, the productivity series reported shown in Figure 1 are likely to give a more accurate picture of New Zealand's productivity performance. However, this comparison highlights the impact that data upgrades and revisions can have on measured productivity.

4.2 Industry productivity

The market sector productivity series provide an understanding of aggregate trends in New Zealand's productivity growth. However, aggregate trends can mask differences in industry productivity trends. Buckle, Haugh and Thomson (2001) found considerable changes in industry growth rates and the proportion of GDP that these industries comprised. In particular, the primary and services sectors showed increasing growth rates. Multifactor productivity results suggest that changes in GDP growth rates across industries may reflect changes in aggregate productivity growth. This section examines multifactor productivity trends in the nine industries comprising the market sector of the New Zealand economy.

4.2.1 Industry level measurement issues

Industry based multifactor productivity series should be approached with caution due to considerable measurement problems at this level of disaggregation. While many of the problems discussed here have implications for results at the aggregate level, these are likely to have a more significant impact on industry level results. For example, the most basic problem – a lower rate of surveying of the population at an industry level – is overcome through aggregation. In contrast, the lower survey rate at the industry level is likely to result in greater volatility in the industry series.

The key measurement issues raised by Diewert and Lawrence (1999) included double deflation in GDP, omitted variables, misallocation of demand, and measurement of financial sector output. Problems with capital stock data and consistency of definition of industry between labour data series were also raised. These last two issues were discussed in section 3 of this paper.

Double deflation is the ideal method of calculating industry based GDP. This requires price and quantity information on gross outputs and intermediate consumption purchases between industries for every period. In practice, sufficient information for each industry to calculate GDP on a double deflation basis is not readily available, and is therefore only used in a few industries. A comprehensive source of information for double deflation is input-output tables, but these are generally only produced on a 5-year basis, with significant lag times between collection and analysis. Statistics New Zealand has introduced double deflation to a further industry, business and property services, since Diewert and Lawrence's (1999) report (Statistics New Zealand 2002). The alternative method of calculating GDP is the single indicator method. This method assumes that the structure between industries is constant, although the weighting assigned to each industry is updated annually.

The calculation of multifactor productivity would ideally take into account a number of currently omitted variables such as land use, natural resource depletion (eg, fishery and forestry stocks) and inventories.[10] Measures of these items are not currently available in New Zealand. Changes in resource use and prices would lead to changes in multifactor productivity growth. At the industry level, differences in usage of land, natural resources and other unaccounted inputs between sectors may create misleading results. For example, land, a key input into agricultural production, has not been valued, while the key inputs in other industries may have been more comprehensively considered (eg, capital services in the manufacturing industry).

Misallocation of demand can arise when intermediate industry consumption is not correctly identified, or allocated to the wrong industry. For example, consider the situation when a firm provides an employee with a company vehicle. The cost of the vehicle is an expense to the firm, reducing GDP. By contrast if the firm paid the worker more in order to purchase their own vehicle, this would increase final demand and GDP. Changes in policies leading to altered incentives for providing fringe benefits, or leading to more self-employed people, may lead to changes in the way consumption is split between intermediate and final demand.

[10] The impact of omitted variables is subsumed with the multifactor productivity series.

By its nature, output from the service sector can be extremely difficult to measure. This is particularly so in the financial services industry because output depends on net interest earnings. These must be split between intermediate or final consumption and between the different industries of the economy. Value added in other service sector industries, such as education, can also be hard to ascertain because of the difficulty in identifying a measurable output. In some cases employment indicators may be used along with an assumed constant employment to output ratio. In other words, for some of the sub-industries within the service sector, constant labour productivity may be assumed (Statistics New Zealand 1996). Difficulties in measuring services sector output has led to the exclusion of parts of this sector from the Australian Bureau of Statistics multifactor productivity series (see Section 5).

Overall, measurement issues at the industry level suggest industry multifactor productivity series should be treated with a degree of caution. This is particularly the case for service sector industries where measurement problems are more pronounced.

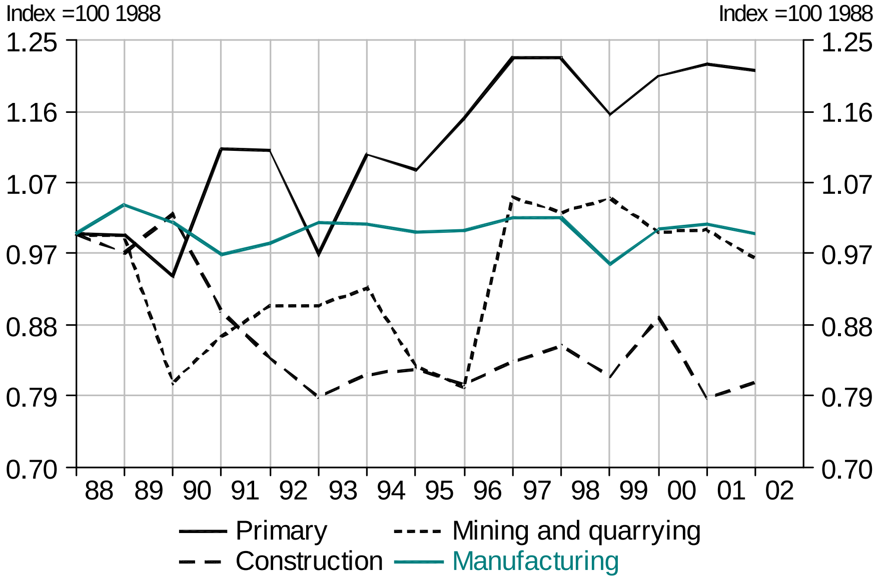
4.2.2 Estimates of multifactor productivity by industry

Industry multifactor productivity estimates were constructed by dividing the chained Laspeyres volumes GDP index by a Fisher input index. The Fisher input index was formed by combining industry hours worked and industry capital stock data, using industry labour cost and industry capital cost data as weights. Industry multifactor productivity series are presented in Appendix 2.

Table 4 – Average multifactor productivity growth by industry

March Year	Primary	Mining and Quarrying	Construction	Manufacturing	Electricity, gas and water
1988 to 1993	-0.52%	-1.91%	-4.59%	0.29%	1.11%
1993 to 2002	2.45%	0.72%	0.25%	-0.16%	-0.93%
1988 to 2002	1.38%	-0.23%	-1.51%	0.00%	-0.21%
	Transport and communications	Business and property services	Personal and community services	Retail and wholesale trade	
1988 to 1993	6.75%	-2.54%	0.82%	-0.38%	
1993 to 2002	5.52%	0.74%	1.48%	1.40%	
1988 to 2002	5.96%	-0.44%	1.24%	0.76%	

Figure 5 – Multifactor productivity: Primary, Mining and quarrying, Construction and Manufacturing Industries



Over the 1988 to 2002 period, the productivity growth of two industries stands out: the Transport, storage and communications industry (average growth of 6.0% per annum) and the Primary industry (average growth of 1.38% per annum) (see Table 4 and Figures 5 and 7). The Personal and community services industry also appears to have had comparatively strong average productivity growth (1.24% per annum, see Table 4 and Figure 6). However, for the reasons discussed above, we view this result with less confidence.

