Recent Productivity Trends in New Zealand Primary Sectors

Agriculture Sector and Forestry & Logging Sector

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Foreword

This technical paper on the productivity trends in the agriculture sector and the forestry and logging sector is an update and extension of MAF Policy Technical Paper 96/2. In the latter, productivity trends in the agriculture sector were measured from year ended March 1972 to 1992 using two approaches, the Laspeyre and the Tornqvist. The extension of the methodologies to the forestry and logging sector brings together all the land based primary sectors that MAF has policy responsibilities for.

Statistics NZ now have the necessary data to March year 1998. The production of essential later data is on hold while the national accounting data are being re-based from 1991/92 to 1995/96.

In this paper, the Laspeyre and the Tornqvist methods are used for comparative purposes. The Tornqvist method is considered a superior, but more data intensive, approach as it takes into account changes in the compositions of gross output and intermediate consumption over time. This is particularly so for the agriculture sector which has experienced a fall in sheep numbers and rises in dairy, deer and beef, together with fluctuating and falling incomes per farm in real terms. The Tornqvist method could not be fully applied in the forestry and logging sector since logs are the only output.

The primary sectors compete on the international arena and are subject to exchange rate volatility due to a floating exchange rate regime and the impacts of the Reserve Bank of NZ activities as it pursues macroeconomic price stability. The primary sectors can only respond to declining terms of trade by increasing productivity.

The authors demonstrate that the primary sectors are among the highest productivity growth sectors in the NZ economy and that such growth has more than doubled in the post-deregulation period from 1985, compared to the pre-deregulation period 1972 to 1984. For agriculture, total factor productivity growth increased from 1.8 percent to 4.0 percent, while for forestry and logging, total factor productivity growth increased from 1.5 percent to 4.6 percent.

I am grateful to Dr Robin Johnson, a private consultant from Wellington, for his involvement with the data compilation, the methodology and the preparation of this technical paper. The agricultural component was the subject of a contributed paper at the January 2000 conference of the Australian Agricultural and Resource Economics Society, and the authors were subsequently asked to submit it for publication with the Australasian Agribusiness Review.

Further updating of productivity trends will be undertaken as new data from Statistic NZ comes available. This will be published as tables in the annual “Situation and Outlook for New Zealand Agriculture and Forestry” and be available on the MAF Internet site.

Alan Walker
Director, Policy Information & Regions

Executive Summary

This paper sets out the methodology for estimating past trends in sector productivity in the farming and forestry sectors and the results therefrom. The farming sector is taken to be those production units who are engaged in primary production up to the point of first sale. The forestry and logging sector consists of those production units engaged in planting forests and logging the trees up to point of sale. Where forestry revenue is less than 50 percent of total revenue from a land based enterprise mix, it is included in the agriculture sector.

The data for this study is drawn from national income statistics prepared by Statistics New Zealand. From the constant price sector accounts, changes in the volume of production and use of real inputs can be derived. Productivity is essentially the ratio of real output to real input. Productivity ratios can be derived for the total volume of production and total inputs used, and for the net volume of production, or real GDP, and the level of factor inputs. These two ratios are called the Total Input Productivity Index (TIP) and the Total Factor Productivity Index (TFP).

The volume of production and input data series are converted to index numbers on a common base year, in this case 1982-83. In preparing such index numbers for this purpose it is well recognised that the choice of base year statistics can introduce a bias into the resulting estimates. In particular, changes in the mix of inputs over a period of years will not be recognised. This is known as a base-weighting problem. To overcome this deficiency a suitable system of changing weights needs to be utilised. In this paper, Tornqvist indexes are used for this purpose. A Tornqvist or Divisia index measures a change in volumes of a variable consisting of several parts, where changing proportions in the use of the parts is reflected in the final index number.

Over the period since 1972, the farm sector has recorded an increase in the growth of factor productivity of 3.5 percent per year. The forestry and logging sector increased its factor productivity by 3.6 percent per year.

These increases in factor productivity have enabled the two sectors to maintain their incomes at a higher level than they would have otherwise, and reflect the respective operators’ determination to use their inputs more efficiently, employ better machinery and plant, and increase the productivity of the people employed in the respective industries. In this way, the two industries also make an important contribution to national export earnings and the national economy.

1. Introduction

These estimates of Tornqvist productivity indexes were first prepared for a productivity conference at the University of New England in 1995 (Johnson 1996). That paper compared Tornqvist indexes with Laspeyre (base-weighted) type volume indexes, and discussed the reasons for using geometrically weighted factor shares as weights. The present paper updates the data series from 1992 to 1998 and checks out the earlier results and their implications. The necessary data for re-weighting national income data is only available back to 1972. While provisional nominal data is available for March 1999, the data in real terms has yet to be derived by Statistics NZ.

Tornqvist weighting can be used for a total input productivity index (TIP) or a total factor productivity index (TFP). The TIP index takes account of changes in the composition of intermediate inputs as well as labour and capital inputs. The TFP index simply expresses net real output as a function of labour and capital input. In national accounting terms, intermediate inputs are deducted from gross output to obtain factor or net output for an industry. Using national accounting conventions involves important assumptions about the marginal returns to intermediate inputs. With marginal revenue equal to marginal cost, any productivity gain is therefore attributed to labour and capital.

Tornqvist weighting is used to overcome biases caused by changes in the respective weights of the components of a given volume index. In the case of intermediate inputs, for example, the use of fertiliser may be changing systematically during the period of observation. Base year weights of different inputs would freeze the true weighting over a period of time. Similarly for the total fertiliser index of volume - a base year weight would freeze the mix of different fertilisers when farmers were changing their respective mixes. These biases can thus arise from any change of use in a productive input and are commonly found in fertilisers, weedkillers, sprays, and other inputs. The same reasoning applies to changes in the mix of outputs.

In the agricultural sector, statistics on a System of National Accounts (SNA) basis are available back to the 1950s. The accounts present nominal estimates of gross output, intermediate inputs and net income (equivalent to gross domestic product). For productivity analysis, these entities must be converted to volume terms. In the case of the agricultural sector, real inputs are deducted from real gross output to obtain real net output. Both gross output and intermediate inputs are deflated separately. Estimating these volume series may be by one implicit index or by the use of price indexes for each component of gross output and intermediate inputs. In turn these price series are derived by statisticians from surveys of the productive sectors. In doing so, the statisticians adopt various methods to weight the individual components of a price index. A base year weighting system introduces the same biases as for the input volume series. Theoretically, such price indexes should also be geometrically weighted as well. This would involve complete access to the databases of the statisticians if it were to be carried out systematically.

The present paper sets out the methodology of estimation of Tornqvist indexes of agricultural productivity for New Zealand since 1972, and then examines the impact of different weighting systems on estimates of TIP and TFP. The use of service costs of capital are discussed and compared with factor shares based on the national accounts. Different methods of depreciating capital stocks are discussed and the results compared. The overall results are compared with other sectors of the economy for which comparable data is available.

A major political-economic paradigm shift occurred in 1984 with the election of a Labour Government. A mini-Budget in December 1984 cancelled government subsidy support to the agricultural sector and the NZ dollar was allowed to freely float from March 1985. For this study we chose a break point of March 1985, for a pre and post reform comparison of growth rates in the various indexes derived.

