Measuring Economic Growth in New Zealand

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Abstract

This paper examines New Zealand's ranking in the OECD based on real GDP per capita. The fall in ranking experienced by New Zealand implies that real GDP per capita growth in New Zealand has been relatively poor in comparison to other OECD countries. The paper examines the history of New Zealand's growth rate and explores the differences between various techniques for measuring average growth rates. The approaches are all shown to be variants of the average annual growth rate but differ in terms of the weighting structure used. Ultimately, the most appropriate technique depends on the underlying data generating process. The implications of data construction techniques for measured growth rates are discussed and differences between the growth rates obtained from different data sources are illustrated. The paper also illustrates the sensitivity of New Zealand growth rates to the sample period chosen.

JEL CLASSIFICATION O47 – Measurement of Economic Growth; Aggregate Productivity
C10 – Econometric and Statistical Methods: General

KEYWORDS Economic Growth; Measuring Growth; International Comparisons

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Measuring Economic Growth in New Zealand

1 Introduction

Recently there has been increased interest in New Zealand's income position relative to other countries, in particular countries in the Organisation for Economic Co-operation and Development (OECD). The increased interest reflects concerns that New Zealand's relative income position has been falling since the 1950s. For example *Growing an Innovative New Zealand* (New Zealand Government, 2002) released in February stated that "New Zealand's relative income declined over much of the post-war period. New Zealand's real per capita income fell from among the highest in the world in the 1950s, to just under the OECD average in 1970, to 20th in the OECD by 1999."

To address such concerns the previous Government (1999-2002) adopted a goal of returning New Zealand's per capita income to the top half of the OECD.

> "*Our economic objective is to return New Zealand's per capita income to the top half of the OECD and to maintain that standing. This will require New Zealand's growth rate to be consistently above the OECD average growth rate for a number of years. That will require sustained growth rates in excess of our historical economic performance."* (New Zealand Government, 2002)

While such goals focus on New Zealand's per capita income, the income measure generally used has been Gross Domestic Product (GDP) per capita.[1] This paper highlights a number of issues that are relevant when measuring economic growth over time and when making international comparisons on the basis of ranking in real GDP per capita.

Section 2 examines New Zealand's ranking within a group of OECD countries, based on our level of real GDP per capita, when several different data sources are used. This highlights that New Zealand's ranking is to some extent influenced by the data source used (though all sources are consistent with New Zealand sliding down the ladder over time).

The fall in our ranking implies that New Zealand's growth rate in real GDP per capita must have been relatively poor over periods of time. This leads to the question of what has been New Zealand's average growth rate since the 1950s and how does this compare with the experience of other countries? However, prior to addressing this question, there are several issues relating to the construction of average growth rates that are important

[1] For example New Zealand Government (2002) illustrates New Zealand's relative decline in per capita income by way of a graph showing New Zealand's GDP per head.

to highlight if a country's performance is to be accurately assessed. One of these issues is how to measure average growth over any given period of time. This issue is discussed in Section 3.

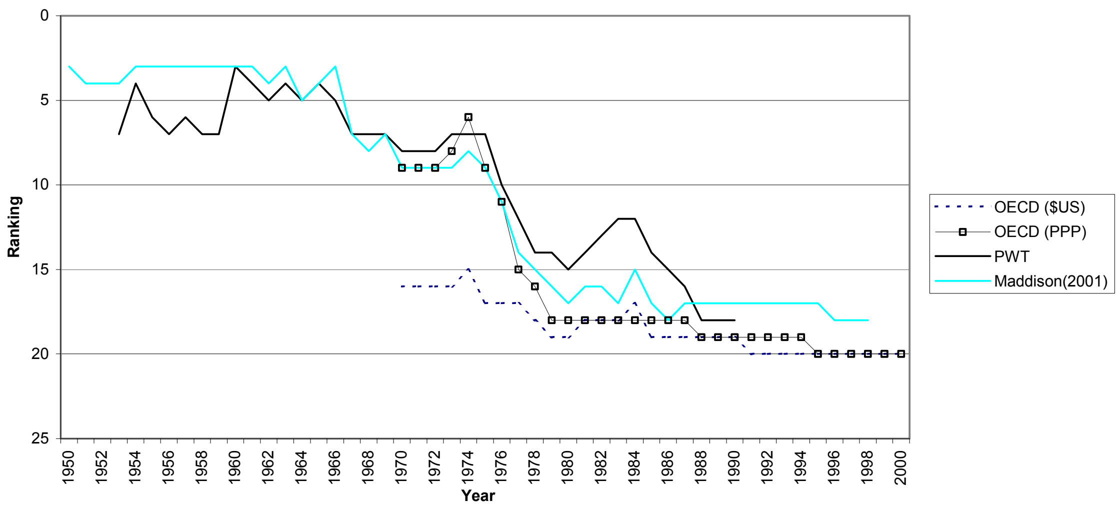
Data construction techniques can have important ramifications for the estimated growth rate. The impact of data construction techniques on measured growth rates are discussed in Section 4.

With the issues raised in Sections 3 and 4 borne in mind, Section 5 examines New Zealand's historical growth performance based on several data sources. Finally, Section 6 concludes by briefly summarising some of the key points.

2 New Zealand's place on the OECD ladder

Figure 1 presents New Zealand's ranking in the OECD, in terms of real GDP per capita, based on data from three different sources. These different data sources are OECD (2002)[2], Maddison (2001), and Penn World Tables (PWT)[3]. The rankings on which Figure 1 is based are displayed in Table 1.

Figure 1 – New Zealand's Real GDP per Capita Ranking Amongst OECD Countries



Regardless of which data source is used, New Zealand's ranking has dropped over time. Note that in Figure 1 the values on the vertical axis are displayed in reverse order, ie higher numbers (lower rankings) are below lower numbers (higher rankings). Consequently a negative slope is associated with a worsening in the ranking over time. However, there is a degree of variation in New Zealand's relative ranking across the different data sources. This implies that data construction and collection techniques can influence the particular ranking that New Zealand attains.[4] It is also interesting to

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[2] Data from two tables of this publication were used. OECD($US) rankings are based on Table A.9 of OECD(2002) which presents GDP per head at the price levels and exchange rates of 1995 (US dollars). OECD(PPP) ranking are based on Table B.7 of OECD(2002) which presents GDP per head at the price levels and PPPs of 1995 (US dollars). In both cases data was obtained electronically via OLISNET to enable annual data from 1970 through to 2000 to be used. The Czech Republic, Hungary, Poland and the Slovak Republic are excluded from the sample due to the incomplete time coverage of their data.