At the aggregate level, New Zealand's productivity growth appears to have accelerated post 1993. Of the nine industries presented here, estimates for six industries show a stronger productivity performance in the period 1993 to 2002 than for the period 1988 to 1993 period. These industries are the Primary, Retail and wholesale trade, Business and property services, Mining and quarrying, Construction and Personal and community services. For all these industries, the increase in average productivity growth between the 1988 and 1993 and 1993 and 2002 was in excess of 0.6% per annum.

The three industries that did not experience an acceleration in productivity growth post 1993 are the Electricity, gas and water, Transport and communications and the Manufacturing industries. Multifactor productivity in the Transport and communication industry was increasing relatively strongly in the period 1988 to 1993 (6.75% per annum), and the rate of productivity growth slowed slightly in the period 1993 to 2002 (5.52% per annum). The Electricity, gas and water industry, which experienced a modest increase in productivity between 1988 and 1993 (1.11% per annum), appears to have declined sharply since the mid 1990s (see Figure 6), resulting in a decline in productivity over the period 1993 to 2002. The manufacturing industry, having experienced some positive productivity growth in the period prior to 1993, experienced a slight decline post 1993. Estimates suggest that manufacturing industry productivity in 2002 was very similar to productivity in 1988.

Figure 6 – Multifactor productivity: Electricity, gas and water, Retail and wholesale trade, Personal and community services and Business and property Industries

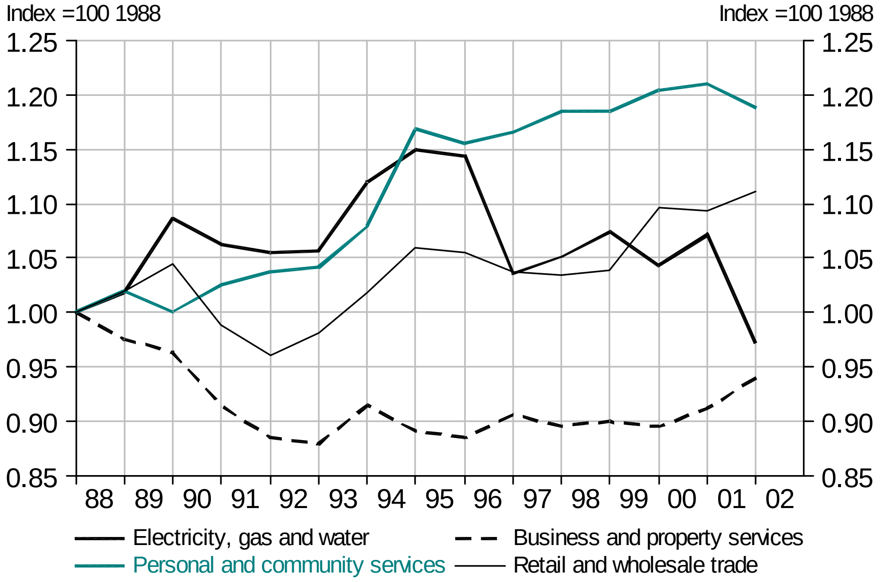
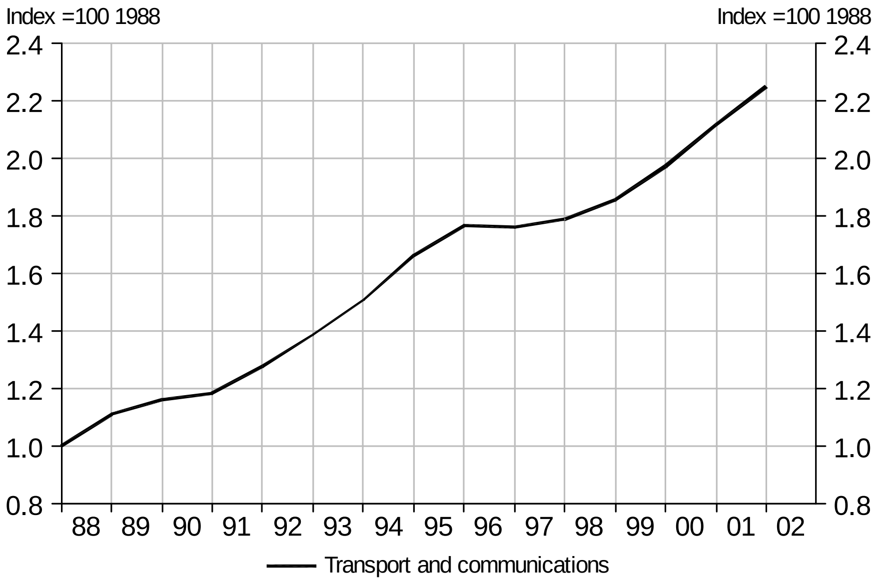


Figure 7 – Multifactor productivity: Transport, storage and communications industry



Some of these differences in productivity performance across industry and across time periods are likely to reflect the consequences of industry reforms. Sub-industries within the Transport and communication industry, such as telecommunications and postal services, along with the Primary industry, were some of the first to undergo reform in the mid 1980. The benefits of these reforms, and the benefits of later reform in other industries, may be reflected in these results. However, results for the manufacturing industry, which has experienced considerable reform, show no multifactor productivity growth. Manufacturing industry productivity results also show surprisingly little volatility. These differences are in productivity performance are consistent with Buckle, Haugh and Thomson (2001) who found a decline in volatility for manufacturing GDP growth, but also that manufacturing sector GDP growth was slower than for the Primary or Services sectors.

Section 4.2.1 noted the possible impact of omitted variables in biasing upwards results for individual industries. Land, one of the key inputs to the primary industry, is omitted from calculations. The extent to which changes in land use patterns and land prices have impacted upon results for the Primary industry are unknown. The Primary industry also includes fisheries. The introduction of fisheries quotas will have increased firm costs and therefore decreased value added in this industry. However this is only a partial consideration of resource value, as the resource input is not included in the input index.

Because measuring service sector output is difficult, multifactor productivity growth for the three service industries should be viewed with caution. Retail and wholesale trade, which spans both the goods and services sectors, has been the third strongest performing industry in terms of productivity growth since 1993. This industry appears to have experienced a fall in multifactor productivity during the early 1990s, which coincided with a decline in New Zealand's domestic absorption rate.

These results show considerable variation in the productivity growth between industries. While some sectors have shown notable growth (Transport and communications, Primary), others have stagnated. When looking at these results, it must be remembered that output of some industries, particularly those in the service sector can be difficult to measure. These measurement problems are recognised by the Australian Bureau of Statistics, and consequently their productivity measures exclude some parts of the service sector.

4.2.3 Comparison with Diewert and Lawrence (1999)

Diewert and Lawrence's Official Database included series for 20 industries in the market sector of the New Zealand economy, for the period 1978 to 1998. Industry analysis in this paper has been at a considerably more aggregated level, looking at nine industries, due to the data limitations discussed in section 3.

Diewert and Lawrence reported their industry level results using trend growth rates. In order to create comparability with the Diewert and Lawrence industry results, we have calculated geometric compound growth rates, our preferred measure, for their industry multifactor productivity estimates over the periods 1987 to 1998 and 1993 to 1998.

Because results for Diewert and Lawrence's industries have been re-calculated using exactly the same index number and growth rate calculation formula, the differences in the results reflect underlying differences in the databases. These are considerable, including the change from using the Philpot capital series to the Statistics New Zealand capital series. Reflecting this, the two studies share some similarities, but notable differences, in their results.

Like the multifactor productivity results, the Diewert and Lawrence official database also suggests that Transport, storage and communications and Primary have been the industries with fastest growing productivity. In addition, the magnitudes of the growth rates appear roughly comparable.