2. Data Sources

There is a considerable history of studies of New Zealand agricultural productivity dating back to the 1950s (Philpott and Stewart 1958, Philpott 1963, Hussey 1970, Johnson 1970, Johnson 1972, Scobie and Eveleens 1986, Narayan and Johnson 1992). There are fewer studies on the forestry side (Diewert and Lawence 1999). These early studies derived volume data series from the national accounts using the double deflation method. In this method, outputs and inputs are deflated separately and real factor income is derived from the difference between the two. This methodology leads to volume indexes that are only consistent with the base year prices and quantities chosen. Only Hussey (1970) explored Solow (1957) type growth equations using both base year weights and changing factor shares. He found considerable variation in technology growth estimates in the period 1921-67 with factor shares generally giving higher rates of growth than base year weights (Johnson 1972, p.80). These results indicate that an investigation of the influence of different weighting systems in New Zealand agricultural productivity statistics was well overdue.

The United States Department of Agriculture (USDA), in a review of US agricultural productivity statistics (1980), maintained that indexes of individual and aggregate inputs are particularly prone to distortion (p.30):

> *In general we should expect to find an association between differing rates of growth of output categories and differing relative prices of the categories, so that a rapidly changing sector of the economy will tend to generate index-number problems. Nonetheless, the aggregation of US agricultural output for most periods does not cause anything like the index-number problems generated by the input indices.*

In the case of pesticides, there had been "drastic" changes in the quantity weights as pesticides types changed, hence no one base year was appropriate. In the case of fertiliser, price changes of different fertilisers led to different use patterns hence the base weights of the price index were no longer appropriate. These examples thus suggest that individual input categories need to be constructed on better weighting systems before aggregation starts. In the pesticide case, use of inputs is under-represented and in the fertiliser case it is over-represented. This procedure is not possible if one is using published national income accounts from Statistics New Zealand, but would theoretically be possible if one were preparing the quantity and price series that go into each category.

In principle, the correct weighting procedures should apply to the aggregation of input categories ("animal health" etc) to total input volume indexes, and the aggregation of output categories ("crops" etc) to total output volume indexes. It is aggregation at this level which is addressed in this paper. In the system used by Statistics NZ, nominal gross output and intermediate inputs are deflated separately in the agriculture account and real net output ("real GDP") calculated by difference. In the forestry account, real net output is proportional to real gross output. In agriculture, changes in the volume of outputs are estimated from physical production and changes in the volume of intermediate inputs from the price series in Statistics cost surveys. The base year in these latter input price series is changed from time to time and at the same time the "weights" or proportions used in production are up-dated. The new price series is chain linked to the old series. Such a process implicitly accounts for the changing importance of input categories in the total mix of inputs. To this extent, the input data used in this study have already been partially "corrected" for base year weight bias. The USDA report recommended that input category weights be converted to a continuous function in discrete time including every new piece of data.

In the appendices to this paper, the data for the categories of outputs and inputs used to weight the volume indexes are set out. In the agriculture account, each output category and each input category is disaggregated into its value, volume and price components back to 1972. In the forestry account, only the gross output, intermediate input and net output data are available in the same format. The volume indexes for labour employed in each sector are taken directly from numbers reported in each sector in the Quarterly Employment Survey (Statistics New Zealand) with part-time employees weighted to give a series of full-time equivalents (Philpott 1994). The volume index for capital employed is based on statistics of total capital in use in each sector. Such a series allows for the retirement of assets when they are no longer in use as compared with asset stocks valued at depreciated cost based on Inland Revenue allowances (Philpott 1994, 1995). For weighting the aggregation of capital and labour volume indexes, the service cost of capital in each year is estimated first and the labour share is obtained by difference. This is discussed further in section 3 below.

3. Methodology

The national income identity for nominal factor income is as follows:

(1) $FI = PQ - SM$

FI = factor income (GDP)

PQ = value of gross output (P = price)

SM = value of intermediate inputs (S = price)

The underlying profit maximisation equation can be written:

(2) $\Pi = PQ - SM - WL - RK$

WL = reward to labour (W = price)

RK = reward to capital (R = price)

In real terms, factor income (FI^*) is estimated by the double deflation method:

(3) $FI^* = PQ/P - SM/S$

Since the aggregates are composed of the individual input (i) and output (j) categories, (3) can be written as:

(4) $FI^*_t = \sum_j Pj_t\, Q_{jt} / P_{jt} - \sum_i S_{it}\, M_{it} / S_{it}$

where $Pj_t\, Q_{jt}$ = price and quantity of the j^{th} output category in year t,

and $S_{it}\, M_{it}$ = price and quantity of the i^{th} input category in year t.

The factor income productivity index can be defined as:

(5) $FIP_t = FI^*_t / (W_o\, L_t + R_o\, K_t)$

This can be rewritten to include base year prices for factor income:

(6) $FIP_t = (P_o\, Q_t - S_o\, M_t) / W_o\, L_t + R_o\, K_t)$

where P_o, S_o, W_o, R_o, are the prices of the base year.

A total input productivity index may also be defined in the same way:

(7) $TIP_t = (P_o\, Q_t / W_o\, L_t + R_o\, K_t + S_o\, M_t)$

To overcome the base year bias problem in the volume indexes and the price indexes, the Tornqvist discrete approximation to a Divisia Index is used here (Diewert (1976)). This defines the Index, Q_t, as the weighted change in the proportions of its base weighted value components:

(8) $Q_t = \sum_i (Q_{it} / Q_{io})^{1/2\, (w_{it} + w_{io})}$

This can be transformed by logarithms to the base e to give the estimation formula:

(9) $\ln Q_t = \sum_i 1/2 (w_{it} + w_{io}) (\ln Q_{it} - \ln Q_{io})$

where w_{it} = the share of the i^{th} input (j^{th} output) in total nominal input (output) in the year t, and

w_{io} = the share of the i^{th} input (j^{th} output) in total nominal input (output) in the base year.

By taking anti-logs, the base year takes on a value of one. The base year for this study is 1982/83 March year. The Tornqvist method estimates the rate of change in aggregate inputs or outputs from the geometrically weighted rate of change of the components of total input and total output. Average percentage growth rates can be estimated for seven indexes derived by this method - total output, total input, factor income, intermediate inputs, total factor input, total input productivity and total factor productivity.

In most studies of factor productivity, factor income is derived from the national accounting identities and then expressed as a ratio of factor income to the weighted average input of labour and capital (equation 6). In this study, the accounting identity for intermediate inputs is not utilised and the Divisia weighted volume index is substituted. Thus we have an expression for factor income which is derived from two Divisia weighted aggregates (total output and total inputs) which is then compared with a Divisia weighted average of capital and labour inputs. Alternatively, the total input factor productivity ratio can be estimated by comparing Divisia weighted total output and the Divisia weighted average of labour, capital and intermediate inputs, e.g.:

Divisia factor income = Divisia total volume index - Divisia intermediate inputs

Divisia factor productivity = Divisia factor income/ Divisia combined factor inputs.

Since two indexes cannot be subtracted, the equivalent value series is derived for each series, subtracted, and then converted back to an index.

The weighting of capital and labour inputs should follow, in theory, the procedure devised by Tornqvist. That involves determining the nominal shares of factor income going to labour and capital (including depreciation). The SNA approach divides factor income into rewards to labour, consumption of capital, operating surplus plus a correction for subsidies and taxes. As there is no separate share for capital, the Tornqvist method cannot be directly used.

There are two methods that can be used to overcome the problem. One method is to accept the wage component as a “paid” reward and attribute the remainder of factor income to capital reward. This gives a nominal factor share that does not vary much from year to year. Another method is to estimate capital rewards first and make wage rewards the residual.