[3] Alan Heston, Robert Summers, Daniel Nuxoll and Bettina Aten, Penn World Tables Version 5.6, Center for International Comparisons at the University of Pennsylvania, January 1995.

[4] Differences in the number of countries included in the various datasets may also lead to different datasets suggesting different rankings. The OECD data displays a ranking out of 26 countries, the PWT data displays a ranking out of 25 countries, and the

observe that New Zealand's GDP per capita ranking based on OECD data was substantially higher when 1995 purchasing power parities (PPPs) are used rather than the 1995 exchange rate against the United States dollar.

Table 1 – New Zealand's GDP per Capita Ranking Amongst OECD Countries

year	OECD ($US)	OECD (PPP)	PWT	Maddison (2001)	year	OECD ($US)	OECD (PPP)	PWT	Maddison (2001)
1950				3	1976	17	11	10	11
1951				4	1977	17	15	12	14
1952				4	1978	18	16	14	15
1953			7	4	1979	19	18	14	16
1954			4	3	1980	19	18	15	17
1955			6	3	1981	18	18	14	16
1956			7	3	1982	18	18	13	16
1957			6	3	1983	18	18	12	17
1958			7	3	1984	17	18	12	15
1959			7	3	1985	19	18	14	17
1960			3	3	1986	19	18	15	18
1961			4	3	1987	19	18	16	17
1962			5	4	1988	19	19	18	17
1963			4	3	1989	19	19	18	17
1964			5	5	1990	19	19	18	17
1965			4	4	1991	20	19		17
1966			5	3	1992	20	19		17
1967			7	7	1993	20	19		17
1968			7	8	1994	20	19		17
1969			7	7	1995	20	20		17
1970	16	9	8	9	1996	20	20		18
1971	16	9	8	9	1997	20	20		18
1972	16	9	8	9	1998	20	20		18
1973	16	8	7	9	1999	20	20		
1974	15	6	7	8	2000	20	20		
1975	17	9	7	9					

The OECD datasets used in this paper include the following 26 countries (lowest ranking possible is 26): Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea (South), Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States.

The Penn World Table (PWT) dataset used in this paper is made up of 25 countries (lowest ranking possible is 25). These are the same as for the OECD datasets with the exclusion of Germany.

The Maddison dataset used in this paper is made up of 24 countries (lowest ranking possible is 24). These are the same as for the OECD datasets with the exclusion of Iceland and Luxembourg.

Ultimately, it appears there will always be a degree of uncertainty as to New Zealand's actual GDP per capita ranking for any particular individual year back to 1950 (and prior) due to different data sources or differences in the units in which GDP per capita is expressed providing different rankings. This uncertainty also applies to pinpointing sub-periods where New Zealand's ranking decline has been the greatest. Three out of the four series for New Zealand's GDP per capita ranking display substantial falls in the mid-to-late 1970s.[5] For example, the series based on PWT data shows that New Zealand

Maddison data displays a ranking out of 24 countries (as outlined in Table 1). These differences in country numbers are not sufficient to explain the differences between the rankings obtained when using the different datasets, implying that data construction and collection techniques also play a role.

[5] The series based on OECD($US) data also displays a falling ranking over this period, although the loss of places is not as great in this series.

dropped from 7th in 1975 to 15th in 1980. Likewise the series based on OECD PPP data shows that New Zealand dropped from 6th in 1974 to 18th in 1979. The Maddison series also shows a sizable decline over this period. The entry of Britain into the European Union and the resulting loss of free entry to British markets for dairy products, and the oil price shocks of the 1970s are potential explanations for New Zealand's relative fall in the real GDP per capita rankings during this period.

Based on the data shown in Table 1, there may be a case for arguing that the mid to late 1960s was also a period in which New Zealand's ranking fell significantly. For example, in 1966 the Maddison series ranked New Zealand 3rd, whereas in 1970 New Zealand's ranking had slipped to 9th. The collapse of wool prices in 1967, due to increased competition from synthetic fibres, coincides with the fall in ranking that occurred during this period.

Other economists have expressed alternative views as to which periods are most significant in New Zealand's slide down the OECD's rankings. For example, Brian Easton states that "The economy mainly lost its placing following two major shocks – in the late 1960s when the price of wool collapsed, and the late 1980s when there was a grossly overvalued real exchange rate."[6] As already discussed, the first of these two explanations is to some extent apparent in the data displayed in Figure 1. The later explanation is not really supported by three of the four series used in this paper, although the PWT series does show that New Zealand's ranking slipped from 12th in 1984 to 18th in 1988. It is clear that dating key periods is itself dependent on the particular data series chosen.

Falls in New Zealand's ranking within the OECD result from relatively poor growth in real GDP per capita in comparison to other OECD countries over time. Therefore it would be of interest to know what has been New Zealand's average growth rate since the 1950s and how does this compare with the performance of other OECD countries? As is the case for determining New Zealand's ranking in the OECD, it is likely that different people will obtain different estimates of New Zealand's growth rate over a period. These estimates are likely to differ due to: the approach taken to measuring the average growth rate over a period; the real GDP series used; the units in which the series is expressed; and the particular time period used. The next section discusses four possible ways of measuring the average growth rate of real GDP per capita over a period of time.

3 Calculating Growth Rates

For a given time series of annual real GDP per capita data, how should the average growth rate for the entire data period, or a particular sub-period of interest, be calculated?[7] There are a number of potential ways of constructing an average growth rate for a particular period. This paper focuses on four alternatives: (a) least squares growth rates; (b) a differenced logarithmic model; (c) the average annual growth rate; and (d) the geometric average growth rate. This section explains the procedures involved in computing growth rates using these alternative techniques. As will be shown, deriving these alternative growth rate estimators algebraically highlights that the different estimates obtained from these methods are all some variant of the average of the annual growth rates. The alternative approaches differ in terms of the averaging technique used on these annual growth rates.

The annual growth rate for a series of T annual observations, say Y_1, Y_2, Y_3, … ,Y_T, is defined as:

[6] Easton(2002) "Of roast pork - Treasury debates the economy." *Listener*.

[7] The discussion that follows is equally relevant for estimating the growth rate in any series. The data does not necessarily need to be annual; what is important is that it is available for regular intervals over time.

$$a_t = \frac{Y_t - Y_{t-1}}{Y_{t-1}} \qquad (1)$$

where Y_t is the observation for year t.[8]

3.1 Least Squares Growth Rates

One common approach to measuring growth rates is the Least Squares or Ordinary Least Squares (OLS) approach. In fact Kakwani (1997) notes that this is the most commonly used procedure for estimating growth rates.