Over all industries, the Diewert and Lawrence results appear to be more positive over the 1987 to 1998 period. Contrasting this, multifactor productivity results appear more positive in the shorter period from 1993. More positive results in the shorter period are a pattern across the three service industries. However, the multifactor productivity growth in Business and Property services industry is more positive across the entire 1987-1998 period. These results may reflect ongoing measurement improvements in what are hard to measure sectors, particularly the methodological change, discussed above, in the business and property services industry.

Multifactor productivity results suggest that the Electricity, gas and water industry experienced poor growth in productivity. Diewert and Lawrence also reported on this industry and their dataset produces a considerably higher estimate of productivity growth. Manufacturing multifactor productivity also performed poorly and this is similar to the results for manufacturing industries reported by Diewert and Lawrence (1999).

5 Australia and New Zealand productivity

This section compares productivity growth in the New Zealand and Australian economies for the period 1988 to 2002. The Australian and New Zealand economies are often compared on the basis of similarities in history, institutions and economic policies (see for example Brook, 1998; Matheson, 2002). Diewert and Lawrence (1999) also compared Australian and New Zealand productivity using index number techniques.

The ABS produces multifactor productivity, labour productivity and capital productivity series for the market sector of the Australian economy. What follows is a brief discussion of the methodology and the data used to construct these productivity series. Further information on the methodology and data used to construct the ABS productivity series can be found in the *Australian System of National Accounts: Concepts, Sources and Methods* (ABS, 2000). These productivity series have been used to evaluate the productivity performance of the Australian economy (see for example Parham, 1999; Quiggin, 2001)

The market sector of the Australian economy is defined by the ABS to include the following industries: Agriculture, forestry and fishing; Mining; Manufacturing; Electricity, gas and water; Construction; Wholesale trade, Retail trade; Accommodation, cafes and restaurants; Transport and storage; Communication services; Finance and insurance; and Cultural and recreational services. The hard to measure industries excluded from the market sector are: Property and business services, Government administration and defence; Education, health and community services; personal and other services; and ownership of dwellings. The ABS market sector comprised approximately 64% of total volume GDP in 2002.

Labour productivity is formed by taking the ratio of market sector gross value added to hours worked. Capital productivity is formed by taking the ratio of market sector gross value added to a measure of capital services. Multifactor productivity is formed by taking the ratio of market sector gross value added to a composite input series of hours worked and capital services. The composite input series is formed using the Törnqvist index formula. An estimate of market sector capital services is formed using detailed capital stock data for each asset type at the industry level. Users cost series, calculated using an industry specific internal rate of return, are used to weight the capital stocks for each asset type.

To maximise scope for comparison with the ABS productivity series it was necessary to construct measures of multifactor productivity, labour productivity and capital productivity using the Törnqvist index and excluding the business and property services and personal and community services industries, to more closely align the New Zealand industry coverage with the ABS definition of the market sector. The resulting 'ABS equivalent' New Zealand market sector was 58% of total volume GDP in 2002.

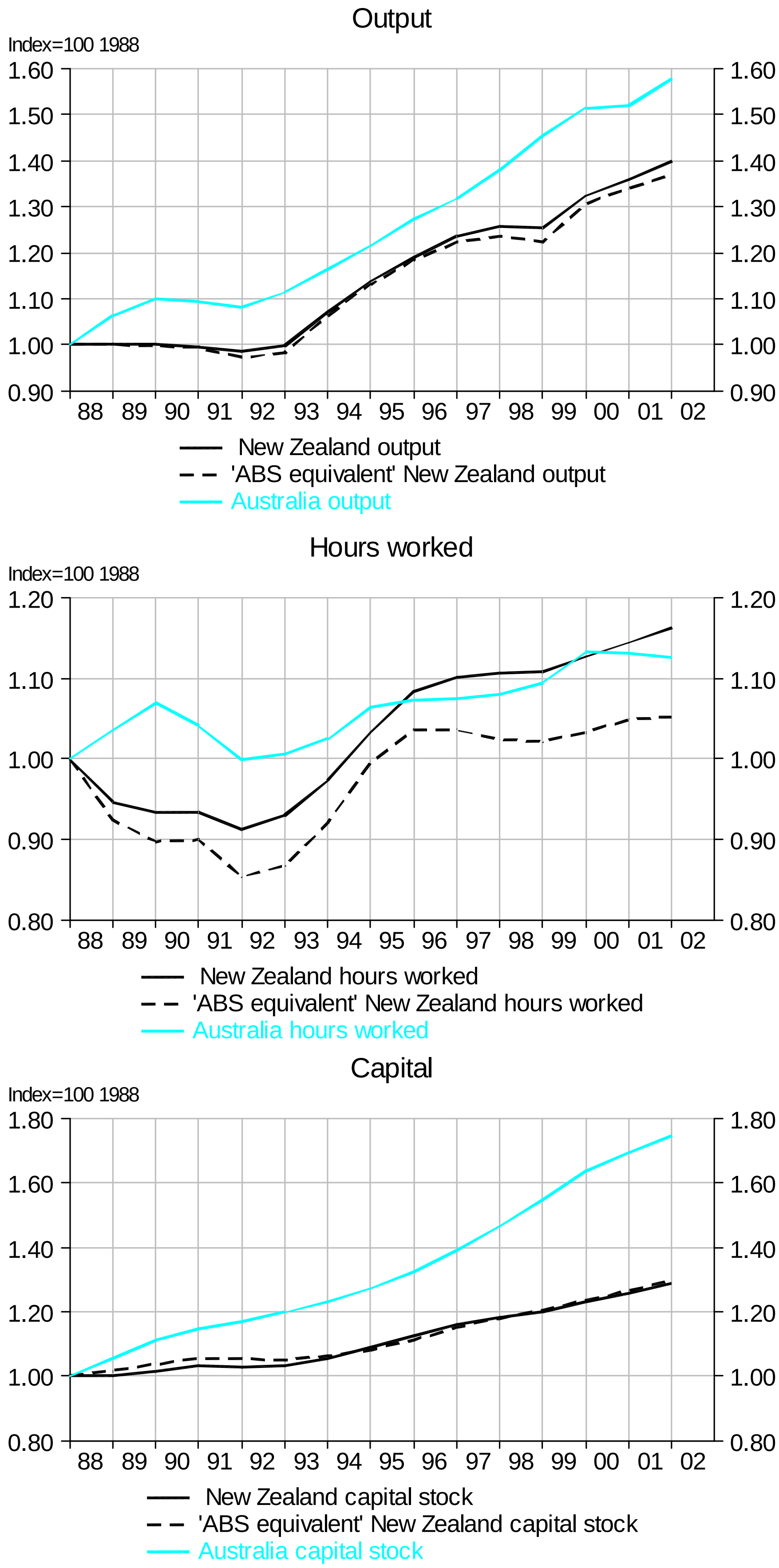
While the New Zealand 'ABS equivalent' productivity series comes relatively close to the industry coverage and specification of the ABS productivity series, some differences remain. First, it was not possible to construct comparable industry data that separates out the finance and insurance industry from the business and property services industry or the cultural and recreational services industry form the personal and community services industry. Second, the ABS uses market prices whereas data used in this paper is formed using producer prices. Third, the ABS capital stock data includes inventories, land and livestock whereas the Statistics New Zealand productive capital stock estimates exclude these asset types. Finally, the ABS aggregate their elemental industry asset type capital stock data using user cost series constructed with an industry specific internal rate of return. Statistics New Zealand forms their industry capital stock data by summing the constant price elemental series on different asset types at the industry level.[11]

Before examining the productivity performance of Australia and New Zealand, it is useful to consider the evolution of output capital and labour in the two countries. Figure 8 shows these series for the New Zealand market sector (as defined in Appendix Table 1), the 'ABS' equivalent market sector, and the Australian market sector. The ABS market series have been rebased to unity in 1988.