This latter procedure was followed in the previous paper (Johnson 1996). In that paper, the reward to capital was the sum of depreciation of capital and the service cost of capital. The total service cost of capital (*SC*) for the agricultural sector relates to the debt level and is estimated as follows:

(10) $SC_t = A_t ((d_t / 100) + ((1-e_t) (mt / 100) (n_t / m_t)))$

where A_t = nominal asset value at beginning of year *t*,

d_t = wastage or disappearance rate during year *t*,

e_t = equity to asset ratio in year *t*,

m_t = interest rate on new mortgages registered in year *t*,

n_t = actual average interest rate paid on sheep and beef farms[1] in year *t*.

The service cost of capital for forestry relates to the opportunity cost of capital employed and wastage of the asset as follows:

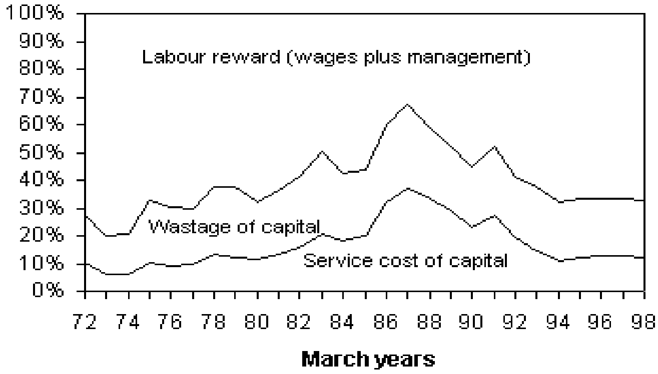
(11) $SC_t = A_t (d_t /100) + ((m_t + m_{t-1} + m_{t-2})/3)/100$

[1] From the Meat and Wool Economic Services of NZ’s annual sheep and beef farm survey.

Thus the service cost of capital in forestry differs in that it is based on total capital employed and a blend of interest rates averaged over the previous three years.

In general, wastage rates are slightly higher than conventional depreciation rates, while the service cost of capital is lower than the full opportunity cost of capital including equity. The factor share of labour varies considerably by this method over a period of time. The resulting factor shares in nominal agricultural GDP, or net income are shown in Figure 1. The share to the service cost of capital mirrors the way monetary policy was pursued over time. The freeing up of the economy from 1984 led to historically high, new mortgage interest rates between 1986 (19.1 percent) and 1988 (18.9 percent). Rates fell steadily to 7.9 percent in 1994 and then rose to remain slightly above 10 percent between 1995 and 1998.

Figure 1: Disposition of nominal agricultural GDP



Remember the objective is to determine appropriate weights in nominal terms for the application of the Tornqvist formula. By using service cost of capital as the weight for capital input volumes, the balance of net output must be considered the labour share made up from equity returns on capital and paid wages[2]. This recognises the special position of self-employed entrepreneurs (i.e. the farmers).

The definition of the capital stock variable requires further discussion. The previous study employed a device to estimate wastage of capital directly. This was possible because of the special attributes of the agricultural sector data where comparisons could be made of the "disappearance" of capital over a specified period of time. Philpott (1995, 1999a) provides another series of capital stocks derived from business depreciation rates. This results in a series not dissimilar to the wastage series. Alternatively, Philpott (1994, 1999a) provides estimates of capital stock based on a vintage model where "disappearance" is estimated for whole blocks of assets on a systematic basis. Philpott's gross capital stocks tend to be 50 per cent higher than his net capital stocks. The gross series is used in this study for measuring real assets employed. All capital stocks are derived from a perpetual inventory model in terms of the following identity:

(12) $K_t = (1 - f)\, K_{t-1} + E_{t-1}$

where K_t = the stock of conventional capital at the beginning of period t in constant prices,

K_{t-1} = the stock of capital at the beginning of period $t-1$,

E_{t-1} = capital expenditure during period $t-1$ in constant prices, and

f = the depreciation or obsolescence rate of capital chosen.

For discussion of the choice of starting dates see Philpott (1994), Industry Commission (1995), Diewert and Lawrence (1999), Philpott (1999b) and Johnson (1999).

[2] The national income identity is W+D+OS+IT-S. Paid interest is deducted from operating surplus. Thus if capital shares are based on depreciation and debt servicing, the wage share is the balance of operating surplus adjusted for indirect taxes and subsidies and wages paid.

4. Results for the Agricultural Sector

The volume of real net output (real factor income) has increased steadily over the period from1972 to 1998 with little growth in total labour employed and gross capital stock employed (Figure 2). The labour force has been in decline since 1982 and the capital stock employed has been in decline since 1987; the latter due to the slowdown of reinvestment. The broad trends in the agriculture sector are set out in Table 1.

Table 1: The agriculture sector of New Zealand (1982-83 prices)

Attribute		1972	1998	Growth rate
Labour force	FTEs	132,000	118,900	-0.5%
Capital employed	$million	$16,850	$18,638	0.3%
Real value added	$million	$1,650	$3,230	3.0%
Labour productivity	$/FTE	$12,490	$127,165	3.6%
Capital productivity	$/$1000 cap	$97.8	$173.3	2.5%
TFP ave factor share	Index	1000	2029	3.3%
TFP Laspeyre	Index	1000	2445	4.1%
TFP Tornqvist	Index	1000	3100	3.5%

Figure 2: Indices of real income, labour units and capital value

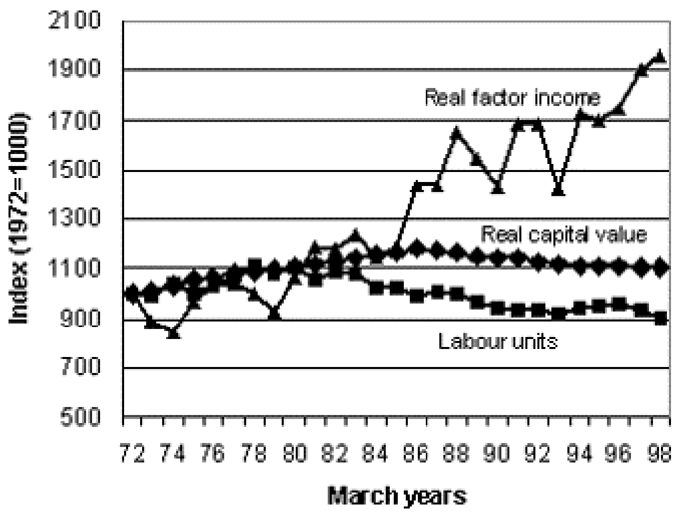
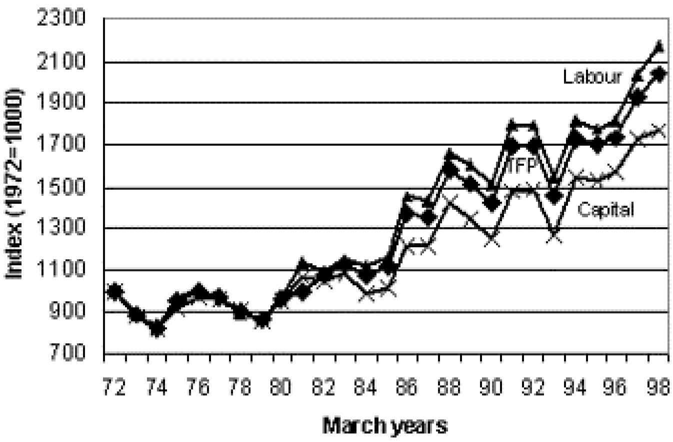


Figure 3 shows the trends in labour and capital productivity and the weighted mean of the two. Fluctuations in productivity are caused by changes in national income from agriculture rather than from the input series.