The OLS approach is based on the compound growth formula:

$$Y_t = Y_1 (1+r)^{t-1} \qquad (2)$$

The compound growth formula states that the value of real GDP per capita at time t is equivalent to the value of real GDP per capita at time 1 grown at a constant annual rate r (with compounding occurring annually over t-1 years).

Taking natural logs of (2) gives:

$$\ln Y_t = \ln Y_1 - \ln(1+r) + t \ln(1+r) \qquad (3)$$

Adding a disturbance term ε_t, and letting $\ln Y_1 - \ln(1+r) = \alpha$ and $\ln(1+r) = \beta$ yields equation (4):

$$\ln Y_t = \alpha + \beta t + \varepsilon_t \qquad (4)$$

By regressing $\ln Y_t$ on t (time) using OLS we obtain an estimate of the slope coefficient ($\hat{\beta}$) that provides an estimate of the instantaneous growth rate ($\ln(1+r)$). The compound rate of growth can be obtained as follows[9]:

$$r_{OLS} = e^{\hat{\beta}} - 1 \qquad (5)$$

It can be shown (see Appendix A.1) that the OLS estimator of β can be expressed as:

$$\hat{\beta} = \sum_{s=2}^{T} k_s \Delta \ln Y_s \qquad (6)$$

where $k_s = \frac{6(T-s+1)(s-1)}{T(T+1)(T-1)}$

That is, $\hat{\beta}$ is a weighted average of the $\Delta \ln Y_s$'s with the k_s's serving as weights. As $\Delta \ln Y_s = \ln Y_s - \ln Y_{s-1} \approx \frac{Y_s - Y_{s-1}}{Y_{s-1}}$ the OLS estimator for β approximates a weighted average of the proportional changes in the series of interest (eg, in the case of annual data, a weighted average of the annual growth rates).

[8] It is possible to construct T-1 annual growth rates from series that has T annual observations.

[9] Solving $\ln(1+r) = \beta$ for r gives $r = e^{\beta} - 1$ hence equation (5).

However, it is worth focusing on the weights. Note that the formula for the weights (k_s) is a quadratic in s. This weighting scheme means that the weights on the annual growth rates first increase with s, until reaching a maximum when $s = \frac{T}{2} + 1$, and then decrease symmetrically until $s = T$.

To illustrate the differing weights applied to the (approximations of) the annual growth rates, Figure 2 plots the weights that would apply if one was working with sample of size T=20. When T=20, the weight given to the annual growth rate in the middle of the sample is 5.26 times the weight given to the growth rates at the end points of the sample. In general the ratio of the highest weight used to the lowest weight used is $\frac{T^2}{4(T-1)}$. The ratio of the highest weight to the lowest weight for values of T between 2 and 100 are shown in Figure 3.

Figure 2 – Weighting Scheme for OLS growth rate estimate (T=20)

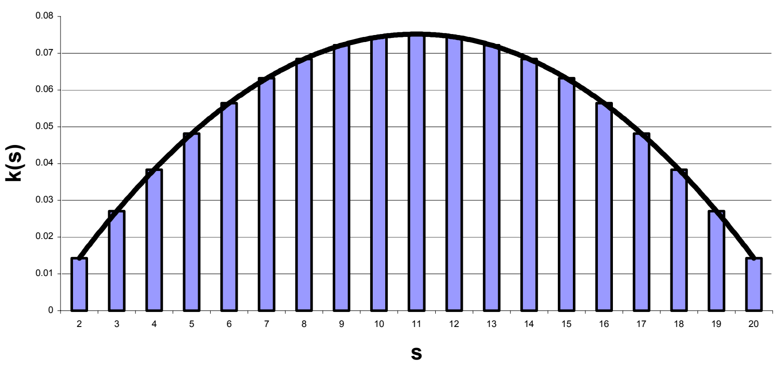
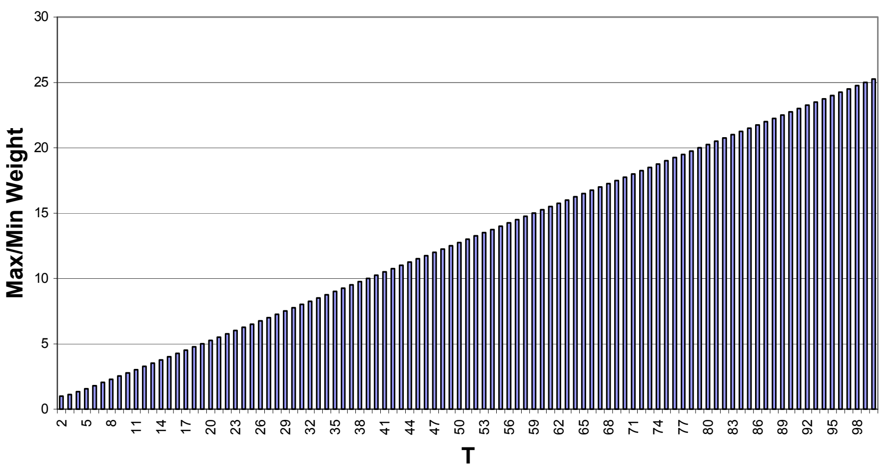


Figure 3 – Maximum/Minimum Weight Ratio for time series of length T



3.2 Log Difference Model Growth Rates

As just discussed, the commonly used least square regression approach results in a quadratic weighting scheme. The use of a different model enables us to obtain an estimator based on a simpler weighting scheme. Consider the model:

$$\Delta \ln Y_t = \beta + \varepsilon_t \tag{7}$$

By noting that this is equivalent to $\ln Y_t = \ln Y_{t-1} + \beta + \varepsilon_t$, recursive substitution enables (7) to be rewritten as:

$$\ln Y_t = \ln Y_1 + \beta(t-1) + \sum_{s=2}^{t} \varepsilon_s \tag{8}$$

Note that the model shown in equation (8) is identical to the model shown in (4) except for the error term[10]. Therefore, the argument (based on manipulating the compound growth formula) that β can be interpreted as a growth rate also holds for this model. In the model shown in (8) the error term is described by a moving average process.

The OLS estimator of β in the model described by equation (7) can be expressed as (see Appendix A.2):

$$\hat{\beta} = \frac{1}{T-1} \sum_{t=2}^{T} \Delta \ln Y_t \tag{9}$$

So $\hat{\beta}$ is just an average of the T-1 $\Delta \ln Y_t$ terms, with each $\Delta \ln Y_t$ term being given an equal weighting of $\frac{1}{T-1}$.

