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PRODUCTIVITY IN THE NEW ZEALAND PRIMARY AND DOWNSTREAM SECTORS

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Abstract

In New Zealand, there has been increasing interest in productivity growth, both at economy-wide and sector levels. The Ministry of Agriculture and Forestry maintains a total factor productivity series for the primary sectors. As part of the ministry's flagship project on growth and productivity, we are reviewing the methodology and extending productivity derivation to downstream industries. This paper presents our research results to date.

Key words: total factor productivity, New Zealand, agriculture, forestry, downstream sectors

Background

Growth and Productivity flagship project at the Ministry of Agriculture and Forestry

'Understanding the drivers of economic growth, productivity, and resource allocation in the sectors' is one among three flagship projects that are currently undertaken at the Ministry of Agriculture and Forestry (MAF). The project aims at monitoring the performance of the sector and developing a better understanding of the sources of sector's growth in order to enhance policy understanding and outcomes.

MAF Policy is uniquely positioned contribute to this policy debate and is better placed than most government organisations to provide practical and grounded advice to the sectors that are central to New Zealand's economic, environmental and social outcomes. The agricultural, horticultural and forestry sectors are at the heart of the New Zealand economy. Including associated processing, service and transport industries, the sectors represent over 17% of the total economy gross domestic product. In addition, around two thirds of New Zealand's merchandise exports come from the land base sectors.

Identifying the linkages between economic growth, productivity and technological change are challenging. The reason for this, in part, is due to differing opinions on the relationships linking the drivers of productivity and technological change to growth. It also reflects the different methodologies and tools available to diagnose productivity growth.

Measuring sector productivity growth forms a core part of the project (others include resource use and industry structure, innovation and technology transfer, and trade and growth). This paper reports initial productivity measurement research results. These results are the starting point to further productivity measurement work that MAF Policy will continue to develop in the future.

History of productivity measurement at MAF

The first research undertaken on productivity in MAF followed an OECD request in early 1994, and culminated in a technical paper by Johnson (1996). From a statistical point of view, agriculture sector data in New Zealand is unique compared to other sectors of the economy in that a comprehensive disaggregation of both gross output and intermediate consumption is available over a reasonably long time period. A Törnqvist approach to total factor productivity (TFP) derivation was used - based on a United States Department of Agriculture publication (USDA, 1980).

In subsequent years, work on productivity measurement continued intermittently through updating to 1998 (Forbes and Johnson, 2001), extending the coverage to the Forestry and Logging Sector (Johnson and Forbes, 2000), and updating to 2002 (SONZAF 2003). The current work extends the analysis by updating to 2006, changing constant price series to 1995/96, redefining capital stock series, and extending the coverage to downstream manufacturing sectors – the Food, Beverage and Tobacco Manufacturing Sector and the Wood and Paper Product Manufacturing Sector.

Literature review of TFP work in New Zealand

Measuring TFP[2] growth has received great interest in New Zealand in the last decade. There are several reasons for this. Firstly, TFP growth contributes significantly to growth in gross domestic product (GDP) and underpins future growth in GDP per capita. Secondly, a lot of attention has been given to New Zealand TFP performance since the 1984 deregulation. MAF was the first to evaluate the impacts of the reform on the primary land based sector. Thirdly, there was a concern that New Zealand TFP growth has been low compared to other OECD countries (McLellan, 2004).

The methods used for measuring TFP growth have been well established (see for example OECD, 2001; Mawson et al, 2003). The four common methods used in measuring TFP are: index number, growth accounting, distance function, and econometric methods. The index number method however is the one that often used by statistical agencies in deriving the economy-wide and industry level TFP.

In New Zealand, there have been several major studies using the index number method to measure aggregate TFP growth. Diewert and Lawrence (1999) was the first comprehensive study that measured productivity for the economy and the major sectors. This study covered period from 1978 to 1998 and provided a comprehensive database on outputs, labour, and capital uses. Subsequent studies have extended the study period and examined alternative data sources (Black et al, 2003; SNZ, 2006). Most studies also provided a measure of productivity for the primary sectors (eg Diewert and Lawrence, 1999; Black et al, 2003, Hall and Scobie, 2006; Lattimore, 2006).

Diewert and Laurence (1999) reported an annual TFP growth rate of 3.9% for the agriculture sector for the period 1972-1998. This is three times higher than the economy-wide TFP growth rate which was estimated at 1.3%. Forestry TFP growth rate was measured at 6.3% for the same period. TFP of the downstream sectors, which include food and beverage, wood

[2] The terms total factor productivity (TFP) and multifactor productivity (MFP) are used interchangeably in the New Zealand productivity literature.

products, and paper products manufacturing, grew at a lower rate during the same time period, being 0.7%, 0.3%, and 1.3% respectively.

Black et al (2003) reported an MFP growth rate of 1.4% for the agriculture, fisheries, and forestry aggregate sector over the period 1988-2002. The sector however had a higher TFP growth rate during 1993-2002 (2.5%).

Both Hall and Scobie (2006) and Lattimore (2006) utilised a similar data set in which the agriculture sector was more narrowly defined compared with other studies. These two studies excluded agriculture services from the output categories in order for the output series to be consistent over a long period of time (1929-2005). Lattimore (2006) reported a TFP growth rate of 1.5% per year for the period before1984, and 2.5% per year after 1984.

The first official productivity measures for the New Zealand economy were released by Statistics New Zealand in March 2006. These were annual labour, capital, and MFP indexes from 1988 to 2005 covering a substantial subset of the economy[3]. The aggregate MFP growth rate of the measured sector was estimated at 1.8% for the period 1988-2005. The future intention of Statistic New Zealand is to provide an annual update of the indexes and eventually extend to lower sectoral levels.

Description of methodology

Since mid 1990s, MAF has maintained a series of TFP for the primary sectors. Before the Growth and Productivity (GAP) project was initiated, on-farm TFP growth estimates were available for the period 1972-2003.

This project continues the current TFP work at MAF. In particular, the study period is extended to 2006. Further methodology experimenting is undertaken. There has also been collaboration with Statistics New Zealand in updating data series and measurement methodology. Furthermore, for the first time, TFP growth is measured for the downstream manufacturing sectors.

Index number method

TFP is measured as a ratio of an output index to a composite input index.

$$TFP_t = \frac{O_t}{I_t} \tag{1}$$

where O_t is output index, I_t is input index, t represents time period t.

[3] The measured sector comprised the Australia and New Zealand Standard Industrial Classification 1996 divisions A to K plus P.

The Törnqvist index method is used to derive the (aggregate) output index (in the case of multiple outputs) and the aggregate input index. In general, the Törnqvist quantity index between period t and t-1 (or chained index) is written as:

$$T_t = \prod_i^n \left(\frac{q_{i,t}}{q_{i,t-1}} \right)^{\frac{1}{2}\left(w_{i,t} + w_{i,t-1} \right)} \tag{2}$$

where q is the quantity of output (or input), w is the share of the output (or input) in total value of outputs (or inputs), n is the number of outputs (or inputs), and i represents output (or input) i.