Figure 3: Agricultural productivity



The rates of change shown in Table 1 are derived from regression estimates of the rate of change over the whole period. Table 2 shows the goodness of fit statistics for the regressions for the variables entering into the total productivity and the factor productivity estimates. Where the Durbin-Watson (DW) test was poor, a first difference transformation was explored. The different specification does not change the growth rate estimates by a great margin. The equation for estimating growth rates is:

(13) $my = a + \beta t$

where my = log to the base e of index,

a = constant,

β = an estimated coefficient,

t = time.

We read β as the multiplicative annual rate of change averaged over the period concerned.

Table 2: Goodness of fit for whole period (1972-98)

	Original data			First differences		
	β	R^2	DW	β	R^2	DW
Tornqvist						
Output	1.016	.90	1.41	1.016	.91	2.01
All inputs	1.007	.02	1.54	-		
TIP	1.015	.86	1.27	1.016	.85	2.16
Factor income	1.034	.88	1.86	-		
Factor inputs	0.998	.12	0.24	0.994	.24	2.33
TFP	1.035	.87	1.52	-		
Laspeyre						
Output	1.018	.92	1.15	1.019	.87	2.04
All inputs	1.009	.03	1.67	-		
TIP	1.017	.89	1.15	1.018	.86	2.06
Factor income	1.040	.91	1.66	-		
Factor inputs	0.999	.05	0.21	0.995	23	2.37
TFP	1.041	.89	1.38	1.044	.90	1.99

Table 3 shows total input productivity (TIP) growth rates estimated from Laspeyre base-weighted index numbers and from Tornqvist geometric weighted index numbers. The latter weights are derived from average value shares between the current year nominal factor shares and the base year factor shares. If an input or an output mix is changing in a systematic way the geometric method makes the appropriate adjustment.

Table 3: Total input productivity by weighting method and periods (annual growth rates)

	Tornqvist			Laspeyre		
	Output	Input	TIP	Output	Input	TIP
1972-84	1.1	0.5	0.6	1.0	0.3	0.7
1985-98	1.8	0.0	1.8	2.2	0.3	1.9
1972-98	1.6	0.7	1.5	1.8	0.9	1.7

Figure 4 shows a comparison of the two weighting methods for gross output of the agricultural sector, Figure 5 shows the comparison for total inputs employed, and Figure 6 shows the comparison for the total input productivity index.

Figure 4: Comparison of agricultural gross output

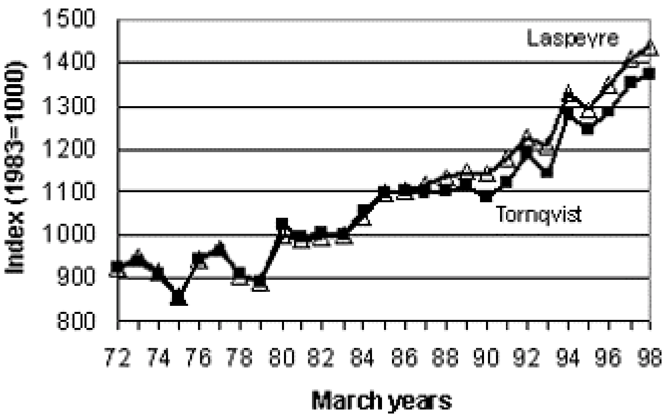


Figure 5: Comparison of agricultural total input indexes

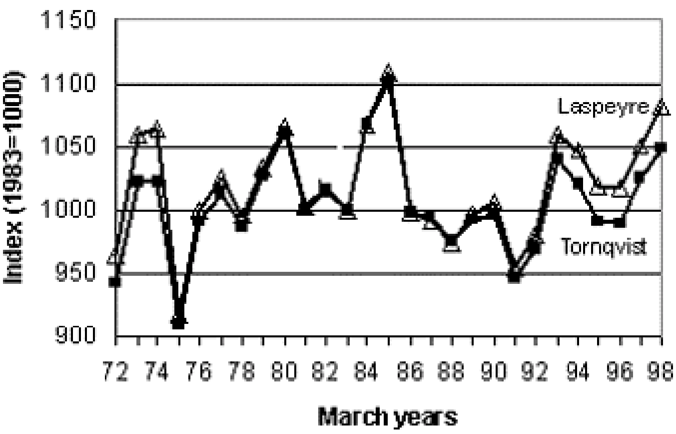
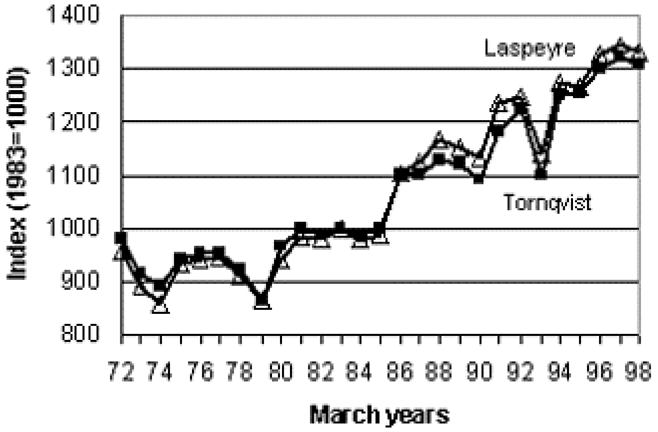


Figure 6: Comparison of total input productivity indexes



Total input productivity tends to be over-stated by base-weighted indexes particularly since 1985. Thus the better estimate of long run total productivity is 1.5 percent per year since 1972. Both methods suggest that the rate of growth has improved since 1985 compared with the earlier period 1972-84.

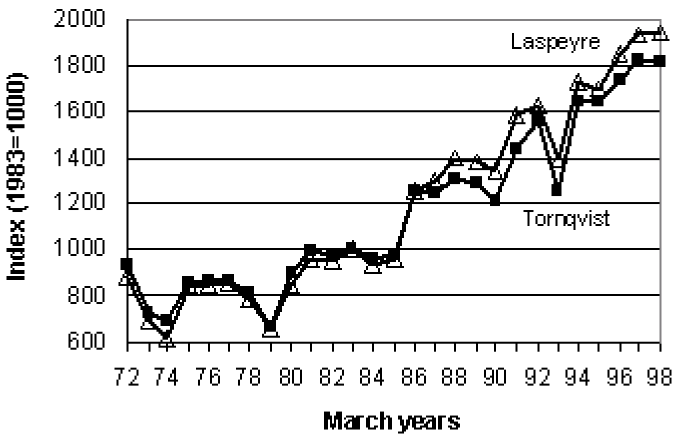
Table 4 shows the results for total factor productivity and Figure 7 shows a comparison of the two weighting methods for the total factor productivity (TFP) index.

Table 4: Total factor productivity by periods (growth rates)

	Tornqvist			Laspeyre		
	Output	Input	TIP	Output	Input	TIP
1972-84	2.6	0.8	1.8	3.1	0.9	2.2
1985-98	3.2	-0.8	4.0	3.7	-0.6	4.3
1972-98	3.4	-0.2	3.5	4.0	-0.1	4.1

Again Tornqvist indexes tend to lower the factor income increase and the factor input increase (slightly) with the resulting effect on the productivity growth rate. Thus the best estimate for factor productivity growth for the period since 1972 is more likely 3.5 percent per year rather than 4.1 percent per year as might have been indicated by the Laspeyre index.