As was the case in section 2.1, the estimate of the slope coefficient ($\hat{\beta}$) provides an estimate of the instantaneous growth rate. The compound rate of growth can be obtained as follows:

$$r_{LD} = e^{\hat{\beta}} - 1 \tag{10}$$

[10] Equation (4) is $\ln Y_t = \alpha + \beta t + \varepsilon_t$ where $\alpha = \ln Y_1 - \ln(1+r)$ and $\beta = \ln(1+r)$ thus equation (4) can be written as $\ln Y_t = \ln Y_1 - \ln(1+r) + t\ln(1+r) + \varepsilon_t = \ln Y_1 + (t-1)\ln(1+r) + \varepsilon_t = \ln Y_1 + \beta(t-1) + \varepsilon_t$ which is the same as equation (8) except for the error term.

3.3 The Average Annual Growth Rate

Noting that $\Delta \ln Y_t$ approximates the annual growth rate implies that $\hat{\beta}$ in equation (9) is approximately equal to the average of the annual growth rates. In fact, using the actual annual growth rates rather than their $\Delta \ln Y_t$ counterparts gives us another simple way of calculating the annualised rate of growth over a period. This approach is referred to as the "average annual growth rate" (AAGR) approach. The average annual growth rate can therefore be specified as:

$$r_{AAGR} = \frac{1}{T-1}\sum_{t=2}^{T}\frac{Y_t - Y_{t-1}}{Y_{t-1}} \tag{11}$$

3.4 Geometric Average Growth Rates

Another way of calculating the average growth rate for a period when an annual time series of data (Y_1 to Y_T) is available is to directly utilise the compound growth formula by using the data points Y_1 and Y_T as follows:

$$Y_T = Y_1(1+r)^{T-1} \tag{12}$$

solving the expression in (12) for r gives:

$$r_{GEO} = \left(\frac{Y_T}{Y_1}\right)^{\frac{1}{T-1}} - 1 \tag{13}$$

Here r is the rate of growth required to grow Y_1 so that it equals Y_T in T-1 years when compounding occurs annually. This approach is referred to as the geometric average approach. The fact that this approach only uses the values of the two endpoints of the series of interest is often considered a weakness. The reason for referring to this approach as the geometric average approach is that it is possible to express 1+r as follows (see appendix A.3 for details):

$$1 + r_{GEO} = \left[\prod_{t=2}^{T}\left(1 + \frac{Y_t - Y_{t-1}}{Y_{t-1}}\right)\right]^{\frac{1}{T-1}} \tag{14}$$

The expression shown in (14) states that $1 + r_{GEO}$ is the geometric average of one plus the annual growth rates obtainable from the data.

3.5 The four approaches summarised

Sections 3.1 to 3.4 have identified four approaches that can be used to measure the average growth rate over a period or sub-period of interest. Table 2 summarises how these approaches measure the growth rate as a function of the time series observations of the series for which average growth rates are being constructed.

Table 2 – four techniques to construct a growth rate

Technique	Construction
1.OLS (r_{OLS})	$r_{OLS} = e^{\hat{\beta}} - 1$ where $\hat{\beta} = \sum_{s=2}^{T} \frac{6(T-s+1)(s-1)}{T(T+1)(T-1)} \Delta \ln Y_s$
2.Log Difference Regression (r_{LD})	$r_{LD} = e^{\hat{\beta}} - 1$ where $\hat{\beta} = \frac{1}{T-1} \sum_{t=2}^{T} \Delta \ln Y_t$
3.Average Annual Growth Rate (r_{AAGR})	$r_{AAGR} = \frac{1}{T-1} \sum_{t=2}^{T} \frac{Y_t - Y_{t-1}}{Y_{t-1}}$
4.Geometric Average (r_{GEO})	$r_{GEO} = \left(\frac{Y_T}{Y_1} \right)^{\frac{1}{T-1}} - 1$

For the time series Y={Y_1, Y_2, Y_3, … , Y_T}

It is possible to show that techniques 2 and 4 are equivalent so that $r_{LD} = r_{GEO}$ (see appendix A.4 for details). That is, the average growth rate for a period calculated by the log difference regression technique would be the same as the average growth rate calculated by the geometric average approach. Another point worth noting is that the log difference regression rate is approximately equal to the $\hat{\beta}$ used in its construction. It was noted that $\hat{\beta}$ estimated in the log difference regression approximately equals the average annual growth rate and therefore the average annual growth rate is approximately equal to the log difference growth rate (and subsequently the geometric average growth rate).[11] That is:

$$r_{GEO} = r_{LD} \approx r_{AAC} \qquad (15)$$

[11] It is widely recognised that $\ln(1+x) \approx x$ when x is small. This implies that $e^x - 1 \approx x$ and therefore $r_{LD} = e^{\hat{\beta}} - 1 \approx \hat{\beta}$. Thus $r_{GEO} = r_{LD} \approx \hat{\beta} \approx r_{AAC}$

Table 3 – A comparison of New Zealand growth rates using the alternative techniques to construct a period growth rate