For example, a composite input index of capital (K) and labour (L) is calculated as:

$$I_t = \left(\frac{K_t}{K_{t-1}} \right)^{\frac{1}{2}\left(w_{k,t} + w_{k,t-1} \right)} \cdot \left(\frac{L_t}{L_{t-1}} \right)^{\frac{1}{2}\left(w_{l,t} + w_{l,t-1} \right)} \tag{3}$$

where w_k and w_l are the shares of capital income and labour income, respectively, in total factor income (GDP), that is:

$$w_{k,t} = \frac{Y_{k,t}}{Y_{k,t} + Y_{l,t}} \quad \text{and} \quad w_{l,t} = 1 - w_{k,t} \tag{4}$$

where Y_k and Y_l represent capital and labour incomes respectively.

The first component on the right hand side of equation (3) represents the contribution of capital to output growth and the second component represents labour contribution.

TFP represents the growth in output that can not be explained by input growth. It is therefore derived using a composite input index. When only one input is used, the output-input ratio is called partial productivity (eg capital or labour productivity). Partial productivity reflects the combined effects of changes in other inputs, as well as technical and efficiency change. For example, labour productivity reflects the joint influence of changes in capital and TFP growth. Therefore it can be expressed as:

$$LP_t = \left(\frac{TFP_t}{TFP_{t-1}} \right) \times \left(\frac{\frac{K_t}{L_t}}{\frac{K_{t-1}}{L_{t-1}}} \right)^{\frac{1}{2}\left(w_{k,t} + w_{k,t-1} \right)}$$

where (K/L) represents the capital to labour ratio. The increase (decrease) of this ratio over time indicates capital deepening (shallowing).

Data

Output

For all sectors, GDP in constant prices is used as output volume. Statistics New Zealand data on constant 1995/96 price GDP for 1988 to 2006 are available for all sectors. These are used to derive output indexes. For the primary sectors, GDP series backdated to 1972 were constructed using constant price 1991/92 data[4].

Capital input

Statistics New Zealand data on industry productive capital stock (PKS) in constant prices is used as capital input volume. To derive capital cost (or income), PKS in current prices is used. This approach is called 'user cost of capital' (UCC) approach. Industry capital cost is specified as:

$$UCC = PKScurrentprices * (d + r) \quad (5)$$

Where d is capital depreciation rate, r is rate of return on capital.

Following Statistics New Zealand approach (SNZ, 2006), depreciation rate is calculated as a ratio between consumption of fixed capital and current price PKS. For the agriculture sector, capital rate of return obtained from Meat and Wool New Zealand is used. For other industries, ten year government bond yield is used.

Recent productivity literature (eg OECD, 2001; Coelli et al, 2005) suggested the use of capital gain and production tax on capital in deriving capital cost. MAF is currently considering these issues. However due to current data unavailability, this paper only reports TFP estimates using the approach as specified in equation (5) above.

Labour input

Statistics New Zealand fulltime equivalent employment (FTE) data is used for labour volume. Labour income (cost) is simply one minus capital cost share. MAF is considering alternative data for labour volume (eg hour paid). However this remains a future research issue.

Statistics New Zealand employment data for the primary sector comes from a combination of the Census of Population and Dwellings and the Household Labour Force Survey (HLFS). This provides full and part time employment details. The latter are converted to full time equivalents by assuming that, on average, part timers are 50% employed on an annual basis. For the manufacturing sectors, employment data comes from a combination of the Quarterly Employment Survey and the HLFS. In this case, employment is expressed as the average weekly employment numbers and the average weekly hours paid.

[4] For the primary sectors, GDP data in current prices and in 1991/92 constant prices are available back to 1972. The 1991/92 constant price series is used to estimate a longer run 1995/96 constant prices series as both series overlap for the year 1995/96. This is a temporary solution until Statistics New Zealand publishes a 1995/96 constant price GDP series backdated to 1978 for all sectors of the economy at the end of 2007.

TFP results and analysis

Results overview and comparative analysis

For both primary sectors, TFP growth has doubled from 1972 to 2006, with an average growth rate of more than 2% per year (Table 1). Results also show that almost all TFP growth come from TFP growth of the period after the 1984 deregulation. This was the start of the era of farming without subsidies and comprehensive financial deregulation. It reflects that farming has become more efficient and utilised better technology[5]. The fluctuations in TFP growth reflect also external shocks. For example, the 1993 dip was the result of an El Nino drought in 1992/93. The 2000 dip reflects the flow-on impacts from the Asian crisis and also El Nino and La Nina droughts which happened around this time. The major fluctuations between 1988 and 1984 in the forestry and logging sector reflect changes in ownership with the sale of government owned forestry estates to the private sector.

The downstream manufacturing sectors experienced modest growth during 1988 and 2005, averaging around 1% for food, beverage, and tobacco manufacturing and 0.4% for wood and paper product manufacturing. This is lower compared to average TFP growth of Statistics New Zealand's measured sector. The food, beverage, and tobacco manufacturing sector experienced a higher TFP growth rate for the period from 1988 to 1993 compared to the subsequent period, averaging 1.8% per year. This is higher than average TFP growth of Statistics New Zealand's measured sector for the same period. TFP growth of the wood and paper product manufacturing sector, however, declined during 1988 and 1993. In the subsequent period to 2005, the sector had an average TFP growth rate of 0.8%, similar to that of food, beverage, and tobacco manufacturing, but lower than Statistics New Zealand measured sector's average.

[5] Index number method assumes efficient production. However, in general, TFP growth reflects efficiency gain, technical change and other factors such as economies of scale, variations in capacity utilization, and measurement errors.