Figure 7: Comparison of total factor productivity indexes



5. Results for the Forestry Sector

The results for the forestry sector are based on a simpler model. The categories making up gross output and intermediate inputs are not estimated by Statistics New Zealand. The following schema shows how the main variables were defined:

Volume of output = Nominal value of gross output/Implicit price of output

Volume of intermediate input = Nominal value of int. inputs/Implicit price of inputs

Volume of net output = Nominal value of GDP/Implicit price of net ouputs

Volume of labour employed = Full-time equivalents employed in the sector

Volume of capital employed = Gross capital stock at 1982-83 prices

Total input productivity (TIP) = Volume of gross output/weighted total input of intermediate consumption, labour and capital

Total factor productivity (TFP) = Volume of net output/weighted input of labour and capital

These statistics were estimated by the Laspeyre method using base year weights (1982-83), and by the Tornqvist method using a moving average of factor shares as in equation (9). The implicit price indexes are derived from a comparison of the nominal and real series of each variable as published by Statistics New Zealand (Appendix 2).

Broad trends in the forestry and logging sector are set out in Table 5. There has not been a big growth in the labour force employed since 1972 but a considerable increase in capital equipment and buildings. Real net output has expanded significantly with the increased capital investment. Depending on the weighting system used, factor productivity has increased by 2.6 to 3.0 percent per year since 1972.

Table 5: The forestry and logging sector in New Zealand (1982/83 prices)

Attribute		1972	1998	Growth rate
Labour force	FTEs	7000	7900	0.5%
Capital employed	$million	$636	$929	1.4%
Real value Added	$million	$120.7	$330.6	4.0%
Labour productivity	$/FTE	$17,242	$41,848	3.5%
Capital productivity	$/$1000 cap	$189.7	$355.8	2.4%
TFP ave factor share	Index	1000	1939	2.6%
TFP Laspeyre	Index	1000	2156	3.8%
TFP Tornqvist	Index	1000	2105	3.6%

Table 6 shows total input productivity (TIP) growth rates estimated by the Laspeyre and the Tornqvist methods. Due to the lack of data on the output categories that make up each volume variable, weighting methods only apply on the input side of the productivity ratio. TIP tends to be under-stated by the Laspeyre method, with higher growth rates in base-weighted inputs. Properly weighted, the growth of inputs has not been so great. Comparisons of the period before and after 1985 show that an increased rate of productivity growth in the latter period. This is similar to the agriculture sector.

Table 6: Forestry – Total input productivity

Method	Tornqvist			Laspeyre		
	Output	Input	TIP	Output	Input	TIP
1972-84	3.5	3.0	0.4	3.5	3.1	0.4
1985-98	4.4	2.3	2.0	4.4	3.0	1.4
1972-98	3.7	2.2	1.5	3.7	2.5	1.2

Table 7 shows total factor productivity (TFP) growth rates estimated by the two weighting systems. Growth in TFP tends to be approximately the same in both methods but there are differences in the sub-periods as the level of input rose significantly up to 1985 and then started to decline. As a result productivity growth was slow in the first period but greatly accelerated in the second period. This was the period when mechanisation of logging was introduced, and the deregulation of Forestcorp took place. There is some doubt whether all the redundant workers at Forestcorp were taken on elsewhere in the same sector or were lost to other sectors. TFP in the forestry sector may be over-stated in this period for this reason.

Table 7: Forestry - Total factor productivity

Method	Tornqvist			Laspeyre		
	Output	Input	TIP	Output	Input	TIP
1972-84	4.6	3.1	1.5	4.6	3.6	1.0
1985-98	4.4	-0.2	4.6	4.4	-0.2	4.6
1972-98	4.0	0.4	3.6	4.0	0.2	3.8

6. Comparative Results

Diewert and Lawrence (1999) estimate the rate of growth of factor productivity in agriculture for the period 1978 to 1998 as 3.87 percent per year. This lies between the above two estimates. For forestry and logging, they estimate factor productivity growth 6.34 percent per year, somewhat higher than in Table 7. For more careful comparison we need to look at the specification of their model.

“To form separate TFP indexes for the 20 industries we now take real production GDP as output, normalise it to equal 1 in 1978, and form a chained Fisher index of the three industry inputs - labour hours, plant and equipment stocks, and building 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 index to form the industry’s TFP index. The industry TFP indexes use our preferred base case specification of production base GDP, the database’s composite labour series, and our net capital estimates”.

The chained Fisher index gives very similar results to the Tornqvist index - it being the geometric average of the Paasche and Laspeyre indexes. Production based GDP is the same as used above; the use of labour hours tends to increase the input of labour and decrease the resulting TFP; and the net capital stock grows more slowly than the gross capital stock used above. Thus the Diewert and Lawrence results are lower by reason of their labour definition but higher by reason of their capital definition. A summary of their sector estimates of industry TFP growth by their methodology is shown in Table 8.

Table 8: TFPs by Diewert and Lawrence (1978-98)

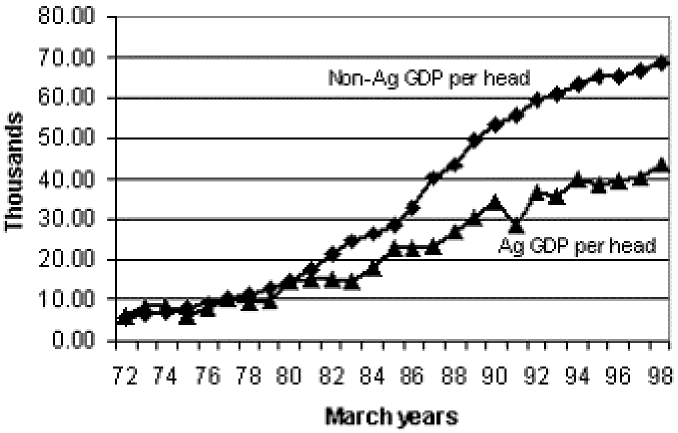
Agriculture	3.87	Fishing	0.25
Forestry	6.34	Mining	4.92
Energy	3.50	Construction	0.63
Trade, restaurants	-0.75	Transport	3.87
Communications	6.77	Finance services	-2.11
Community services	0.03	Textiles	0.68
Wood products	0.30	Food & beverages	0.68
Paper products	1.28	Chemicals	0.25
Non-metallic minerals	2.36	Basic metals	1.01
Machinery	0.03	Other manufacturing	2.43

The particular reasons for the growth or lack of growth in each sector needs to be examined against the background of labour and capital input changes, the uptake of technology, and other factors which might bear on productivity increases. This data does give a uniform set of answers though as Diewert and Lawence point out there are still definitional problems in some sectors (particularly the service sectors) which need to be resolved. For the record, the agriculture sector is third equal in the productivity comparisons over the period concerned.

7. Productivity & Income

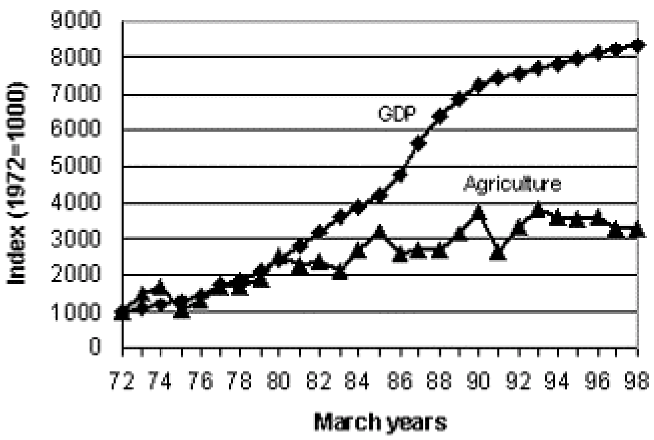
Agricultural producers in New Zealand continue to complain of the low incomes they receive (compared with the past). Clearly, the high gains in productivity have not been translated into farm incomes. This can be seen from a comparison of nominal GDP per head earned in farming compared with the rest of the economy (Figure 8). Up to 1980, farm producers earned comparable incomes in GDP terms to the rest of the economy. Since that time, there has been a consistent deterioration in relative incomes. Two factors stand out, the economic reforms from 1984 and commodity terms of trade.