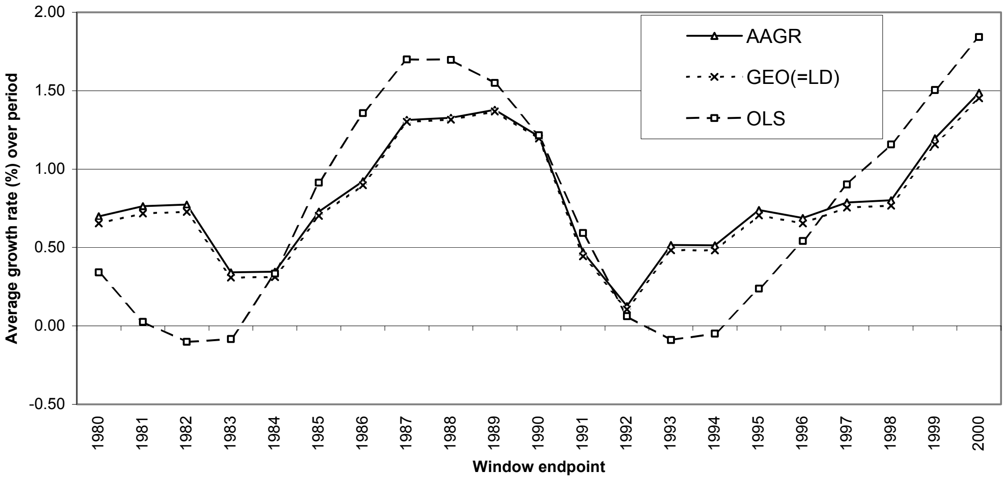
			Average Growth Rate (% per annum)				Difference compared to AAGR	
Year	Real GDP per capita	Window that Growth is Measured over	AAGR	GEO	OLS	LD	GEO & LD	OLS
1970	12921							
1971	13204							
1972	13646							
1973	14423							
1974	14980							
1975	14458							
1976	14457							
1977	13835							
1978	13744							
1979	13695							
1980	13791	1970-1980	0.70	0.65	0.34	0.65	-0.04	-0.36
1981	14181	1971-1981	0.76	0.72	0.03	0.72	-0.05	-0.74
1982	14673	1972-1982	0.77	0.73	-0.10	0.73	-0.05	-0.88
1983	14874	1973-1983	0.34	0.31	-0.08	0.31	-0.03	-0.43
1984	15454	1974-1984	0.35	0.31	0.33	0.31	-0.03	-0.01
1985	15507	1975-1985	0.73	0.70	0.91	0.70	-0.03	0.18
1986	15807	1976-1986	0.92	0.90	1.36	0.90	-0.03	0.43
1987	15743	1977-1987	1.31	1.30	1.70	1.30	-0.01	0.39
1988	15660	1978-1988	1.33	1.31	1.70	1.31	-0.01	0.37
1989	15687	1979-1989	1.38	1.37	1.55	1.37	-0.01	0.17
1990	15530	1980-1990	1.21	1.19	1.22	1.19	-0.01	0.01
1991	14823	1981-1991	0.47	0.44	0.59	0.44	-0.03	0.12
1992	14829	1982-1992	0.13	0.11	0.06	0.11	-0.02	-0.07
1993	15607	1983-1993	0.52	0.48	-0.09	0.48	-0.03	-0.61
1994	16214	1984-1994	0.51	0.48	-0.05	0.48	-0.03	-0.56
1995	16635	1985-1995	0.74	0.70	0.24	0.70	-0.03	-0.50
1996	16872	1986-1996	0.69	0.65	0.54	0.65	-0.03	-0.15
1997	16972	1987-1997	0.79	0.75	0.90	0.75	-0.03	0.11
1998	16904	1988-1998	0.80	0.77	1.16	0.77	-0.03	0.36
1999	17600	1989-1999	1.20	1.16	1.50	1.16	-0.04	0.31
2000	17938	1990-2000	1.49	1.45	1.84	1.45	-0.04	0.36
		1970-2000	1.13	1.10	0.84	1.10	-0.03	-0.29

Note: The GDP per Capita series is GDP per head at the price levels and exchange rates of 1995 (US dollars) as published in (OECD 2002). Data was obtained electronically to 3 decimal places and data to this level of accuracy was used in the growth rate calculations.

AAGR, GEO, OLS and LD refer to the growth rate obtained using the Average Annual Growth Rate, Geometric Average, Ordinary Least Squares and Log Difference techniques respectively.

Table 3 illustrates the results obtained by using the four growth rate techniques outlined earlier. Estimates of the average growth rate in New Zealand real GDP per capita over a number of different 10-year windows are computed as well as the average growth rate of the entire period (1970-2000). This means that for each window a sub-series of 11 data points is used. Not surprisingly, the growth rates calculated using the geometric average and log difference techniques are identical and only differ to the average annual growth rates by up to 5 one hundredths of a percent. There is substantial variation between the growth rate computed using the OLS technique and the other three techniques. In some cases the difference between the growth rates obtained using the OLS technique and the average annual growth rate technique is greater than the average annual growth rate value. The quadratic weighting scheme used in the OLS technique results in the OLS growth rates being materially different from the growth rates obtained using the other techniques, even when the rates are calculated over the entire sample.

Figure 4 -A comparison of different growth rate construction techniques (NZ growth rates measured over different 10 year windows)



Source: Author's growth rate calculations based on OECD data as shown in Table 4.

Figure 4 provides an alternative representation of the data in Table 3 and plots the average growth rate in New Zealand's real GDP per capita for moving 10-year periods as measured using the different growth rate approaches. Thus the first growth rate plotted for each series is for the period 1970 to 1980, the second for the period 1971 to 1981 and so on. Figure 4 again highlights that the growth rate estimates for a particular period can vary significantly depending on the technique used, with the OLS growth rate at times differing substantially from the rates obtained using other approaches.

3.6 Choice of Method

Section 3.5 highlighted that growth rates obtained from the OLS approach sometimes differed substantially to those obtained from the other 3 methods. Given this, what is the most appropriate way of calculating a growth rate? This depends on the data generating process underlying the data being used. In the case that the log of GDP per capita is stationary around a deterministic trend and hence does not contain a unit root, then it is appropriate to use the OLS approach. On the other hand when the log of GDP per capita is integrated of order one (I(1)) the log difference approach is more appropriate.[12] As the log difference approach provides the same results as the geometric average approach, and is approximately equal to the average annual growth approach, there is little in it when choosing between these three approaches.

The average annual growth rate approach involves a weighting structure (standard arithmetic weights) that makes it intuitively simple. The geometric average approach (and consequently log difference approach) is also quite intuitive and has the advantage that if one takes the value of real GDP per capita at the start of the sample period of interest and grow it at the geometric average growth rate for the appropriate number of years, the value obtained will be that of the final value of real GDP per capita in the sample period of

[12] Regression analysis based on time series data implicitly assumes that the underlying data is stationary. When a series is integrated of order 1 (I(1)) taking the first difference will result in a stationary series.

interest. In general this will not be the case when the other growth rate approaches are used.

As shown in Table 4, the natural log of all the New Zealand real GDP per capita series used in this paper are integrated of order 1 (I(1)). What this means is, that with New Zealand data at least, the use of the OLS approach to calculate an average growth rate should be avoided and one of the other 3 approaches used. Due to its simplicity, when growth rates are computed in the rest of this paper the average annual growth rate has been used.

Table 4 - Unit Root tests on the natural log of New Zealand real GDP per capita series

Real GDP per capita series	ADF Test on log of series (levels)	ADF Test on log of series (first difference)	Order of Integration
OECD (PPP)	-3.075 (1)	-3.224** (0)	I(1)
OECD ($US)	-3.075 (1)	-3.224** (0)	I(1)
Calibrated	-1.633 (0)	-2.630* (0)	I(1)
Maddison (2001)	-2.269 (1)	-7.059** (0)	I(1)
Penn World Tables	-1.794 (1)	-5.376** (0)	I(1)
Preliminary PWT	-1.654 (1)	-6.048** (0)	I(1)

Both a constant and trend were included in the Augmented Dickey-Fuller (ADF) tests when conducted on levels data. Numbers in brackets in the second and third columns indicate number of lags used in these tests. The lag lengths were determined using the Schwarz criterion.