Figure 1. TFP of agriculture, forestry, and dowstream sectors

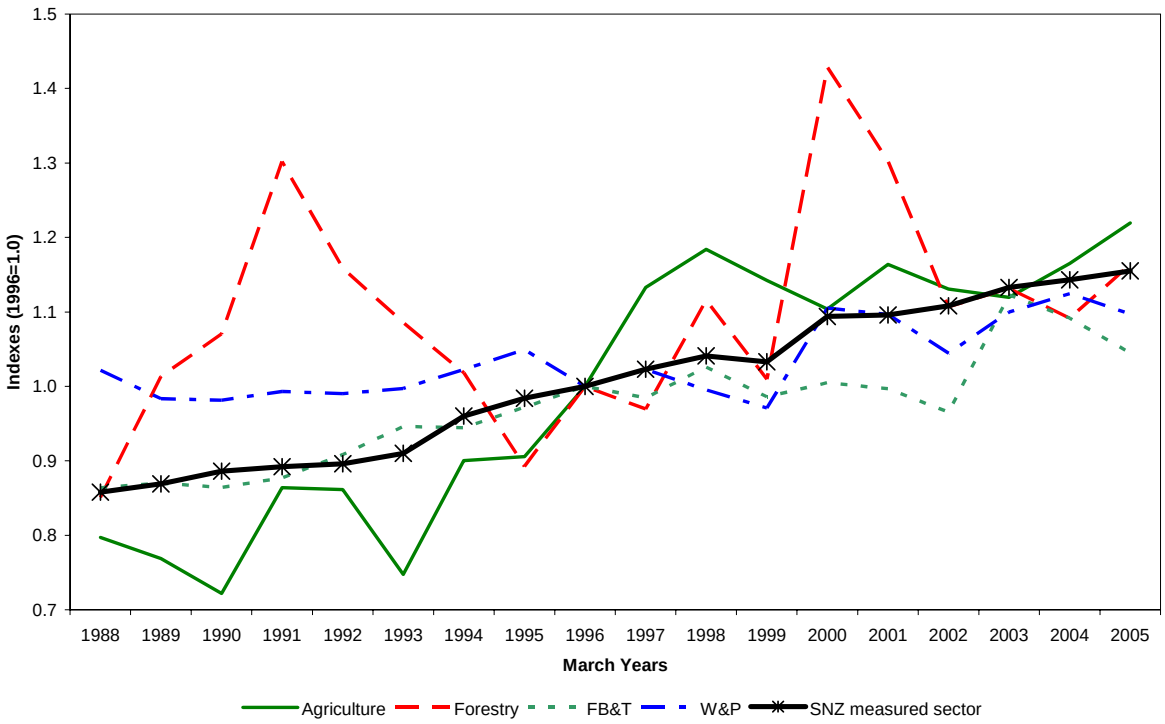


Table 1: Agriculture, forestry, and downstream sectors TFP growth
(annual average growth rate %, 1972-2006)

Time Period	Agriculture	Food, Beverage & Tobacco Manufacturing	Forestry & Logging	Wood & Papers Manufacturing	SNZ Measured Sector
1972-2006	2.0%		2.7%		
1972-1984	-0.5%		1.2%		
1984-2006	3.4%		3.6%		
1988-2005	2.5%	1.1%	1.9%	0.4%	1.8%
1988-1993	-1.3%	1.8%	5.0%	-0.5%	1.2%
1993-2005	4.2%	0.8%	0.6%	0.8%	2.0%

Agriculture

Agriculture TFP growth during 1972 and 2006 can be broken into five different phases: (1) a no-growth period 1972-84; (2) a modest growth period 1984-93 (3.2% per year); (3) a strong growth period 1993-98 (9.6% per year); (4) a TFP declining period 1998-2003 (-1.1% per year); and (5) a recent growth period 2003-06 (1.9% per year). Agriculture labour productivity and capital productivity mimic these trends, although in recent years the former grew at a higher rate (2.6% per year) while the later declined at 1% per year (Figure 2).

The fluctuation in TFP growth could be further explained by the movements of output and input growth. As shown in Figure 3, between 1972 and 1984, input was almost flat with no

growth in output, which made this the no-growth period. From 1984 to 1993, output grew 1.7% per year, while input decreased 1.4% per year, which led to a modest TFP growth period. The strong growth period 1993-1998 was the result of an output growth at 7.8% per year and input decrease at 1.7% per year. From 1998 to 2003, input increased slightly at 1% but output was flat, which explains the decline in TFP growth. In the last three years, input showed a decline of 0.5% per year while output grew 1.4% per year, which led to an increase in TFP growth.

The decrease of input between 1984 and 1998 reflects a reduction in capital input of 1.5% per year between 1984 and 1993 and 0.8% between 1993 and 1998 and a reduction in labour input of 0.8% and 2% for the corresponding periods (Figures 3-4). Both capital and labour increased during 1998-2003, around 1% per year on average. In the last three years, capital continued to increase at 2.4% per year while labour decreased at 1.2% per year. This led to a significant higher capital to labour ratio compared with the rest of the period.

Over the 1972-2006 period, output grew by 1.6% per year, there was no contribution from capital, and labour contribution declined at 0.4% per year (Figure 6). TFP grew at 2% per year which offset the negative contribution from labour. However, from 2003 onwards, capital contribution slightly increased at 0.4% per year, while labour contribution declined further at 1% per year.

An improved capital contribution was also reflected in slightly higher contribution from capital deepening to labour productivity growth (Figure 8). From 2003 onwards, capital deepening contribution to labour productivity has growth at an averaged rate of 0.7% per year, much higher than the 1972-2006 average of 0.1%. Needless to say, TFP growth is also a significant contribution to sector labour productivity growth. Results showed that during the study period labour productivity grew at 2.1% per year, which was made up of 2% TFP growth, and 0.1% capital deepening growth.