Over the entire period 1988 to 2002, average output growth in the Australian market sector has been stronger than in the 'ABS equivalent' New Zealand market sector. However, most of the difference arises in the period 1988 to 1993. Average output growth in both countries between 1993 and 2002 was almost identical at 3.80% for New Zealand and 3.95% for Australia. During this period output growth was stronger in New Zealand up until 1998, but slowed compared to Australian in 1998 and 1999. Higher average output growth in Australia between 1988 and 1993 was sourced from higher growth in hours worked and the capital stock. The higher rate of capital accumulation is one of the striking differences between New Zealand and Australia from Figure 8 (a point which is discussed in more detail later in this section).

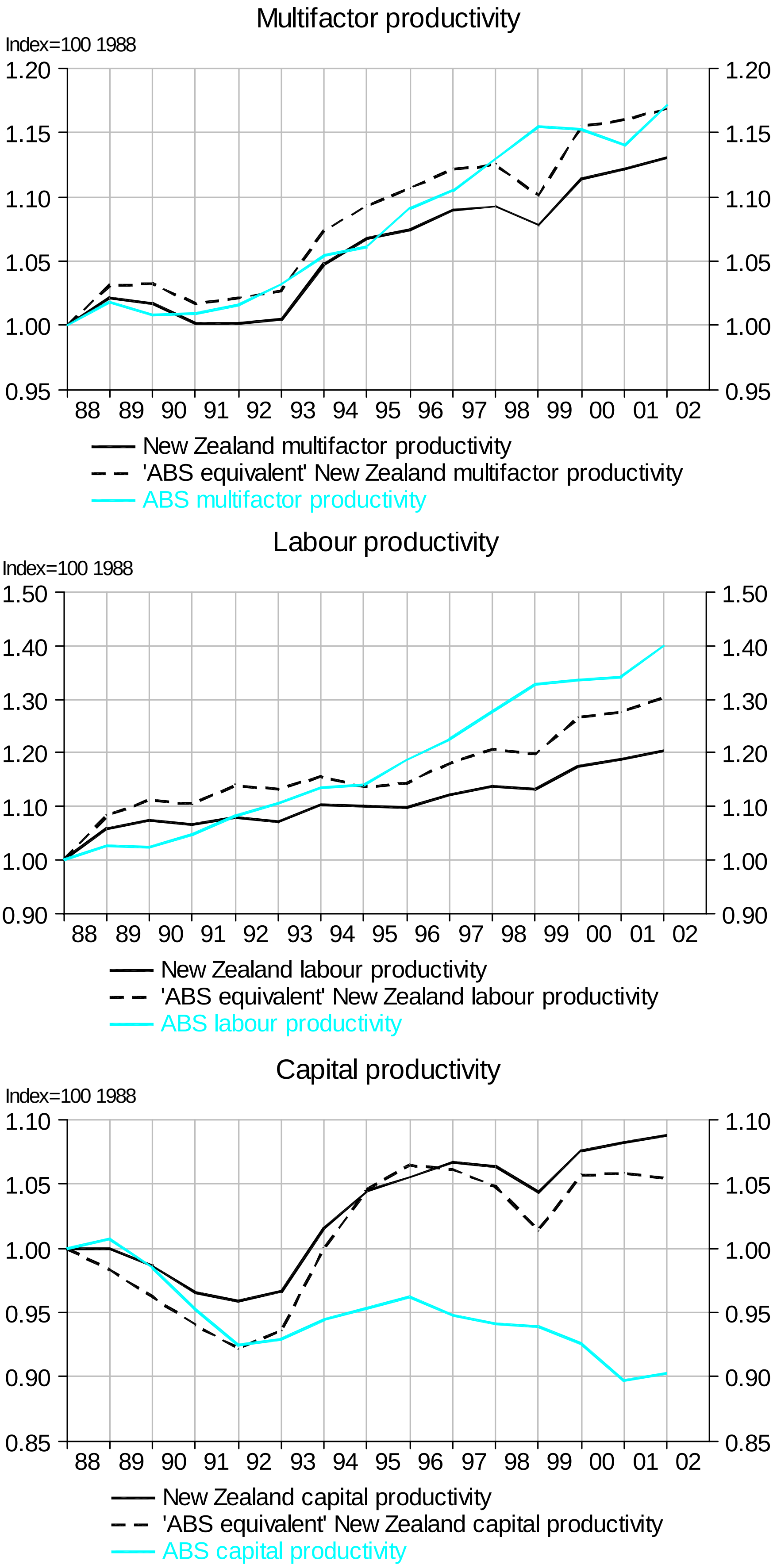
[11] Hall (1968) showed that the rental price (user cost of capital) is the price that should be used to aggregate different types of capital goods. When user cost of capital data are used to aggregate asset type capital stocks, greater weight is given to assets that depreciate relatively faster, compared to the approach of directly aggregating capital stocks. This may mean that growth in the New Zealand market sector and the New Zealand 'ABS equivalent' market sector capital stock series is lower than if industry capital stocks had been constructed using user cost of capital data to aggregate industry asset type capital stocks. This may occur because certain asset types such as plant and machinery and transport equipment, which usually have higher depreciation rates compared to building and structures, have been growing faster than other asset types (such as building and structures) at the economy-wide level. Norsworthy and Harper (1981) found that US capital stock growth was around 0.2% per annum higher when the economy-wide capital stock was constructed using user cost of capital data to aggregate asset type capital stocks, compared to the approach of directly aggregating asset type capital stocks.

Figure 8 – Australia and New Zealand output, labour and capital comparison



Source: Calculated from ABS (2002) data

Figure 9 – Australia and New Zealand productivity comparison



Source: Calculated from ABS (2002) data

Table 5 – Australia and New Zealand productivity comparison

	Multifactor productivity		Labour productivity		Capital productivity	
March Year	Australia	New Zealand 'ABS equivalent'	Australia	New Zealand 'ABS equivalent'	Australia	New Zealand 'ABS equivalent'
1988 to 1993	0.83%	0.54%	2.14%	2.53%	-1.13%	-1.31%
1993 to 2002	1.29%	1.44%	2.43%	1.56%	-0.34%	1.33%
1988 to 2002	1.13%	1.12%	2.32%	1.91%	-0.62%	0.38%

Source: Calculated from ABS (2002) data

Figure 9 compares 'ABS equivalent' New Zealand market sector productivity, the ABS market sector productivity and New Zealand market sector productivity reported shown in Figure 1. Again, the ABS productivity series have been rebased to unity in 1988. Table 5 reports average growth rates in the 'ABS equivalent' New Zealand market sector productivity series and the ABS market sector productivity series.

Excluding the business and property services and the personal and community services industries from the New Zealand market sector makes a considerable difference to multifactor and labour productivity. In both cases the 'ABS equivalent' New Zealand multifactor and labour productivity series lie above the corresponding New Zealand market sector series. The capital productivity series are very similar. The change in industry coverage highlights the impact the difficult to measure sectors can have on measured productivity growth.