* signifies a unit root null is rejected at the 5% significance level

** signifies a unit root null is rejected at the 1% significance level

4 Data Construction Techniques and Measured Growth Rates

Section 3, examined different techniques to estimate an average growth rate over a particular period. Figure 4 highlighted that when these different techniques were applied to a common data series, the OLS approach could result in average growth estimates that looked quite different to those obtained from the other approaches. That is, the choice of average growth rate estimation technique can be quite important. Another factor that must be borne in mind is what dataset to use when calculating average growth rates over a period. For example, there exist several potential series for New Zealand's real GDP per capita and these series differ in the length of their coverage and how real GDP per capita has been measured[13].

This section illustrates the differences in New Zealand's growth rate in real GDP per capita when different data sets are used. Six data sets are used in this illustration. Their details are shown in Table 5.

[13] For some longer series the way in which GDP per capita is measured may not be consistent across the whole series, raising doubts about the validity of some comparisons across time.

Table 5– Sources of New Zealand real GDP per capita data used in this paper

Dataset Source	Coverage	Additional Details
OECD($US)	Year beginning 1 April 1970 to year beginning 1 April 2000	GDP per capita at the price levels and exchange rates of 1995 (US dollars) As published in OECD(2002) although data obtained electronically through OLISNET
OECD(PPP)	Year beginning 1 April 1970 to year beginning 1 April 2000	GDP per capita at the price levels and purchasing power parities (PPP) of 1995 (US dollars) As published in OECD(2002) although data obtained electronically through OLISNET
Calibrated chain-weighted real production GDP per capita series	Year beginning 1 April 1978 to year beginning 1 April 1999	Annual real GDP series obtained by aggregating Haugh (2001)'s quarterly series. Per capita adjustment made using population data.
Maddison(2001)	Year beginning 1 April 1950 to year beginning 1 April 1998	GDP per capita in 1990 Geary-Khamis dollars. As published in Maddison (2001).
Penn World Tables (PWT5.6)[14]	1950 to 1992	The variable RGDPCH is used. This is Real GDP per capita in constant dollars (Chain Index) expressed in international prices, base 1985.
Preliminary Penn World Tables (PWT6.0)[15]	1950 to 1997	The variable RGDPCH is used. This is defined as Real per capita GDP chain method (1996 prices). This dataset is yet to be finalised but updates and extends the time coverage of the previous PWT release.

The New Zealand series described in this table are presented in Appendix B.

For each of these series New Zealand's average growth rate over every possible ten-year window has been calculated using the average annual growth rate (AAGR) approach outlined in Section 3. As the series are of different lengths the number of possible windows for each series also differs. Figure 5 shows the average growth rate for each ten-year period plotted against the window endpoint.[16] This means that a value for, say, 1990 represents the average growth rate over the period 1980 to 1990. Likewise, a value

[14] Alan Heston, Robert Summers, Daniel Nuxoll and Bettina Aten, Penn World Tables Version 5.6, Center for International Comparisons at the University of Pennsylvania, January 1995.

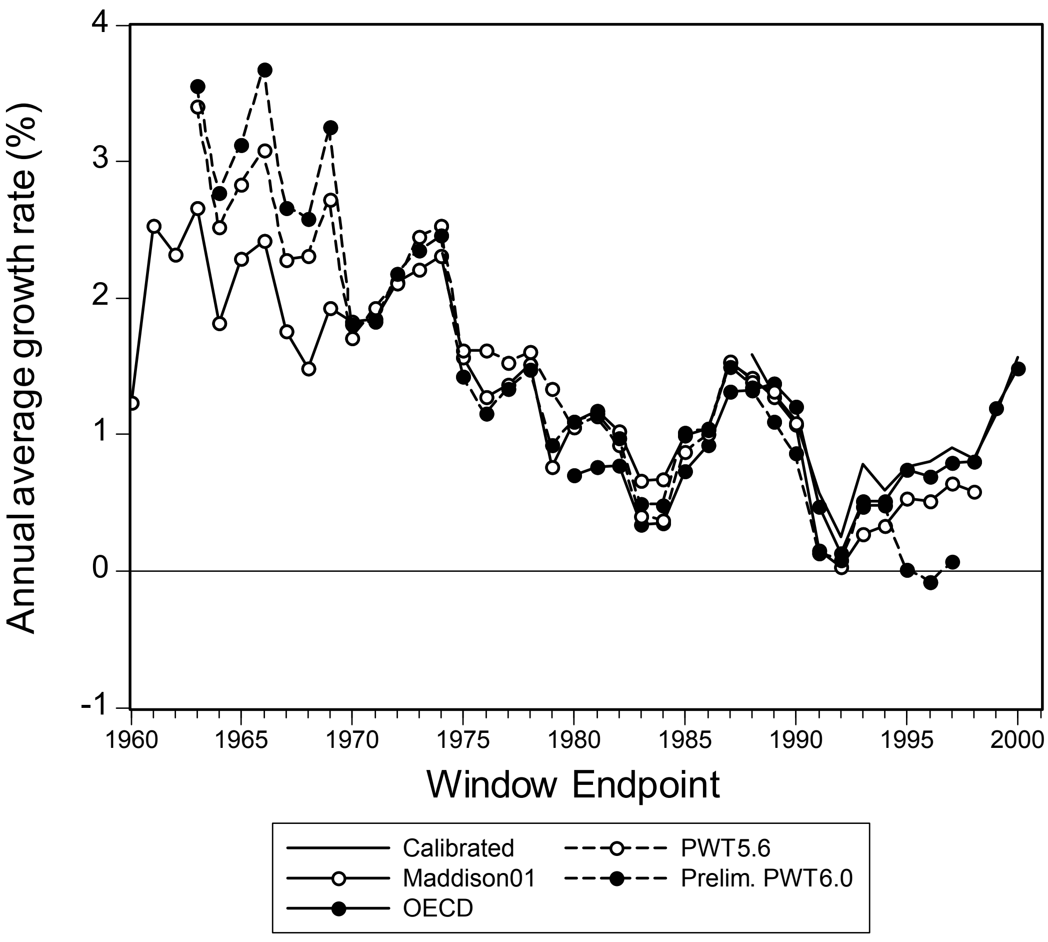
[15] Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.0, Center for International Comparisons at the University of Pennsylvania, December 2001

[16] Appendix C provides the numerical values plotted in Figures 5 and 6.

for 1970 represents the average growth rate over the period 1960 to 1970. Figure 5 illustrates the variation between the average growth rate for a ten-year period when different data sets are used.