Figure 2. Agriculture sector productivity indexes

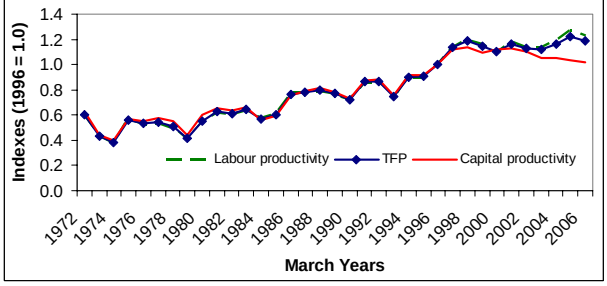


Figure 3. Agriculture: input, output, & TFP indexes

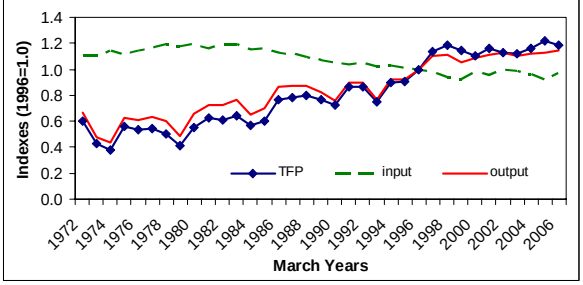


Figure 4. Agriculture: capital and output indexes

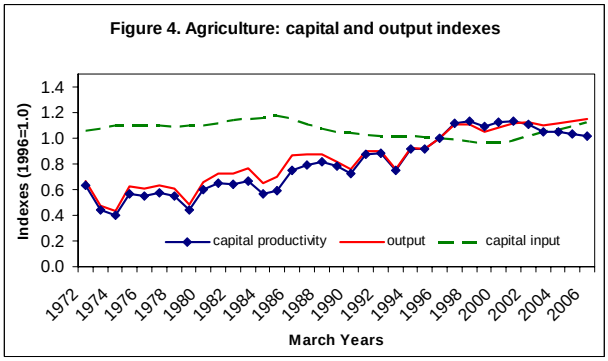


Figure 5. Agriculture: labour and output indexes

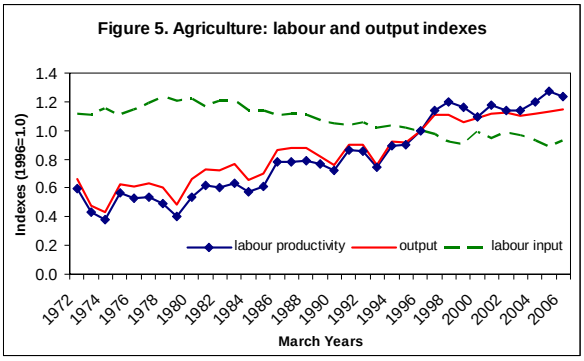


Figure 6. Agriculture: contribution to sector GDP growth

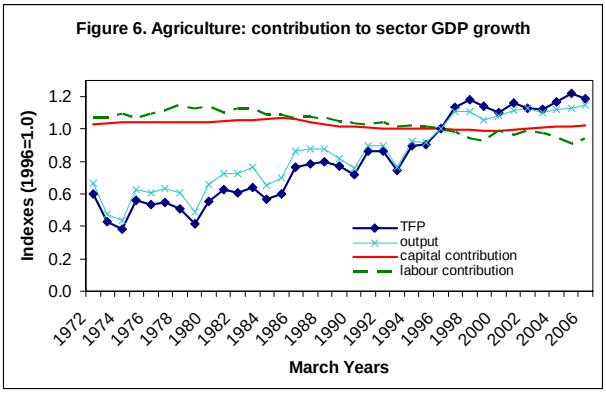


Figure 7. Agriculture: capital to labour ratio indexes

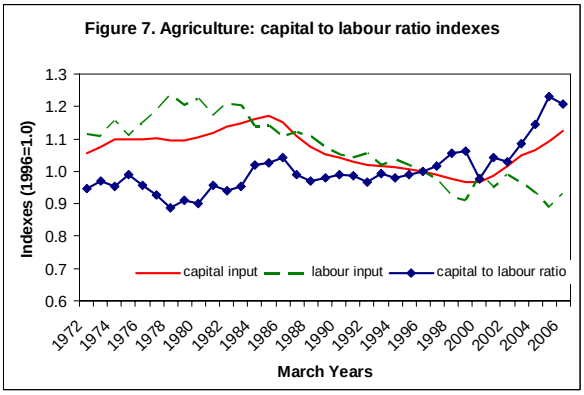
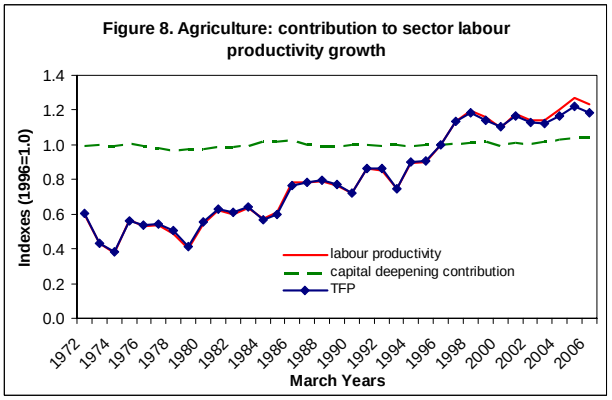


Figure 8. Agriculture: contribution to sector labour productivity growth



Forestry and Logging

Forestry and logging TFP growth also experienced different phases over the period from 1972 to 2006. There was modest growth between 1972 and 1984 (averaging 1.2% per year). Then there were two growth peaks in 1991 and 2000. This led to strong growth of 12% per year between 1984 and 1991. Since 2000, there was a period of declining growth until 2004 (averaging -6.5% per year), before TFP growth rising up again at 8% per year in the last two years. Labour productivity growth closely followed TFP growth, although having a slightly higher growth rate at 3.2% per year between 1972 and 2006. Capital productivity, however, grew at a lower rate over the period, averaging 1.2% per year (Figure 9).

Figure 10 shows the movements in forestry and logging output and input that helps to explain the fluctuation of TFP growth during the studied period. Between 1972 and 1984, both output and input increased, however output increased at a slightly higher rate (4.4% per year) compared with 3.2% per year of input growth. This led to modest TFP growth of 1.2% per year. From 1984 to 1991, output continued to grow at 5% per year while input decreased at 6.3% per year, leading to TFP growth of 12% per year. The next period from 1991 to 1995 experienced a decline in TFP growth as input grew at a much faster rate than output (13.6% vs 3.3% per year). In the following period until 2000, output continued to grow modestly at 2.2% while input decreased at 7% per year, this improved TFP growth at 10% per year. From 2000 to 2004, input grew much faster than output (10.3% vs 3.1% per year), this decreased TFP growth at 6.5% per year. In the last two years, both output and input have declined, although output declined at a slower rate than input (-3.4% vs -10.8% per year), this lead to a TFP growth rate of 8% per year.

The fluctuation in forestry and logging input reflected the volatile movement in labour input (Figure 11). Capital input growth has been quite flat during the first half of the studied period, although slightly increased in the second half. Input growth between 1972 and 1984 was made up of both capital and labour growth. Similarly, input decline between 1984 and 1991 was made up of both capital and labour input decline, although labour volume declined at a much higher rate (-9.4% vs -0.6% per year). Capital input kept increasing between 1991 and 2000, however labour input increased between 1991 and 1995 but declined between 1995 and 2000. In recent years, capital input increased modestly at 2.2% per year while labour input decreased significantly at 13% per year. This is reflected in a higher capital to labour ratio growth (17.4%) as compared with an average rate of 4.3% for the whole period.

The contribution of capital growth to the sector GDP growth has been quite flat during the studied period (Figure 14). In contrast, labour contribution has been quite volatile due to the fluctuation in its volume. TFP growth contributed significantly to sector GDP growth. For the 1972-2006 period, GDP growth averaged 3.4% per year, TFP growth contributed 2.7%, while capital and labour contributed 0.3% and 0.4% respectively (Table 2). Between 1972 and 1984, labour contribution outweighed TFP contribution (2.7% vs 1.2%). However, for the second part of the studied period, labour contribution declined at an average rate of 0.9% per year.