Figure 8: Nominal GDP per head



Prior to 1980, a regime of producer support and a fixed exchange rate appears to have kept relative prices stable between the farm sector and the rest of the economy. The main determinant of changes in farming incomes is the commodity terms of trade. Farmers are at the mercy of international commodity price trends, modified by changes in the exchange rate and the competitive structure in the value added chain between farm gate and FOB. Figure 9 shows the trends in the price indexes of GDP and agriculture from 1972 to 1998. From 1980, agricultural prices have lagged well behind average prices in New Zealand. Over much of the 1985 to 1998 period, the non-tradeable sector remained shielded from international price competitiveness, while the export sector experienced this from the start.

Figure 9: Relative price trends for agriculture and GDP



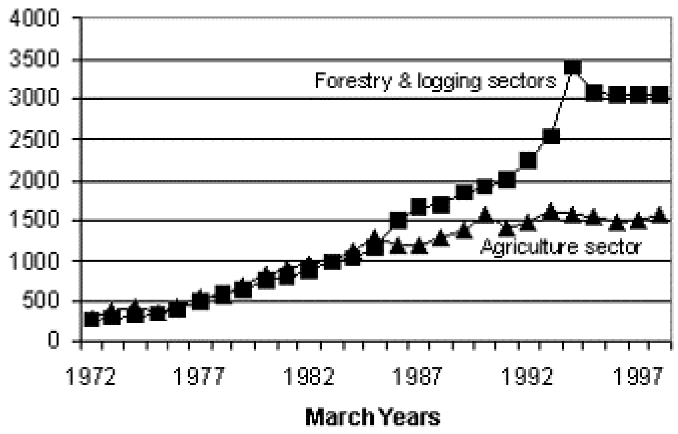
Structural adjustments within the farm sector have taken place in response to the reforms since 1984 and these reflect in the strong productivity growth that is evident from our analysis.

Economic farm sizes have steadily increased along with the shedding of farm labour and an increasing reliance on off-farm income. At the same time, there has been an increase in subdivison into lifestyle blocks, with the number more than doubling over the last 10 years to about 98,000.

The forestry sector has not been depressed by world commodity prices as much as the agricultural sector. This can be seen in Figure 10, which sets out a comparison of implicit gross output price deflators (nominal gross output divided by real gross output) for each sector. An implicit price deflator measures average commodity prices used to value real gross output. For the forestry and logging sector, Philpott's data was used up to 1980, and Statistics NZ from 1981 onwards with a change in methodology for measuring standing forest stock change.

Up to 1985, both sets of prices are roughly similar. But from 1985 to 1995 the demand for logs far outstripped agricultural products in terms of prices. Since 1995, the demand for logs from Asia has dropped and product prices have eased off. Up to 1995, the forestry and logging sector enjoyed higher incomes to proprietors and had funds available for re-investment. These increases in investment have in turn enabled productivity increases to be obtained thus adding to a generally prosperous sector.

Figure 10: Implicit gross output price deflators



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Appendix 1: Agricultural Sector

Table A1: Real outputs ($million 1982-83 prices) - years ending 31 March

	Wool	Sheep	Cattle	Pigs	Dairy	Poultry	Crops	Fruit	Veg	Other	Services	Livestock Sales	Stock Change	Total
72	663	416	741	99	1082	106	212	117	202	131	200*	468	210	4647
73	638	379	719	92	1052	112	192	124	180	125	200*	927	22	4762
74	594	347	743	86	1000	118	198	141	173	166	200*	812	29	4607
75	628	346	674	83	1067	118	206	133	210	176	200*	423	58	4322
76	667	376	721	85	1148	127	252	127	167	180	250*	678	-39	4739
77	666	388	704	100	1165	128	264	131	178	179	250*	691	31	4875
78	638	393	686	97	1063	119	244	139	215	169	250*	475	81	4569
79	659	386	663	87	1151	120	249	162	201	180	250*	547	-152	4503
80	741	456	673	85	1208	126	239	172	214	201	250*	472	221	5058
81	796	463	657	84	1160	133	235	186	200	212	300*	447	107	4980
82	758	453	686	85	1156	136	245	228	222	226	300*	451	89	5035
83	755	499	717	86	1183	146	267	213	225	220	351	458	-80	5040
84	751	476	577	89	1221	144	309	253	227	227	370	459	149	5252
85	767	518	617	97	1353	152	295	317	222	237	392	415	144	5526
86	754	369	489	103	1360	153	304	418	230	237	407	415	315	5554
87	724	510	680	94	1211	136	301	558	252	218	541	442	-16	5651
88	668	398	653	92	1289	131	261	702	264	243	550	438	110	5799
89	736	415	730	91	1257	172	182	724	278	249	592	414	-34	5806
90	661	368	565	91	1268	180	264	728	311	271	627	358	69	5761
91	615	358	644	87	1339	168	258	892	305	279	622	347	145	6059
92	633	398	661	93	1433	172	249	836	317	310	639	395	72	6208
93	521	353	670	101	1444	177	256	861	332	345	671	375	-8	6098
94	578	362	685	101	1614	187	263	798	366	346	702	361	309	6672
95	584	388	704	104	1602	203	249	774	397	374	623	334	119	6455
96	518	369	792	197	1725	222	276	869	409	375	695	326	21	6794
97	517	387	728	99	1906	214	301	922	410	364	688	428	107	7071
98	560	417	807	101	1988	225	264	909	424	386	724	390	43	7238

Source: Statistics NZ

Notes: Each product category has been deflated by the implicit price index for that category.

* Estimated. Data not collected.

Table A2: Real inputs ($million 1982-83 prices) - years ending 31 March

	Feed	AH/ Weed	Fert	Fuel/ R&M	Freight	Nec	Bought L'stock	Cap Dev	Total
72	234	137	546	857	136	755	318	-60	2923
73	283	142	622	962	164	817	472	-76	3386
74	267	127	630	987	167	870	377	-77	3348
75	228	113	420	763	117	712	349	-51	2651
76	235	134	546	807	120	749	508	-60	3039
77	238	169	525	858	126	806	457	-73	3106
78	225	172	578	789	118	699	413	-74	2920
79	226	203	547	812	122	789	522	-89	3132
80	226	225	541	823	119	864	577	-103	3272
81	216	218	479	805	117	773	496	-107	2997
82	215	216	476	828	119	784	495	-111	3022
83	219	205	427	772	122	766	517	-105	2923
84	218	250	458	827	134	856	657	-89	3311
85	229	278	534	883	145	933	571	-58	3515
86	210	259	336	731	121	882	457	-31	2965
87	211	251	352	653	110	894	457	-11	2917
88	205	234	322	606	94	860	537	-8	2850
89	232	243	389	616	104	1009	429	-8	3014
90	247	272	397	677	106	967	437	-12	3091
91	241	269	376	652	107	911	301	-12	2845
92	252	270	426	656	105	946	332	-12	2975
93	332	337	550	721	120	981	373	-9	3405
94	307	320	536	676	121	1069	309	-14	3324
95	342	305	511	644	122	1057	213	-13	3181
96	395	308	549	602	103	1029	194	-13	3167
97	405	316	573	619	106	1059	293	-13	3358
98	434	336	611	641	114	1069	357	-13	3549

Source: Statistics NZ

Note: Some categories are amalgamated to match earlier data availability. Each input category has been deflated by the implicit price index for that category.