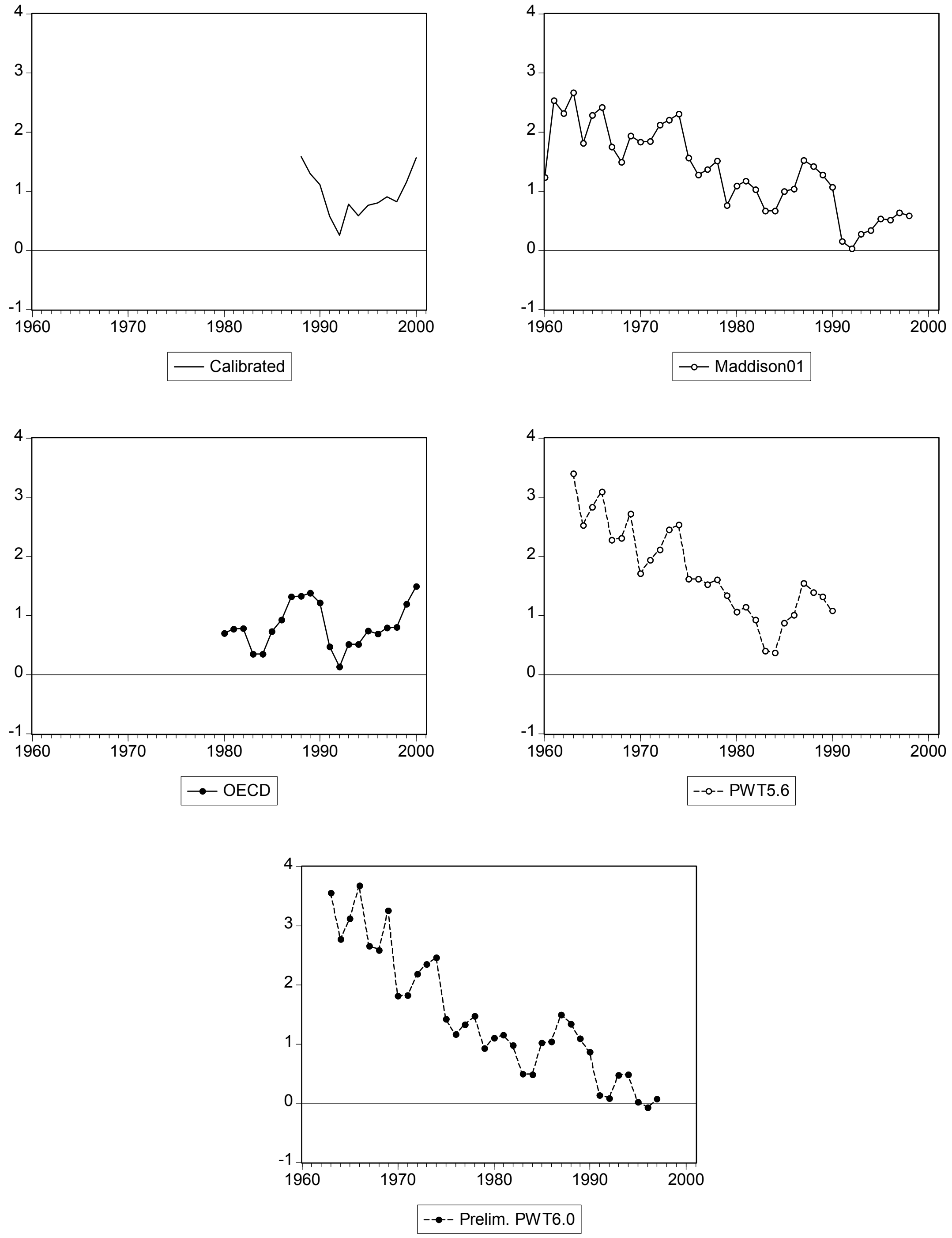
One feature of Figure 5 is that there appears to be more variability in the growth rates obtained using different data sets earlier on in the sample. This is particularly the case if one omits the preliminary Penn World Table data that is yet to be finalised. However, it is worth pointing out that as the graph displays the average growth rate for a ten-year period even small differences would result in material differences in real GDP per capita over time. For example, even when we exclude the preliminary Penn World Table data, the average growth rate for the period ending 1992 (ie 1982 to 1992) differs between data sources by up to a bit under 0.5% per annum. If actual performance was to differ by this much then real GDP per capita would have increased by nearly 5% more over the ten year period when comparing performance for this period under the highest and lowest growth estimates.

Figure 5 – A comparison of New Zealand's growth rates obtained from different data sets (NZ growth rates measured over different 10 year windows)



Note: The average annual growth rate method was used to obtain the average growth rates presented in this figure.

Figure 6 – A comparison of New Zealand's growth rates obtained from different data sets (NZ growth rates measured over different 10 year windows)



Note: The average annual growth rate method was used to obtain the average growth rates presented in this figure.
Vertical axis displays annual average growth rate (%)
Horizontal axis displays year of window endpoint

Figure 6 illustrates the growth rates for each series shown in Figure 5 separately (using consistent scales). Casual observation of the Maddison and PWT plots in Figure 6 could suggest a downward trend over time in New Zealand's average growth rate. However such a conclusion is likely to be misleading due to changes over time in the way in which real GDP for New Zealand has been measured.

4.1 Changes in the way New Zealand real GDP is measured

Over time there have been efforts to improve the way real GDP is measured. Unfortunately, however, these improvements mean that real GDP series constructed on a consistent basis and covering a long historical time period are not available. Consequently long time series of annual GDP data either tend to include data constructed in several different ways or require a considerable proportion of the series to be based on estimated rather than measured values.

Statistics New Zealand released upgraded national accounts at the end of 2000 and in mid 2001. These introduced a number of important changes, including moving from a fixed weight to a chain linked calculation of constant price (real) data, the adoption of the international accounting standard, System of National Accounts 1993 (SNA93), and the Australia New Zealand Standard Industrial Classification (ANZSIC). Real GDP figures back as far as the June quarter of 1987 are available on this consistent basis. These new SNA93 chain linked series are now New Zealand's official data series and replace the previous official series that was based on a different accounting standard called System of National Accounts 1968 (SNA68). The previous official series was also a fixed weight rather than chain weighted series (more details of what this means are provided below). The previous official fixed weight series was available from September 1977.[17] What this means is that real GDP series that provide estimates of New Zealand's real GDP for time intervals that include 1977 are likely to include data that is constructed in several different ways. When this is the case, estimates of economic performance for different sub periods are probably not strictly comparable and unfortunately there is no easy way around this.