Figure 9. Forestry and Logging Sector Productivity Indexes

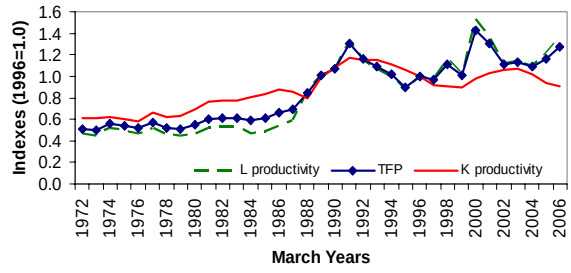


Figure 10. Forestry and Logging: input, output, & TFP indexes

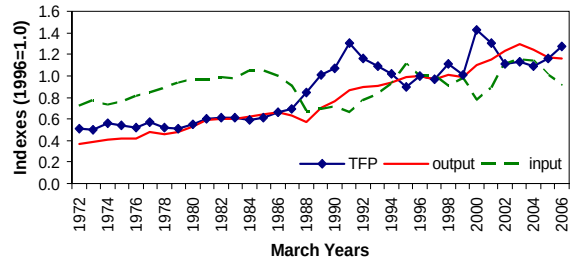


Figure 11. Forestry and Logging: capital, labour, and capital deepening

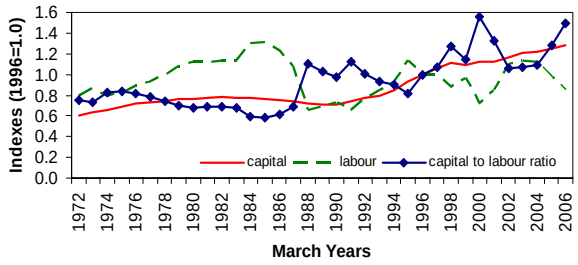


Figure 12. Forestry and Logging: labour productivity index

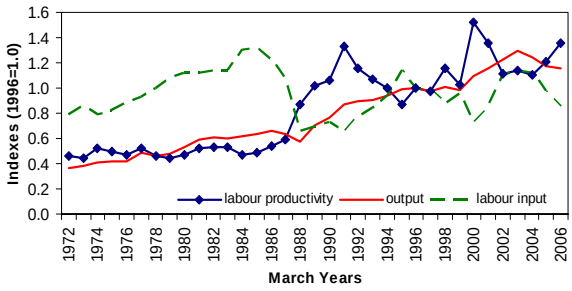


Figure 13. Forestry and Logging: capital productivity

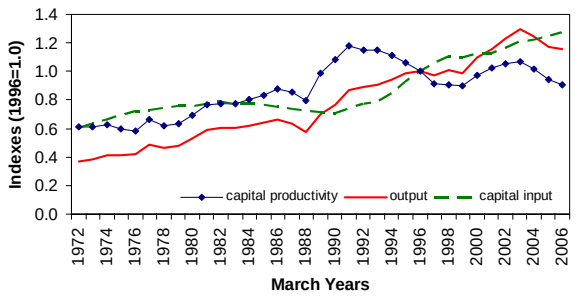


Figure 14. Forestry and Logging: Contribution to sector GDP growth

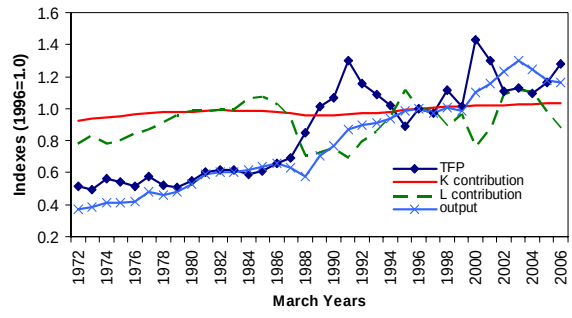
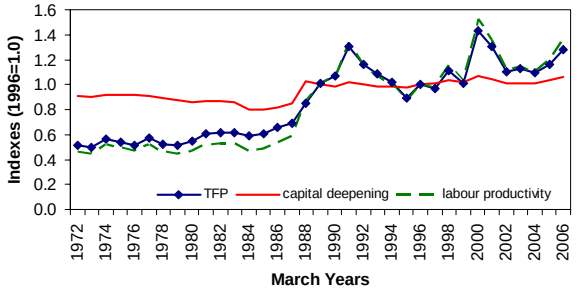


Figure 15. Forestry and Logging: contribution to sector labour productivity growth



Food Beverage and Tobacco manufacturing

The food, beverage, and tobacco manufacturing (FB&T) sector experienced a modest TFP growth period from 1987 until 1998. However TFP growth slowed down from 1998 to 2003, and declined further thereafter. The period with the highest growth rate was between 1987 and 1993 (2.3% per year), then growth slowed down to 1.7% per year during 1993 and 2003. In the last three years, TFP growth declined by 2.8% per year. These fluctuations led to an annual average growth rate of 1.2% for the whole 1987-2006 period, while capital productivity declined by 1.4%, and labour productivity increased by 2.6% (Figure 17).

Between 1987 and 2006, output (GDP) grew at 2.1% per year. The period between 1993 and 2003 experienced the highest output growth rate of 3.8% per year. There was no growth in output in the last three years (Figure 16). Input declined between 1987 and 1993 (-2% per year), and increased by 2.2% per year for the rest of the period. This explains why TFP growth has been slow in the second part of the study period.

Capital input has been on the rise since the beginning of the studied period, averaging 3.5% per year. However, labour input declined from 1987 to 1993 (-4.8% per year), then slowly increased at an average of 1.7% per year for the rest of the studied period. Since 1998, capital input has increased rapidly, averaging 4.5% per year, while labour input grew at a slower rate of 2% per year. This has led to a higher capital to labour ratio growth at 2.5% per year compared with only 0.5% per year in the previous 1993-98 period (Figure 20).

In contrast to the primary sector, results showed a significant contribution from capital to output growth (Figure 21 and Table 2). From 1987 to 2006, output grew at 2.1% per year, this was made up of 1% contribution from capital growth, 1.2% from TFP growth, and -0.1% from labour growth. In recent years, both capital and labour contributed significantly to output growth, averaging 1.4% for capital and 1.6% for labour, which helped to offset declining TFP growth (-2.8% per year). Similarly, capital deepening contributed significantly to labour productivity growth, averaging 1.2% per year for the period 1987-2006.