Table A3: Labour and capital employed - years ending 31 March

	Employment (th. FTEs)	Capital Stock (Gross) ($million 1982-83 prices)	Capital Stock (Net) ($million 1982-83 prices)
72	132.1	16858	13065
73	131.4	16996	13085
74	136.7	17397	13280
75	131.6	17746	13458
76	136.2	17917	13435
77	140.9	18122	13451
78	146.5	18372	13514
79	142.9	18479	13468
80	145.2	18637	13533
81	138.8	18838	13674
82	143.4	19011	13815
83	142.7	19281	14030
84	135.1	19514	14120
85	135.3	19691	14215
86	131.0	19924	14301
87	132.8	19843	14052
88	131.5	19646	13722
89	127.3	19424	13375
90	124.7	19270	13126
91	123.2	19190	12998
92	124.1	19040	12820
93	121.7	18862	12601
94	124.7	18737	12428
95	125.9	18688	12313
96	126.7	18666	12257
97	123.9	18609	12122
98	118.9	18638	12075

Source: B P Philpott 1994 and 1999a. Gross stock is based on estimated wastage rates. Net stock is based on conventional depreciation rates.

Table A4: Service prices of borrowed capital - years ending 31 March

	Nominal Stock ($million)	Depn (ratio)	1-equity (ratio)	Mort. Rate (ratio)	Sheep Rate (ratio)	Service Cost ($million)	Prop. Stock (%)
72	4467.2	0.0292	0.3057	0.0800	0.0588	210.8	4.72
73	4918.3	0.0292	0.2235	0.0814	0.0578	207.2	4.21
74	5557.0	0.0289	0.1933	0.0831	0.0624	227.6	4.10
75	6534.7	0.0292	0.2060	0.0906	0.0626	275.1	4.21
76	7671.5	0.0301	0.1994	0.0988	0.0658	331.6	4.32
77	9260.9	0.0304	0.2063	0.1084	0.0718	418.8	4.52
78	10664.3	0.0303	0.2253	0.1131	0.0759	505.4	4.74
79	11947.6	0.0302	0.2035	0.1189	0.0724	537.0	4.49
80	14407.5	0.0299	0.1967	0.1294	0.0889	683.0	4.74
81	16748.8	0.0296	0.1814	0.1472	0.0949	784.1	4.68
82	19631.4	0.0293	0.1700	0.1608	0.1058	928.8	4.73
83	22150.7	0.0293	0.1881	0.1723	0.1070	1094.8	4.94
84	22931.9	0.0295	0.1998	0.1500	0.1070	1166.7	5.09
85	25031.9	0.0296	0.2334	0.1575	0.1060	1360.2	5.43
86	28254.7	0.0295	0.2908	0.1914	0.1180	1803.1	6.38
87	29701.4	0.0293	0.3001	0.1836	0.1220	1957.7	6.59
88	31026.0	0.0293	0.3064	0.1890	0.1280	2125.9	6.85
89	32125.6	0.029	0.2940	0.1560	0.1240	2102.8	6.55
90	33463.8	0.0289	0.2471	0.1490	0.1250	2000.7	5.98
91	34176.0	0.0291	0.2504	0.1440	0.1160	1987.2	5.81
92	34237.0	0.0293	0.2466	0.1110	0.0960	1813.6	5.30
93	34474.9	0.0294	0.2151	0.0930	0.0840	1636.5	4.75
94	34369.0	0.0296	0.2000*	0.0790	0.0770	1546.6	4.50
95	34914.0	0.0296	0.2000*	0.1010	0.0830	1613.0	4.62
96	34729.0	0.0296	0.2000*	0.1060	0.0920	1667.0	4.80
97	34652.0	0.0296	0.2000*	0.1040	0.0940	1677.2	4.84
98	34467.0	0.0296	0.2000*	0.1050	0.0890	1633.7	4.74

* Estimated

Notes: The service cost formula is given in the text. Nominal capital valuation includes livestock. Depreciation is the wastage rate from Narayan and Johnson (1992). Equity is the average of the Dairy Production Survey and the Economic Service Survey. The mortgage rate of interest is the rate on new mortgages (Statistics New Zealand). The sheep rate of interest is the average of the Economic Service Survey.

Table A5: Weighted indexes of total output, total input and total productivity - years ending 31 March (1982-83=1.000)

	Total Output	Total Input	Total Input Productivity
72	924	943	980
73	936	1.022	916
74	911	1.021	892
75	855	910	940
76	942	990	951
77	963	1.013	950
78	909	986	922
79	890	1.026	868
80	1.024	1.060	966
81	999	1.000	998
82	1.006	1.016	990
83	1.000	1.000	1.000
84	1.055	1.067	989
85	1.099	1.101	998
86	1.102	998	1.104
87	1.097	994	1.104
88	1.102	975	1.130
89	1.112	992	1.121
90	1.088	997	1.091
91	1.120	947	1.182
92	1.187	968	1.226
93	1.144	1.039	1.101
94	1.276	1.020	1.251
95	1.245	990	1.257
96	1.287	989	1.301
97	1.353	1.024	1.321
98	1.370	1.049	1.306

Table A6: Weighted indexes of non-factor inputs, factor inputs, factor income and factor productivity – years ending 31 March (1982-83=1.000)

	Non-Factor Inputs	Factor Income	Factor Inputs	TFP
72	979	849	905	937
73	1.138	657	907	724
74	1.099	650	938	693
75	901	792	921	860
76	1.032	817	944	866
77	1.053	838	968	866
78	979	813	993	818
79	1.061	656	982	667
80	1.117	897	996	900
81	1.022	967	975	992
82	1.032	970	996	974
83	1.000	1.000	1.000	1.000
84	1.136	943	978	964
85	1.199	961	982	979
86	1.012	1.226	979	1.252
87	1.000	1.231	986	1.248
88	979	1.272	973	1.308
89	1.032	1.222	949	1.287
90	1.057	1.130	931	1.213
91	965	1.333	927	1.438
92	1.011	1.430	921	1.552
93	1.151	1.134	906	1.251
94	1.115	1.498	913	1.641
95	1.057	1.505	918	1.640
96	1.057	1.605	921	1.743
97	1.132	1.659	908	1.827
98	1.197	1.608	886	1.814

Notes: Factor income is estimated by converting the weighted index of gross output and the weighted index for non-factor inputs to constant dollars and finding the difference. The difference is then converted back to an index number. Total factor productivity (TFP) is the measure of the increase in productivity in national income terms.