Average multifactor productivity growth for the period 1988 to 2002 increases from 0.88% per annum using the New Zealand market sector series to 1.12% per annum using the 'ABS equivalent' series. Average labour productivity growth increases from 1.33% per annum to 1.91% per annum. These differences in average growth are partly due to the alternative paths taken by the 'ABS equivalent' and New Zealand market sector series up to the early 1990s. Thereafter, the two productivity series follow similar growth paths (albeit with a level difference). This is also confirmed when looking at average growth for the sub-periods 1988 to 1993 and 1993 to 2002. Differences in average multifactor and labour productivity growth are more marked between the 'ABS equivalent' and New Zealand market sector series in the period 1988 to 1993, than in the period 1993 to 2002 (see Table 5).

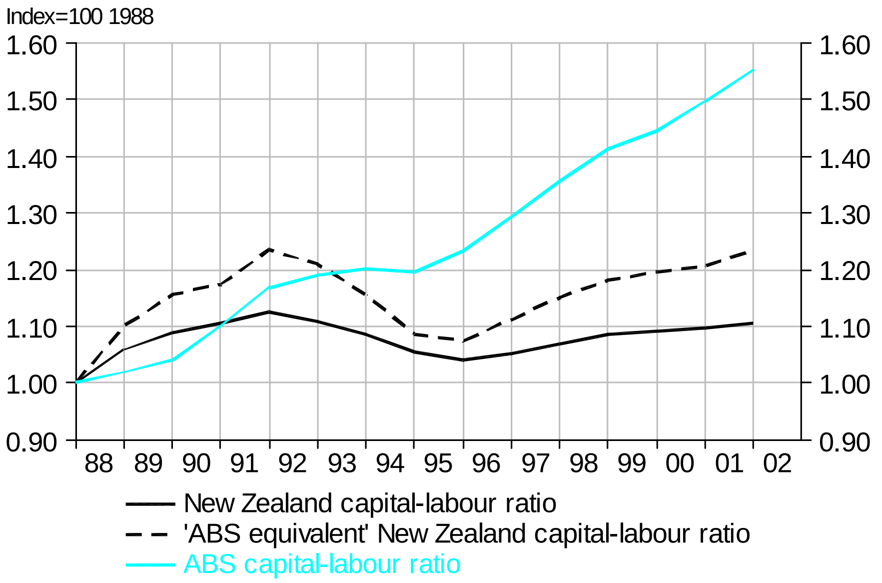
For the period 1988 to 2002, average multifactor productivity growth in Australia and New Zealand (ABS equivalent) was almost identical at 1.13% and 1.12% per annum, respectively. During this period, the one time in which the Australian and New Zealand multifactor productivity series diverge is in 1999. Buckle, Kim, Kirkham, McLellan and Sharma (2002) argued that the 1997 and 1998 summer droughts had a substantial adverse impact on New Zealand's GDP during this period. Climatic shocks are likely to be captured within multifactor productivity and the stagnation and then decline in multifactor productivity during 1998 and 1999 is consistent with the idea that adverse climate shocks had a negative impact on New Zealand's GDP during this time.

Within a growth accounting framework, labour productivity growth can be decomposed into multifactor productivity growth and growth in the capital-labour ratio. This provides a useful organising framework for analysing the proximate sources of labour productivity growth, although it should be kept in mind that this is not a model of economic growth and therefore does not capture the interaction between factor accumulation and multifactor productivity or the ultimate influences on input accumulation and multifactor productivity growth.

While average multifactor productivity growth in New Zealand and Australia has been similar over the period 1988 to 2002, the evolution of the capital-labour ratios in the two countries has been different. Between 1988 and 1993 average growth in the capital labour ratio was higher in New Zealand than in Australia (see Figure 10), and labour productivity growth was also higher in New Zealand. In contrast, labour productivity growth was higher in Australia than in New Zealand over the period 1993 to 2002. During this period Australia experienced higher growth in the capital-labour ratio compared to New Zealand. In summary, New Zealand's lower labour productivity growth after 1993 was associated with a lower rate of capital accumulation per unit of labour.[12]

On the other hand, New Zealand's slower rate of capital accumulation compared to Australia since 1994 is reflected in New Zealand's stronger capital productivity growth. As New Zealand has sourced more of its output growth from growth in the labour input since 1994, capital productivity has increased in New Zealand. In contrast, capital productivity has declined in Australia. Stronger growth in the labour input in New Zealand is likely to have been welfare enhancing by the extent to which growth in hours worked has been sourced from increases in labour force participation, unemployed workers finding employment, and underemployed workers working more hours.

Figure 10 – Australia and New Zealand capital-labour ratios



Source: Calculated from ABS (2002) data

There are several potential explanations for the difference in the evolution of capital-labour ratios between Australia and New Zealand.

The higher rate of capital accumulation per unit of labour input in Australia compared to New Zealand after 1993 may reflect differences in the industrial structure between the two economies. For example, the Australian economy has a larger mining and quarrying industry compared to New Zealand which, given the high degree of capital intensity in the mining and quarrying industry, may be a factor behind Australia's higher rate of capital accumulation.

[12] Footnote 11 noted there may be a downward bias in New Zealand 'ABS equivalent' market sector capital stock growth. However, if this bias is present it is unlikely to explain all of the substantial difference in growth in the capital-labour ratios between Australia and New Zealand after 1993.

The IMF (2002) has suggested a high concentration of household wealth in housing assets and the small size of New Zealand's domestic market as being additional reasons for New Zealand's lower rate of capital accumulation compared to Australia. A high concentration of wealth in housing assets means there is less domestic savings to finance domestic investment.[13] New Zealand's small domestic market makes it difficult to achieve internal economies of scale and hence reduces the opportunities for profitable investment.

A further explanation is the impact of changes in factor market regulation on firms' incentive to source output growth from employing more labour versus investing more in physical capital. For example, the impact of welfare and labour market reform in New Zealand in the early 1990s may have resulted in firms employing more labour rather than investing more in physical capital in meeting output growth.

The relative price of labour to capital is a measure of the cost to firms of investing in more capital versus employing more labour. When the relative price of labour to capital increases, firms are likely to invest more in physical capital and employ less labour. Conversely, when the relative price of labour to capital decreases, firms will employ more labour and invest less in physical capital.

Figure 11 shows the 'ABS' equivalent' New Zealand capital-labour ratio and the relative price of labour to capital. The price of labour (or implicit hourly wage) is calculated by dividing sole proprietors adjusted compensation of employees by the Törnqvist labour input index. Likewise, the price of capital (or implicit cost of capital) is calculated by dividing the sole proprietors adjusted operating surplus by the Törnqvist capital input series.