Figure 16. Food, Beverage, & Tobacco Manufacturing: input, output, & TFP indexes

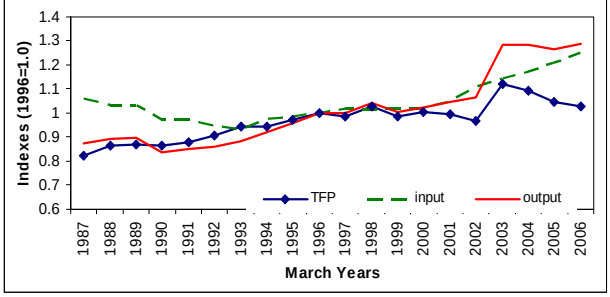


Figure 17. Food, Beverage and Tobacco Manufacturing Sector Productivity Indexes

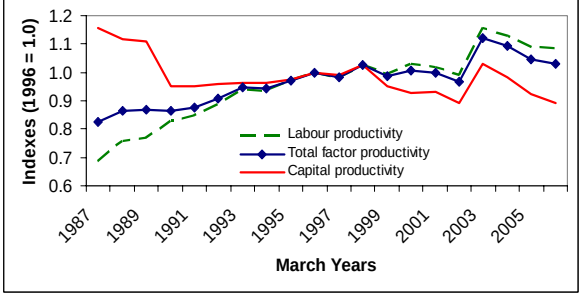


Figure 18. FB&T: labour and output indexes

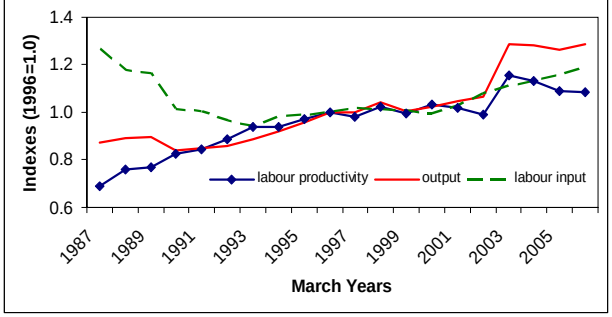


Figure 19. FB&T: capital and output indexes

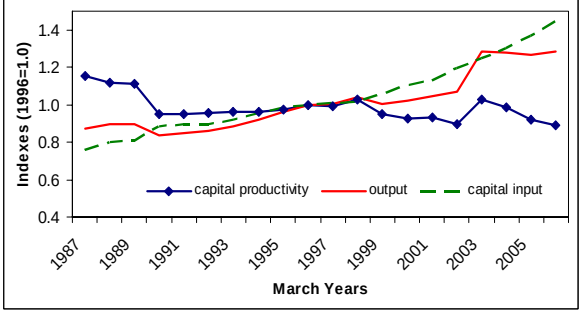


Figure 20. FB&T: capital to labour ratio indexes

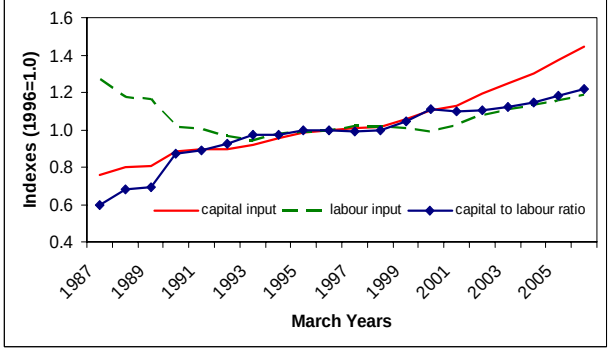


Figure 21. FB&T: TFP, capital, and labour contribution to sector GDP growth

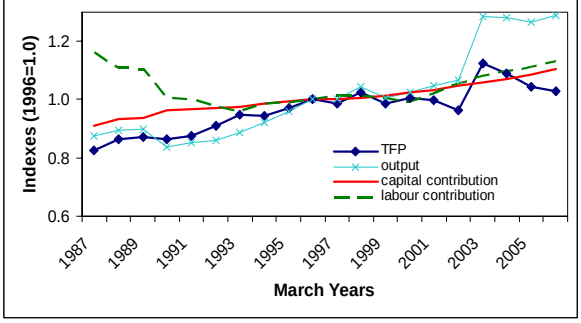
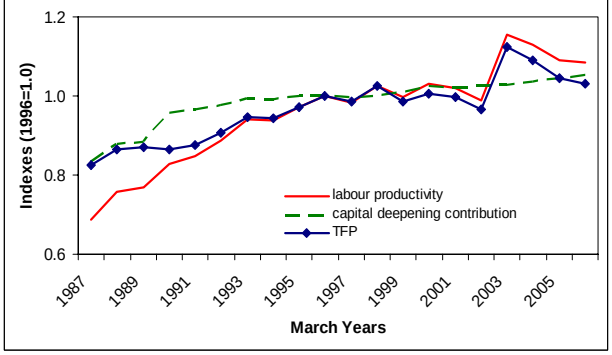


Figure 22. FB&T: contribution to labour productivity



Wood and Paper product manufacturing

The wood and paper product manufacturing (W&P) sector TFP grew 1.4% per year from 1987 to1993, followed by a no growth period until 1999. The next period until 2004 experienced the strongest growth, averaging 3% per year. However, in the last three years, TFP has declined at 4.7% per year. All these fluctuations led to an average growth rate of 0.6% for the period 1987 to 2006, while capital productivity declined by 1.7% per year, and labour productivity grew by 2.1% (Figure 23). However, all productivity indexes decreased sharply from 2004.

Between 1987 and 1993, output grew 2.1% per year while input grew 0.7% per year, leading to modest TFP growth of 1.4% per year. In the next six years to 1999, input grew slightly higher than output (1.8% vs 1.4% per year), leading to TFP declining at 0.4% per year. From 1999 to 2004, output increase sharply at 4.8% per year while input continued to grow at 1.8% per year, leading to an average TFP growth rate of 3%. From 2004 onwards, output growth declined by 0.7% per year while input expanded at 4.2% per year, leading to TFP declining at 4.7% per year.

Input's slow growth between 1987 and 1993 was due to a decrease in labour input (-2.6% per year), however this was offset by capital growing at a higher rate (4.8% per year). Capital input kept growing at a similar rate until 2004 and only slowed down in the last three years to 2.6%. Labour input growth was almost flat until 2004 and then increased by 5.2% per year. Subsequently, this led to an increased capital to labour ratio from 1987 to 2004 (4.7% per year), but declined in recent years (-2.4% per year).

Capital growth contributed significantly to output growth during the studied period. From 1987 to 2006, output grew at 2.3% per year, which was made up of 1.6% contribution from capital, 0.6% contribution from TFP growth, and only 0.1% from labour growth. Only in recent years, did contribution from labour increase by 3.1% while capital continue to contribute about 1%.