Appendix 2: Forestry Sector

Table F1: Forestry gross output - years ending 31 March

Year	Nominal Gross Output	Real Gross Output ($million 1982-83 prices)	Implicit Price Index
72	99	352	281.3
73	116	392.2	295.8
74	132	422.1	312.7
75	134	385.1	348.0
76	157	386.4	406.3
77	225	435.1	517.1
78	246	407.4	603.9
79	278	423.1	657.0
80	359	465.8	770.7
81	426	519.7	819.7
82	468	533.7	876.9
83	531	531.0	1000.0
84	566	543.9	1040.5
85	659	563.1	1170.2
86	869	581.9	1493.4
87	948	570.3	1662.3
88	850	506.9	1676.9
89	1148	620.3	1850.7
90	1308	679.3	1925.6
91	1542	765.9	2013.3
92	1767	789.1	2239.2
93	2034	802.5	2534.5
94	2831	830.2	2534.5
95	2674	872.6	3064.3
96	2699	881.1	3063.2
97	2634	860.1	3062.3
98	2729	891.4	3061.5
99	2646	863.7	3063.6

Sources: Philpott 1994, Statistics NZ 1999.

Table F2: Forestry intermediate inputs - years ending 31 March

Year	Nominal Inputs	Real Inputs ($million 1982-83 prices)	Implicit Prices
72	43	231.3	185.9
73	48	265.9	180.5
74	54	287.3	188.0
75	68	249.7	272.3
76	82	249.9	328.1
77	119	277.2	429.3
78	125	256.4	487.6
79	136	266.3	510.7
80	163	293.1	556.0
81	206	327.1	629.9
82	252	335.9	750.3
83	334	334.2	999.3
84	351	342.4	1025.2
85	360	354.3	1025.2
86	471	366.2	1286.1
87	487	358.7	1357.6
88	517	318.7	1622.2
89	590	390.5	1510.8
90	693	427.5	1621.2
91	841	482.1	1744.5
92	917	496.7	1846.1
93	983	505.0	1946.7
94	1337	522.7	2558.0
95	1368	549.3	2490.6
96	1401	554.3	2527.4
97	1350	541.2	2494.3
98	1410	560.8	2514.2
99	1350	543.4	2484.4

Sources: Philpott 1994, Statistics NZ 1999.

Table F3: Forestry net output (real GDP) - years ending 31 March

Year	Nominal GDP	Real GDP ($million 1982/83 prices)	Implicit Prices
72	56	120.7	0.464
73	68	126.3	0.538
74	78	134.8	0.579
75	66	135.4	0.487
76	75	136.5	0.549
77	106	157.9	0.671
78	121	151.0	0.801
79	142	156.9	0.905
80	197	172.7	1.141
81	220	192.6	1.142
82	216	197.8	1.092
83	197	196.8	1.001
84	215	201.6	1.067
85	300	208.8	1.437
86	398	215.7	1.845
87	461	211.6	2.179
88	333	188.2	1.770
89	557	229.8	2.424
90	615	251.8	2.442
91	701	283.8	2.470
92	850	292.4	2.907
93	1052	297.6	3.535
94	1494	307.5	4.858
95	1306	323.4	4.039
96	1298	326.8	3.972
97	1284	318.9	4.026
98	1319	330.6	3.990
99	1296	320.3	4.047

Sources: Philpott 1994, Statistics NZ 1999.

Table F4: Forestry labour and capital inputs

Year	Labour Units Th FTEs	Gross Capital Stock ($mil 1982-83)	Gross Capital Formation ($mil 1982-83)
72	7.0	636	44
73	7.6	661	49
74	7.0	690	50
75	7.3	719	52
76	7.8	749	56
77	8.2	783	41
78	8.8	801	47
79	9.5	824	44
80	9.9	843	35
81	9.9	853	39
82	10.0	866	38
83	10.0	878	18
84	11.5	870	21
85	11.6	865	21
86	10.8	869	16
87	9.4	850	12
88	5.8	836	17
89	6.1	828	11
90	6.4	814	15
91	5.7	805	29
92	6.7	802	34
93	7.3	805	37
94	8.1	815	47
95	9.8	838	43
96	9.1	859	54
97	9.0	889	58
98	7.9	929	

Sources: Philpott 1994, 1999 and 1999a

Table F5: Productivity indexes - Laspeyre

Year	Gross Output	Total Input	TIP	Net Output	Factor Input	TFP
72	0.663	0.698	0.949	0.614	0.709	0.865
73	0.739	0.781	0.945	0.642	0.758	0.847
74	0.795	0.812	0.979	0.685	0.731	0.936
75	0.725	0.753	0.963	0.688	0.762	0.902
76	0.728	0.769	0.945	0.694	0.806	0.860
77	0.819	0.836	0.980	0.803	0.846	0.948
78	0.767	0.813	0.943	0.768	0.892	0.860
79	0.797	0.852	0.935	0.797	0.946	0.842
80	0.877	0.915	0.959	0.878	0.979	0.896
81	0.979	0.980	0.998	0.979	0.984	0.995
82	1.005	1.001	1.003	1.006	0.995	1.009
83	1.000	1.000	1.000	1.000	1.000	0.999
84	1.024	1.050	0.976	1.025	1.093	0.937
85	1.061	1.074	0.987	1.062	1.097	0.966
86	1.096	1.076	1.018	1.097	1.044	1.049
87	1.074	1.028	1.045	1.076	0.950	1.131
88	0.955	0.865	1.103	0.957	0.714	1.338
89	1.168	1.006	1.161	1.168	0.730	1.598
90	1.279	1.080	1.184	1.280	0.744	1.720
91	1.442	1.165	1.237	1.443	0.695	2.074
92	1.486	1.216	1.222	1.487	0.758	1.960
93	1.511	1.246	1.212	1.513	0.797	1.895
94	1.563	1.300	1.202	1.563	0.853	1.832
95	1.643	1.394	1.178	1.644	0.971	1.691
96	1.659	1.390	1.193	1.661	0.935	1.775
97	1.620	1.368	1.184	1.621	0.941	1.722
98	1.679	1.385	1.212	1.681	0.887	1.893

Table F6: Productivity indexes - Tornqvist

Year	Gross Output	Total Input	TIP	Net Output	Factor Input	TFP
72	0.663	0.701	0.945	0.613	0.714	0.859
73	0.739	0.777	0.951	0.642	0.757	0.848
74	0.795	0.800	0.994	0.685	0.747	0.917
75	0.725	0.761	0.952	0.688	0.784	0.877
76	0.728	0.780	0.933	0.694	0.828	0.838
77	0.819	0.844	0.971	0.802	0.866	0.926
78	0.767	0.822	0.933	0.767	0.902	0.851
79	0.797	0.858	0.929	0.797	0.943	0.845
80	0.877	0.919	0.954	0.877	0.972	0.903
81	0.979	0.978	1.000	0.979	0.979	1.000
82	1.005	0.999	1.006	1.005	0.991	1.014
83	1.000	1.000	1.000	1.000	1.001	0.998
84	1.024	1.022	1.003	1.024	1.019	1.005
85	1.061	1.048	1.012	1.061	1.029	1.031
86	1.096	1.060	1.034	1.096	1.010	1.085
87	1.074	1.023	1.050	1.075	0.960	1.119
88	0.955	0.921	1.037	0.956	0.871	1.098
89	1.168	0.995	1.174	1.168	0.812	1.438
90	1.279	1.050	1.218	1.280	0.809	1.582
91	1.442	1.098	1.313	1.442	0.755	1.909
92	1.486	1.132	1.312	1.486	0.795	1.868
93	1.511	1.146	1.319	1.512	0.822	1.840
94	1.563	1.194	1.310	1.563	0.866	1.805
95	1.643	1.309	1.255	1.643	0.968	1.697
96	1.659	1.302	1.274	1.661	0.944	1.759
97	1.620	1.288	1.258	1.620	0.956	1.695
98	1.679	1.289	1.303	1.680	0.917	1.832