Figure 11 – New Zealand capital-labour ratio and the relative price of labour to capital

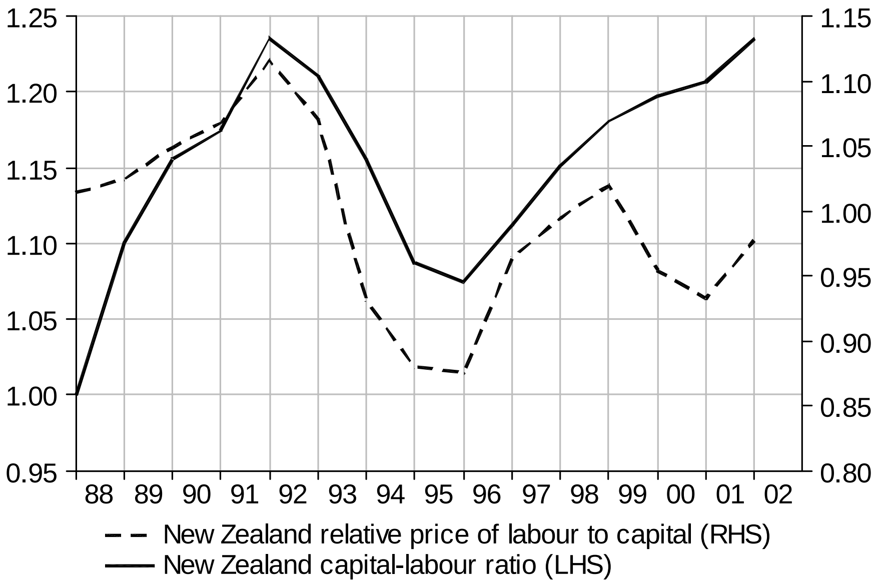


Figure 11 shows that over the period 1988 to 1992 the relative price of labour to capital increased. During this period New Zealand's capital-labour ratio increased (ie, the New Zealand economy experienced capital "deepening"). Between 1992 and 1996 the relative price of labour to capital fell by 22%. This occurred shortly after the introduction of the Employment Contracts Act (1991) and welfare reform. Maloney and Savage (1996) have

[13] However, Claus, Haugh, Scobie and Tornquist (2001) have argued that New Zealand's domestic investment does not appear to have been constrained by the level of domestic savings as New Zealand has used foreign savings to meet investment demand.

suggested that the ECA was at least in part responsible for lower real wage growth in New Zealand relative to Australia after 1991. Firms appear to have employed labour rather than capital during this period resulting in a decline in the capital-labour ratio between 1992 and 1996 (ie, New Zealand experienced capital "shallowing"). A similar phenomenon occurred in Australia between 1988 and 1993 where Australia experienced strong growth in the labour input (although the capital ratio did not decline as it did in New Zealand). Parham (1999) has pointed out that strong labour growth was associated with a decline in real wages.

Lower productivity (quality) workers finding employment in the 1990s is a further possible reason for relatively lower labour productivity growth. Maloney and Savage (1996), in comparing labour market outcomes between Australia and New Zealand, questioned whether

> "…recent labour market reforms slowed the gains in productivity made under earlier product market reforms? Or is this poor productivity performance only a temporary by-product of accelerated job growth in New Zealand, as lower skilled, less productive workers find employment during this rapid expansion? More time will have to elapse before we can make any assessments over the long term effects of changes in the industrial relations system on labour productivity."
>
> Maloney and Savage 1996:107

Because no quality adjustment has been made to the labour input, changes in labour quality will be reflected in multifactor productivity. It is not apparent from Figure 9 that there was any deceleration in multifactor productivity growth following the introduction of the Employment Contracts Act (1991) and welfare reform. However, this does not mean that lower productivity workers gaining employment had no impact of multifactor productivity growth because other factors, such as a general up-skilling of the existing workforce, may have had offsetting impacts. Hence, the affect of changes in labour market regulation and welfare reform on capital accumulation and labour productivity warrants further investigation.

6 Conclusions

This paper has provided new market sector and industry productivity series for the New Zealand economy for the period 1988 to 2002. These series were constructed using an industry database containing official Statistics New Zealand data, including upgraded National Accounts and productive capital stock data that were first released in 2000. Throughout, productivity series have been constructed using index number techniques, building on the substantial work of Diewert and Lawrence (1999) in *Measuring New Zealand's Productivity*.

Measured over alternative business cycles, average multifactor productivity growth for the market sector of the New Zealand economy ranged from around 0.8% to 1.2% per annum. Average labour productivity growth varied in a much tighter range between approximately 0.7% and 0.9% per annum. There appears to have been a noticeable improvement in market sector multifactor productivity after 1993. Average multifactor productivity growth increased from 0.09% per annum in the period 1988 to 1993 to 1.32% per annum in the period 1993 to 2002. This result is consistent with both a structural improvement in New Zealand productivity growth and earlier research showing improvements in New Zealand GDP growth dating from the early 1990s (Razzak, 2002; Buckle, Haugh and Thomson, 2002). However, owing to the short period covered by the productivity data it was not possible to use formal tests for structural breaks in New Zealand's productivity after 1993.

The comparable Diewert and Lawrence (1999) productivity series to those reported in this paper were constructed using the 'Official' Database. In general the New Zealand market sector productivity series were similar to the Diewert and Lawrence (1999) productivity series, although the two capital productivity series appeared to diverge from the mid-1990s.

Multifactor productivity growth has been strongest in the Transport and communications industry, followed by the Primary industry. Diewert and Lawrence (1999) also reported strong multifactor productivity growth in these industries. Excluding hard to measure industries from the market sector, to form 'ABS equivalent' productivity series for New Zealand, resulted in significantly higher average multifactor and labour productivity growth in New Zealand.

In the period up to 1993, labour productivity growth was higher in New Zealand than in Australia, however between 1993 and 2002, labour productivity growth was lower in New Zealand. Because multifactor productivity growth has been similar in both countries, the difference in the evolution of capital-labour ratios in the two countries accounts for the difference in labour productivity growth. The impact of changes in labour market regulation and welfare reform on New Zealand's capital accumulation and labour productivity growth warrants more detailed investigation.

This paper has provided a basis for further work on New Zealand's productivity. One strand of work is to improve the coverage and quality of the industry database used in this paper. Existing data could be backdated further and additional inputs (such as human capital, land and inventories) could be collected or constructed. This could also include the construction of industry capital stock series that have been weighted using user cost of capital series to aggregate asset type capital stock data at the industry level. Sensitivity analysis of the productivity series to alternative data (for example, the QES hours paid data) could also be undertaken. Another strand of work is to use the industry productivity series to examine the industry sources of aggregate productivity growth. This will provide policy makers with a basis for evaluating why some industries have contributed more to aggregate productivity growth than have others. Another area that warrants investigation is the relative importance of technological change versus economies of scale in generating industry productivity growth, using a technique proposed by Diewert and Fox (2003). Insights from this work are important as policy settings are likely to differ depending on whether scale economies or technological change is the main driver of productivity growth.

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Appendix 1 – Industry productivity database

To form aggregate and industry productivity series for the market sector of the New Zealand economy it is necessary to have data on values and volumes of output, labour and capital. This appendix discusses the data used to form an industry productivity database in more detail.

The level of industry disaggregation for which productivity series can be constructed is determined by the industry hours worked data. Compared with the production and income GDP accounts and the capital stock data, industry hours worked data on an ANZSIC basis are constructed at a more aggregate level. Therefore, even though data on production and income GDP (compensation of employees and operating surplus) and the capital stock are available for 31 industries (ie, the two digit industry level), hours worked data are only available for a more aggregated nine industries (ie, the one digit industry level). This made it necessary to form more aggregate industry output and capital series, which matched the corresponding industry hours worked level of industry disaggregation, using data on production and income GDP and the capital stock for the 31 industries. Appendix Table 1 provides a summary of how the various data were aggregated to form nine comparable industries for use in constructing aggregate and industry productivity series.