Figure 23. Wood and Paper Products Manufacturing Sector Productivity Indexes

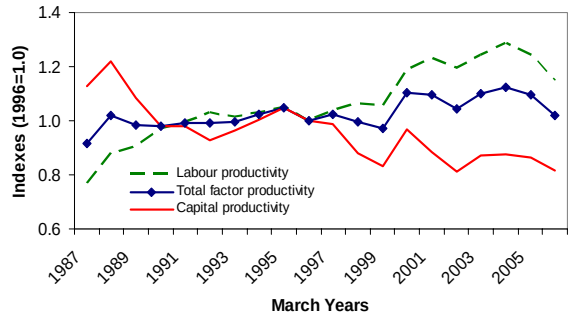


Figure 24. Wood and Paper Products manufacturing: input, output, and TFP indexes

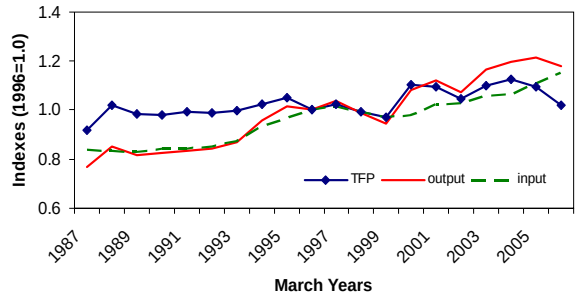


Figure 25. W&P Manufacturing: capital to labour ratio

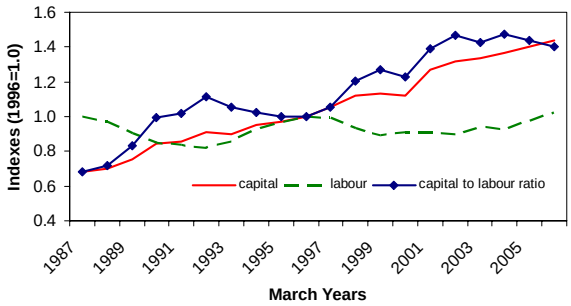


Figure 26. W&P Manufacturing: labour productivity

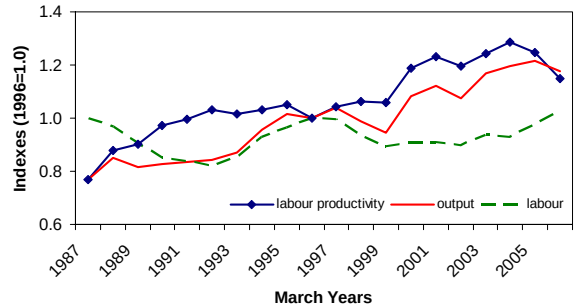


Figure 27. W&P Manufacturing: capital productivity

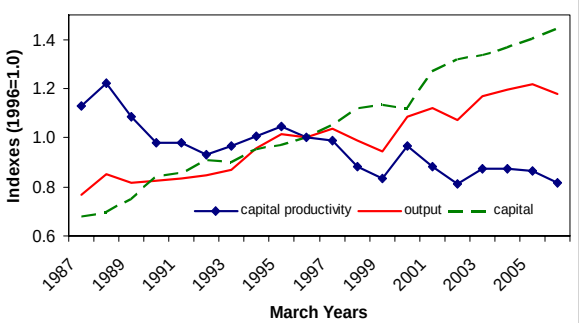


Figure 28. W&P Manufacturing: contribution to sector GDP growth

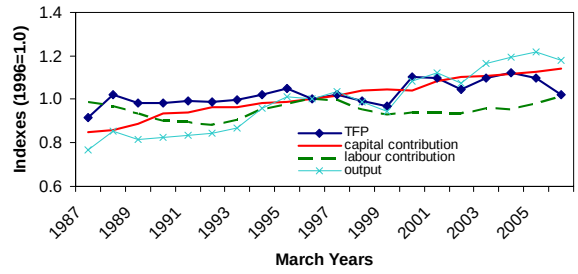


Figure 29. W&P Manufacturing: contribution to sector labour productivity growth

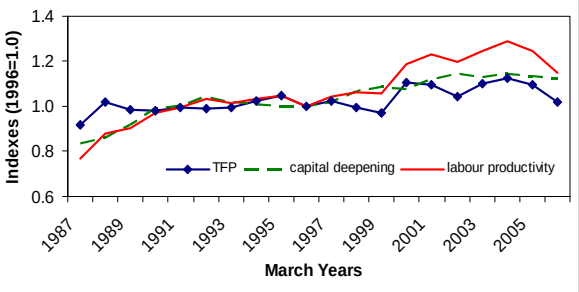


Table 2. Contribution of TFP, capital, and labour to sector GDP growth
(annual average growth rate %, 1972-2006)

Time Period		Agriculture	Food, Beverage &Tobacco Manuf.	Forestry & Logging	Wood & Papers Manuf.	SNZ Measured Sectors
1972-2006	Output growth	1.6%		3.4%		
	K contribution	0.0%		0.3%		
	L contribution	-0.4%		0.4%		
	TFP contribution	2.0%		2.7%		
1972-1984	Output growth	-0.1%		4.4%		
	K contribution	0.3%		0.5%		
	L contribution	0.1%		2.7%		
	TFP contribution	-0.5%		1.2%		
1984-2006	Output growth	2.6%		2.9%		
	K contribution	-0.2%		0.2%		
	L contribution	-0.6%		-0.9%		
	TFP contribution	3.4%		3.6%		
1988-2005	Output growth	1.5%	2.0%	4.3%	2.1%	2.8%
	K contribution	-0.1%	0.9%	0.4%	1.6%	1.0%
	L contribution	-0.9%	0.0%	2.0%	0.1%	0.0%
	TFP contribution	2.5%	1.1%	1.9%	0.4%	1.8%

Sensitivity analysis

Chained vs unchained TFP

In MAF's previous works, only unchained TFP indexes were reported. In this study, we opted to present chained TFP indexes, which were often suggested by the literature (see for example OECD, 2001). Chained TFP is derived by changing the fixed base year comparison to a year-to-year comparison. For example, all indexes are expressed as a ratio between a quantity of the current year (t) and a quantity of the previous year (t-1), and average weight (value share) is calculated for weights of period t and (t-1). The formulae in the methodology section described this method.

Results show that there is trivial difference between a chained and an unchained TFP index. As Table 5 shows, there is no difference between the two indexes for all sectors except

forestry and logging. The differences that happened with this sector perhaps due to more fluctuations in TFP growth rate during the study periods.

Table 5. Experiment results for chained and unchained TFP indexes

Period	Agriculture		Forestry		FB&T		W&P	
	Unchained	Chained	Unchained	Chained	Unchained	Chained	Unchained	Chained
72-06	2.0%	2.0%	2.9%	2.7%				
72-84	-0.5%	-0.5%	1.0%	1.2%				
84-06	3.4%	3.4%	3.9%	3.6%				
87-06					1.2%	1.2%	0.6%	0.6%

Capital rate of return

For all sectors except agriculture, government 10 year bond yield is used as interest rate for capital cost derivation. An alternative for the agriculture sector is a return on capital from industry data source. Meat and Wool New Zealand Economic Services has a long time series from their sheep and beef farm survey and this data is used here. Results showed that TFP growth estimates using 10 year bond yield are very close to those using the sheep and beef rate of return. Average TFP growth for the 1972-2006 period using 10 year bond yield was 1.9% per year, while TFP growth using sheep and beef data was just slightly higher at 2% per year.

Conclusion

Concluding remarks

This paper reports MAF recent and ongoing research in measuring TFP growth in the primary and downstream manufacturing sectors. Over the study period 1972-2006, primary sector TFP has increased, averaging 2% for agriculture and 2.7% for forestry and logging. Following financial deregulation and removal of government subsidies after 1984, TFP growth was significantly higher, averaging 3.4% for agriculture and 3.6% for forestry and logging. TFP growth contributed significantly to sector GDP growth. Contributions from capital and labour input growth have been negligible.

TFP growth of the downstream manufacturing sectors have been lower than those of the primary sectors. Between 1988 and 2005, TFP growth of food, beverage, and tobacco manufacturing averaged 1.1% per year and wood and paper product manufacturing's averaged 0.4% per year. These are lower than TFP growth of Statistics New Zealand's measured sector over the same period. Capital contribution to sector GDP growth was quite significant in both sectors. However, labour contribution was negligible.

Future research

What remained to be done is further experiments with methodology and data sources. For example, the use of capital gain and taxes need to be considered in deriving the user cost of capital. Subject to data availability, this would bring MAF's method closer to that of Statistics New Zealand. In term of data sources, work can be done, for example, in using alternative measures for labour volume such as hours paid. Adjusting for labour quality could be another interesting area to look at.

MAF's further work will explore sub-sector level of the primary and manufacturing sectors. This will be important to better understand the various sources of productivity growth in the agricultural and forestry sectors. In conjunction to understanding the sub-industry sources of productivity growth, further diagnosis of the elements of growth will provide further evidence from which better growth policies can be developed. With an established method, it only requires the availability of data at a disaggregate level. Future challenge will also include examining the factors that influence sector TFP growth.