Appendix Table 1 – Aggregation of industry data

Production GDP (National Accounts) and compensation of employees and gross operating surplus (National Accounts – Income GDP)	Hours worked (Household Labour Force Survey)	Industry breakdown used for constructing productivity series
1. Agriculture Fishing Forestry and logging	Agriculture, Forestry & Fishing	Primary
2. Mining and Quarrying	Mining & Quarrying	Mining & Quarrying
3. Food, Beverage and Tobacco Manufacturing Textiles and Apparel Manufacturing Wood and Paper Products Manufacturing Printing, Publishing and Recorded Media Petroleum, Chemical, Plastics and Rubber Products Manufacturing Non-Metallic Mineral Products Manufacturing Metal Product Manufacturing Machinery and Equipment Manufacturing Furniture and Other Manufacturing	Manufacturing	Manufacturing
4. Electricity, Gas and Water Supply	Electricity, Gas and Water Supply	Electricity, gas and water supply
5. Construction	Construction	Construction
6. Wholesale Trade Retail Trade (including motor vehicle repairs) Accommodation, Cafes and Restaurants	Wholesale & Retail Trade Accommodation, Cafes & Restaurants	Trade
7. Transport and Storage	Transport & Storage	Transport and communications

Communication Services	Communication Services	
8. Finance, Insurance Property Services Business Services	Finance & Insurance Property & Business Services	Business services
9. Education Health and Community Services Cultural and Recreational Services Personal and Other Community Services	Education Health & Community Services Other Services (which includes Government Administration and Defence)	Personal and community services

Output

Output data were primarily sourced from Statistics New Zealand's System of National Accounts (1993) production based GDP series. Annual March year volume GDP at the two digit industry level, which are chained Laspeyres constant price series with a fixed weight Laspeyres tail from 1999 onwards, are available for the period 1988 to 2002. These data were then aggregated to form the nine industries in the industry productivity database. Aggregation of the industries was by simple summing. While this is theoretically unsuitable for chained data, advice from Statistics New Zealand, and experimentation, suggest that the overall result between this and chaining is very similar.

Annual March year nominal GDP data at the two digit industry level are available from Statistics New Zealand's income GDP accounts for the period 1988 to 1999. These data were then aggregated to form the nine industries in the industry productivity database. Nominal GDP data for the period 2000 to 2002 were projected forward using nominal expenditure GDP data for the entire economy, following the method suggested by Diewert and Lawrence (1999, p. 283) (who also faced the problem of a shorter time series for industry nominal GDP compared to industry volume GDP). This method is outlined below.

First, an implicit output price for the entire economy for 1999 to 2002 was found by dividing nominal expenditure GDP by real expenditure GDP. Percentage changes in the implicit output price for the entire economy were then used to project forward the implicit output price for each of the nine industries. Finally, the projected industry implicit output price series were used to reinflate volume GDP to yield nominal GDP.

This method does not allow for relative changes in prices between industries. As a sensitivity test, industry level nominal GDP was projected forward using Producer Price Index output prices by industry. While some differences in the level of GDP occurred at the industry level, when used to weight up the industry outputs, the alternative projections had a negligible affect on the aggregate productivity results.

Labour

Statistics New Zealand produces data from two surveys that could be used to form industry labour input series: The Quarterly Employment Survey (QES) – a firm based survey – and Household Labour Force Survey (HLFS) – a private household based survey. In addition to other labour market data, the QES provides industry information on the number of paid hours, whereas the HLFS provides industry information on the number of hours worked.

HLFS hours worked data are the preferred measure of the labour input for two reasons. First, the HLFS hours worked series sets out to capture the number of *actual* hours worked. In contrast, the QES measure of hours paid does not exclude sick leave and holidays, and is unlikely to reflect increases/decrease in the number of hours worked by salaried workers during peak/slack periods. Second, the QES industry coverage is not as great as the HLFS industry coverage. The QES does not cover agriculture, hunting, and fishing industries. Furthermore, work without pay in the family business and causal employment (eg, cash jobs, cottage industries) and geographical units with less than one full time equivalent (FTE) worker are excluded from the QES hours. Nonetheless, some researchers prefer to use the QES hours paid data as it does not involve human recollection error and because the industry data are considered to be more robust as the QES classifies firms into industries rather than relying on individual employee survey records. Appendix Table 2 summarises they key differences between the HLFS and QES.

Appendix Table 2 – Key differences between the HLFS and the QES

Characteristics	HLFS	QES
Timing	Every week in a year.	Pay week ending on or immediately before the 20th of the middle month.
Coverage	Individuals in private households.	Businesses with more than 2 FTEs and with turnover GST registered > $30,000 per year.
Period	Average over a quarter.	1 week in a quarter.
Type of interviewing	Interview administrated. First is face to face, respondents are then telephoned from then on.	Form is posted. Respondent posts/faxes/telephones data through.
Seasonal	Students working in Feb but studying in March.	Captures information in the survey week only.
Age	15+	All ages
Weighting	Data is re-weighted every 5 years using Census data.	Data is weighted using Business Frame survey FTE info, updated every quarter since 1999.
Sample Exclusions	Excludes the following: Non-private dwellings; Long-term residents of old peoples home hospital and psychiatric institutions; Inmates of penal institutions; Members of the permanent armed forces; Members of non-NZ armed forces overseas; Overseas visitors; and Offshore islands except for Waiheke Island.	Excludes the following industries: - Agricultural and Agricultural Contracting - Hunting and Trapping - Fishing - Seagoing work - Owning and leasing of real estate - Armed forces (civilian staff are included) - Domestic service in households.
Measures	Employment	Filled Jobs
Survey Size	15,000 households (30,000 people approx).	18,000 businesses at geo level.
Sources	There is one source of data - the survey.	Primary data is collected from the QES and secondary data is collected from the Business Frame.
Unit non-response	Weights up by age and sex to get a representative of the population.	Imputed for item & unit non-response. Weights not updated since 1989.
Non-respondents	Non-responding HHs are excluded from the survey results.	Imputed if key firm.

Questionnaire

Forms & Questions	Forms & questions have remained consistent since Dec 1985.	Forms & questions has remained consistent since taking over from DOL in 1989.
Survey Established	Dec 1985.	Since 1952 - Stats took over in Feb 1989.
Definitions/Classifications		
Definitions/ Classifications	Different definitions/classifications are used in both surveys	
Employment	A person may have 2 jobs (part time) but this counted as 1 employed person.	Measures filled jobs so a person with 2 jobs will count twice.
Place of employment	Primary industrial place.	Primary & secondary industrial place are recorded.
Who is employed?	Unpaid family helper are measured as employed i.e. in the labour force.	May not count unpaid family workers.
Casual/ Voluntary	More likely to be measured. LF status - in the labour force.	Less likely to be measured.

Source: Taken from a Statistics NZ table

Statistics New Zealand changed the HLFS industrial classification during the time period used in this paper. Hours worked data using the old New Zealand Standard of Industrial Classification (NZSIC) cover the period 1988 to 2002, whereas the HLFS ANZSIC hours worked data cover the period 1998 to 2002. To form comparable industry productivity data, ANZSIC hours worked data were backdated using the NZSIC hours worked data. Backdating was done by taking the level change in the industry NZSIC hours worked series and using this to rate back the corresponding industry ANZSIC hours worked data, beginning in 1998.

Industry labour cost data were derived by dividing adjusted industry compensation of employees by total hours worked. Because the System of National Accounts classifies the labour income of sole proprietors as operating surplus, an adjustment needs to be made to industry compensation of employees to more accurately reflect industry compensation for total hours worked. This adjustment was done by adding an estimate of sole proprietors' labour income to industry compensation of employees from the income GDP accounts.

Industry compensation of employees data for the period 1988 to 1999 were drawn from Statistics New Zealand's income GDP accounts. Industry compensation of employees data were extended to 2002 using the annual percentage changes in compensation of employees for the entire economy to rate forward the industry data. Estimates of industry sole proprietors' labour income were derived by multiplying industry sole proprietors' total hours worked by the private sector ordinary time wage rate. One digit industry level data on total hours worked by sole proprietors were obtained from Statistics New Zealand. The private sector ordinary time wage rate was sourced form the QES.

Capital

Industry capital stock data were sourced from Statistics New Zealand's productive capital stock series. These industry capital stock series are available for the period 1988 to 1999. To complete the capital stock series up to 2002, the industry capital stock series were projected forward for the remainder of the period using annual percentage change in the economy wide capital stock for the period 2000 to 2002.

Industry capital cost data were constructed by taking the ratio of implicit operating surplus by the capital stock. The implicit operating surplus for each industry was calculated by subtracting compensation of employees from nominal GDP. This method assumes capital is the residual claimant in the revenue from production (net of intermediate material costs).

Appendix 2 – Market sector New Zealand productivity series

Appendix Table 3 – Market sector multifactor and partial productivity estimates

March Year	Multifactor productivity	Labour productivity	Capital productivity
1988	1.0000	1.0000	1.0000
1989	1.0211	1.0586	0.9996
1990	1.0174	1.0734	0.9861
1991	1.0018	1.0669	0.9657
1992	1.0012	1.0788	0.9586
1993	1.0046	1.0725	0.9666
1994	1.0480	1.1021	1.0155
1995	1.0681	1.1015	1.0446
1996	1.0744	1.0977	1.0554
1997	1.0900	1.1225	1.0665
1998	1.0926	1.1364	1.0634
1999	1.0783	1.1326	1.0441
2000	1.1139	1.1747	1.0763
2001	1.1223	1.1880	1.0823
2002	1.1309	1.2036	1.0877

Appendix Table 4 – Multifactor productivity series: alternative index formulae

March Year	Chained Fisher	Chained Törnqvist	Chained Laspeyres	Chained Paasche	Unchained Laspeyres	Unchained Paasche
1988	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1989	1.0211	1.0211	1.0210	1.0212	1.0210	1.0212
1990	1.0174	1.0175	1.0178	1.0170	1.0174	1.0172
1991	1.0018	1.0017	1.0042	0.9995	1.0014	1.0002
1992	1.0012	1.0011	1.0028	0.9996	1.0009	1.0022
1993	1.0046	1.0045	1.0067	1.0026	1.0060	1.0032
1994	1.0480	1.0479	1.0495	1.0465	1.0488	1.0391
1995	1.0681	1.0680	1.0692	1.0669	1.0692	1.0539
1996	1.0744	1.0743	1.0755	1.0732	1.0774	1.0583
1997	1.0900	1.0899	1.0910	1.0889	1.0930	1.0703
1998	1.0926	1.0925	1.0933	1.0918	1.0959	1.0722
1999	1.0783	1.0782	1.0791	1.0776	1.0842	1.0551
2000	1.1139	1.1138	1.1145	1.1134	1.1243	1.0908
2001	1.1223	1.1222	1.1228	1.1218	1.1380	1.0989
2002	1.1309	1.1308	1.1311	1.1307	1.1498	1.1086

Appendix Table 5 – Industry multifactor productivity series: Primary, mining and quarrying, construction, and manufacturing industries

March Year	Primary	Mining and Quarrying	Construction	Manufacturing
1988	1.0000	1.0000	1.0000	1.0000
1989	0.9993	0.9980	0.9763	1.0382
1990	0.9460	0.8088	1.0259	1.0145
1991	1.1090	0.8683	0.9007	0.9733
1992	1.1080	0.9076	0.8409	0.9877
1993	0.9742	0.9079	0.7908	1.0147
1994	1.1027	0.9311	0.8193	1.0133
1995	1.0827	0.8300	0.8265	1.0028
1996	1.1491	0.8025	0.8061	1.0046
1997	1.2273	1.0474	0.8365	1.0218
1998	1.2268	1.0280	0.8563	1.0212
1999	1.1545	1.0464	0.8168	0.9618
2000	1.2038	1.0025	0.8927	1.0059
2001	1.2190	1.0059	0.7888	1.0124
2002	1.2113	0.9681	0.8086	1.0004

Appendix Table 6 – Industry multifactor productivity series: Electricity, gas and water, transport and communications, business and property services, personal and community services, and retail and wholesale trade industries

March Year	Electricity, gas and water	Transport and communications	Business and property services	Personal and community services	Retail and wholesale trade
1988	1.0000	1.0000	1.0000	1.0000	1.0000
1989	1.0186	1.1104	0.9758	1.0192	1.0192
1990	1.0862	1.1612	0.9631	1.0010	1.0442
1991	1.0624	1.1828	0.9144	1.0251	0.9889
1992	1.0545	1.2759	0.8852	1.0371	0.9608
1993	1.0569	1.3862	0.8794	1.0416	0.9810
1994	1.1199	1.5087	0.9143	1.0793	1.0184
1995	1.1501	1.6621	0.8912	1.1684	1.0596
1996	1.1443	1.7659	0.8845	1.1550	1.0543
1997	1.0358	1.7616	0.9059	1.1664	1.0374
1998	1.0514	1.7872	0.8955	1.1856	1.0343
1999	1.0741	1.8568	0.8994	1.1854	1.0394
2000	1.0429	1.9710	0.8948	1.2039	1.0970
2001	1.0717	2.1180	0.9117	1.2101	1.0933
2002	0.9713	2.2490	0.9398	1.1886	1.1120

Appendix Table 7 – Australia and New Zealand productivity series

March Year	Multifactor productivity		Labour productivity		Capital productivity	
	Australia	New Zealand 'ABS equivalent'	Australia	New Zealand 'ABS equivalent'	Australia	New Zealand 'ABS equivalent'
1988	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1989	1.0257	1.0312	1.0276	1.0825	1.0220	0.9836
1990	1.0444	1.0324	1.0552	1.1119	1.0293	0.9619
1991	1.0339	1.0172	1.0524	1.1048	1.0064	0.9406
1992	1.0351	1.0215	1.0772	1.1391	0.9734	0.9222
1993	1.0421	1.0272	1.1117	1.1332	0.9450	0.9363
1994	1.0585	1.0738	1.1366	1.1551	0.9496	0.9999
1995	1.0819	1.0931	1.1669	1.1369	0.9652	1.0459
1996	1.0889	1.1070	1.1724	1.1440	0.9743	1.0647
1997	1.1193	1.1214	1.2193	1.1810	0.9835	1.0616
1998	1.1333	1.1250	1.2593	1.2069	0.9688	1.0481
1999	1.1591	1.1013	1.3131	1.1975	0.9624	1.0142
2000	1.1848	1.1549	1.3641	1.2652	0.9597	1.0570
2001	1.1825	1.1605	1.3738	1.2770	0.9459	1.0583
2002	1.1696	1.1687	1.3793	1.3030	0.9166	1.0549