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Appendix

Agriculture sector

Year	Labour kFTE's	PKS constant ($millions)	GDP constant ($millions)	GDP index	K&L index	TFP chained
1972	132.1	18151	3297	0.6655	1.1044	0.6026
1973	131.4	18532	2360	0.4764	1.1072	0.4303
1974	136.7	18921	2157	0.4354	1.1455	0.3801
1975	131.6	18940	3106	0.6269	1.1140	0.5628
1976	136.2	18932	3018	0.6092	1.1411	0.5338
1977	140.9	18990	3153	0.6364	1.1681	0.5448
1978	146.5	18862	2994	0.6044	1.1957	0.5055
1979	142.9	18869	2406	0.4857	1.1766	0.4128
1980	145.2	19007	3275	0.6612	1.1922	0.5546
1981	138.8	19261	3601	0.7268	1.1589	0.6271
1982	143.4	19599	3596	0.7258	1.1919	0.6089
1983	142.7	19791	3790	0.7651	1.1924	0.6416
1984	135.1	19987	3239	0.6538	1.1568	0.5652
1985	135.3	20188	3459	0.6981	1.1620	0.6008
1986	131.0	19834	4292	0.8665	1.1310	0.7661
1987	132.8	19097	4342	0.8764	1.1204	0.7822
1988	131.5	18537	4337	0.8755	1.0984	0.7970
1989	127.3	18107	4066	0.8208	1.0674	0.7689
1990	124.7	17944	3756	0.7582	1.0503	0.7219
1991	123.6	17709	4448	0.8979	1.0394	0.8638
1992	125.2	17560	4462	0.9007	1.0456	0.8614
1993	121.0	17473	3777	0.7624	1.0198	0.7476
1994	122.7	17450	4589	0.9263	1.0288	0.9004
1995	120.7	17339	4556	0.9197	1.0153	0.9058
1996	118.6	17218	4954	1.0000	1.0000	1.0000
1997	115.5	17028	5486	1.1074	0.9776	1.1328
1998	109.7	16796	5496	1.1094	0.9370	1.1840
1999	107.8	16634	5221	1.0539	0.9227	1.1422
2000	117.2	16628	5377	1.0854	0.9833	1.1038
2001	112.5	17001	5525	1.1153	0.9582	1.1639
2002	117.2	17516	5579	1.1262	0.9962	1.1305
2003	114.6	18056	5463	1.1027	0.9851	1.1195
2004	110.6	18369	5545	1.1193	0.9608	1.1650
2005	105.2	18816	5596	1.1296	0.9263	1.2195
2006	110.4	19380	5690	1.1486	0.9691	1.1851

Forestry and Logging

Year	Labour kFTE	PKS constant ($millions)	GDP constant	GDP index	K&L index	TFP index
1972	7.0	774	444	0.3693	0.7212	0.5121
1973	7.6	811	465	0.3865	0.7780	0.4968
1974	7.0	851	496	0.4125	0.7333	0.5625
1975	7.3	888	498	0.4143	0.7648	0.5417
1976	7.8	926	502	0.4177	0.8114	0.5148
1977	8.2	942	581	0.4832	0.8441	0.5724
1978	8.8	960	556	0.4621	0.8904	0.5190
1979	9.5	975	577	0.4800	0.9413	0.5099
1980	9.9	977	636	0.5284	0.9676	0.5461
1981	9.9	993	709	0.5895	0.9730	0.6058
1982	10.0	1010	728	0.6053	0.9857	0.6141
1983	10.0	997	724	0.6021	0.9798	0.6145
1984	11.5	991	742	0.6168	1.0501	0.5874
1985	11.6	987	769	0.6389	1.0535	0.6065
1986	10.8	970	794	0.6600	1.0017	0.6589
1987	9.4	952	759	0.6305	0.9109	0.6922
1988	5.8	931	691	0.5744	0.6750	0.8509
1989	6.1	916	845	0.7024	0.6934	1.0130
1990	6.4	913	925	0.7689	0.7184	1.0703
1991	5.8	948	1043	0.8670	0.6660	1.3018
1992	6.8	998	1075	0.8936	0.7714	1.1584
1993	7.5	1017	1093	0.9086	0.8368	1.0857
1994	8.3	1087	1131	0.9401	0.9233	1.0182
1995	10.0	1195	1189	0.9884	1.1077	0.8922
1996	8.8	1286	1203	1.0000	1.0000	1.0000
1997	8.8	1367	1170	0.9726	1.0031	0.9696
1998	7.7	1427	1213	1.0083	0.9040	1.1154
1999	8.5	1410	1187	0.9867	0.9772	1.0097
2000	6.4	1449	1323	1.0998	0.7699	1.4285
2001	7.5	1451	1390	1.1554	0.8873	1.3023
2002	9.7	1498	1480	1.2303	1.1118	1.1066
2003	10.0	1559	1562	1.2984	1.1476	1.1314
2004	9.9	1573	1496	1.2436	1.1391	1.0917
2005	8.6	1605	1412	1.1737	1.0087	1.1636
2006	7.5	1643	1395	1.1596	0.9071	1.2784

Food, beverage and tobacco manufacturing

Year	Labour k's	PKS constant ($millions)	GDP constant ($millions)	GDP index	K&L index	TFP chained
1987	77.7	6953	4266	0.8735	1.0582	0.8255
1988	72.1	7355	4364	0.8935	1.0344	0.8638
1989	71.4	7431	4385	0.8978	1.0318	0.8702
1990	62.0	8113	4095	0.8385	0.9701	0.8643
1991	61.5	8239	4157	0.8511	0.9704	0.8771
1992	59.3	8253	4204	0.8608	0.9476	0.9084
1993	57.7	8456	4327	0.8860	0.9362	0.9463
1994	60.1	8789	4496	0.9206	0.9746	0.9446
1995	60.5	9062	4688	0.9599	0.9877	0.9718
1996	61.2	9194	4884	1.0000	1.0000	1.0000
1997	62.4	9282	4889	1.0010	1.0167	0.9846
1998	62.2	9339	5091	1.0424	1.0160	1.0259
1999	61.8	9711	4915	1.0063	1.0208	0.9859
2000	60.8	10156	5003	1.0244	1.0195	1.0048
2001	62.9	10360	5116	1.0475	1.0509	0.9968
2002	66.0	10977	5211	1.0670	1.1055	0.9652
2003	68.1	11497	6280	1.2858	1.1453	1.1227
2004	69.4	11978	6260	1.2817	1.1743	1.0915
2005	71.0	12606	6180	1.2654	1.2110	1.0449
2006	72.6	13289	6286	1.2871	1.2497	1.0299

Wood and paper product manufacturing

Year	Labour k's	PKS constant ($millions)	GDP constant ($millions)	GDP index	K&L index	TFP index
1987	29.2	2705	1507	0.7680	0.8376	0.9169
1988	28.3	2778	1673	0.8527	0.8347	1.0216
1989	26.4	2993	1601	0.8160	0.8297	0.9835
1990	24.8	3352	1621	0.8262	0.8417	0.9816
1991	24.5	3397	1639	0.8354	0.8412	0.9931
1992	23.9	3619	1658	0.8451	0.8533	0.9903
1993	25.0	3585	1707	0.8700	0.8725	0.9972
1994	27.1	3790	1879	0.9577	0.9367	1.0224
1995	28.2	3855	1990	1.0143	0.9667	1.0492
1996	29.2	3980	1962	1.0000	1.0000	1.0000
1997	29.1	4183	2036	1.0377	1.0145	1.0229
1998	27.2	4468	1942	0.9898	0.9947	0.9950
1999	26.1	4511	1854	0.9450	0.9733	0.9709
2000	26.6	4459	2126	1.0836	0.9804	1.1052
2001	26.6	5049	2200	1.1213	1.0227	1.0964
2002	26.2	5249	2105	1.0729	1.0272	1.0445
2003	27.4	5325	2290	1.1672	1.0614	1.0997
2004	27.1	5441	2345	1.1952	1.0630	1.1244
2005	28.5	5591	2385	1.2156	1.1080	1.0972
2006	30.0	5733	2311	1.1779	1.1534	1.0212