4.2 Different approaches to constructing real GDP series (Chain versus Fixed weights) and their influence on growth rates

Annual GDP series measure the total value of goods and services produced in an economy over a 12-month period. Nominal GDP series simply sum over all possible goods and services the total value of each type of good or service produced in the 12 months. For each good or service, the total value is the number of units of the good or service produced, multiplied by the price of a unit of that good or service for that year. An increase in nominal GDP from one year to the next can therefore be attributed to an increase in prices, an increase in the volume of goods and services produced, or most probably, some combination of these two. For example, if in year 2 all prices are 10% higher than they were in year 1, and the same quantity (volume) of each good or service is produced, then nominal GDP will be 10% higher. If these goods and services must be shared amongst the same number of people in each year, is the country better off? The answer is no as in aggregate people have the same quantity of goods and services available for consumption.

Real GDP series overcome this problem by removing the impact of price changes. Consequently, changes in real GDP reflect changes in the volume or quantity of goods and services produced. Such a series is commonly referred to as being expressed in constant prices or real terms. There are several approaches to doing this, with the approaches differing in the choice of which year's prices are used in the construction of

[17] The calibrated real GDP series produced by Haugh (2001) comprises of "Statistics New Zealand 's quarterly chain series from June 1987 onwards appended to a calibrated chain series for the period back to September 1997. The latter is derived by exploiting the statistical relationship between the period of overlapping chain and fixed series (1987:2 to 2000:2)." (Buckle, Haugh and Thomson, 2001)

the index.[18] As is illustrated below, the choice of which year's prices are used has implications for the growth rates that can be obtained from the series. This section begins by considering the difference between two types of volume indexes (the Laspeyres and Paasche indexes).

A Laspeyres index calculates the total value of GDP holding prices constant at their first year levels. Table 6 presents a theoretical example of real GDP in the first and second year constructed using the Laspeyres method (note the total value of each commodity for each year utilises the first year's prices). In the example, real GDP has grown by 18.1%.

Table 6 – Example of a Laspeyres Index

	Year 1			Year 2	
	Quantity	Price	Value	Quantity	Value
	q_1	p_1	p_1q_1	q_2	p_1q_2
Commodity					
A	10	8	80	15	120
B	15	12	180	15	180
C	20	5	100	25	125
Total (real GDP)			360		425

Source: Statistics New Zealand (1998) - with very minor amendments

A Paasche index calculates the total value of GDP holding prices constant at their second (or last) year levels. Table 7 presents a theoretical example of real GDP in the first and second year using the Paasche method (note the total value of each commodity for each year utilises the last (second) year's prices). In the example, real GDP has grown by 15.4%.

Table 7 – Example of a Paasche Index

	Year 1		Year 2		
	Quantity	Value	Quantity	Price	Value
	q_1	p_2q_1	q_2	p_2	p_1q_2
Commodity					
A	10	60	15	6	90
B	15	210	15	14	210
C	20	120	25	6	150
Total (real GDP)		390			450

Source: Statistics New Zealand(1998) - with very minor amendments

Clearly the growth rate is dependent on which approach (Laspeyres or Paasche) is used. The result that the growth rate of the Laspeyres index is greater than the growth rate shown by the Paasche index is not just due to the construction of the example[19]. The reason why Laspeyres indexes tend to exhibit higher growth than Paasche indexes is due to the substitution effect that occurs when relative price changes occur. People tend to purchase more of goods that have become relatively cheaper and less of goods that have become relatively more expensive. Consequently goods that have become relatively cheaper tend to have faster growth (in terms of numbers of units produced and consumed) and goods that have become relatively more expensive tend to have slower growth. By using first year prices (before the relative price changes), the Laspeyres approach gives a higher weight to fast growing commodities and a smaller weight to slow growing commodities.

[18] This discussion relies heavily on Statistics New Zealand (1998).

[19] Note that the physical quantities of the goods produced are the same in both Tables 6 and 7.

In terms of what drives differences in the growth rates obtained from the two approaches, Statistics New Zealand (1998) states "What matters is the extent to which the pattern of **relative** prices (ie the ratio of the price of one commodity to another) changes over time and not the general rate of inflation. If all prices were to increase at the same rate the two volume indices would be equal, but if some prices go up faster than others, and especially if some go down while others go up, the two volume indices will diverge. The more variation there is in the price changes, the more the volume indexes will diverge."

Things become even more complex when one is interested in constructing values for real GDP over more than 2 periods. There are two general approaches. The first is known as the fixed weight index approach and uses the prices of just one period. Real GDP for each period in the series is calculated by multiplying the price of each commodity (in the chosen base year) by the quantity of the commodity produced in the year for which real GDP is being calculated. Until recently, this is the approach that Statistics New Zealand used and when using this approach 1991/1992 was chosen as the base year's prices to be used. For each year, the quantity of a particular commodity produced was multiplied by that commodity's 1991/1992 price. Summing this product over all commodities gave a value for real GDP expressed in 1991/1992 prices. Consequently, the values of real GDP prior to 1991/1992 are constructed using the Paasche index approach (as the 1991/1992 prices being used relate to a later period than the quantities of commodities produced). On the other hand, values of real GDP for years after 1991/1992 utilise the Laspeyres index approach. As a Laspeyres index tends to register higher growth rates than a Paasche index, this means that it is likely that growth prior to 1991/92 (based on a Paasche index) would be understated to growth post 1991/1992 (based on a Laspeyres index).

One issue that arises with fixed weight series is that the growth rates between consecutive years are sensitive to the choice of base year chosen. "In general, moving the base year forward in time will tend to reduce growth rates previously recorded so that they have to be revised downwards. History is rewritten." (Statistics New Zealand, 1998) Statistics New Zealand (1998) provides an illustration of this by comparing annual growth rates for total real gross domestic expenditure when 1991/92 prices were used with the growth rates when 1982/83 prices are used.[20] Table 8 reproduces a table summarising the results. As can be seen from the table the differences in annual growth rates are quite substantial.

Table 8 – Comparison of annual growth rates for fixed weight real gross domestic expenditure series with different base years

Year ended March	**Published base-weighted series in 1982/83 prices: percent growth from previous year**	**Published base-weighted series in 1991/92 prices: percent growth from previous year**	**Difference**
1988	2.8	0.8	-2.0
1989	1.6	1.1	-0.5
1990	1.1	-0.1	-1.2
1991	-0.9	-0.8	0.1
1992	-0.9	-1.1	-0.2
1993	0.6	0.8	0.2

Source: Based on Table C from Statistics New Zealand (1998)

The second general approach to obtaining real GDP values for multiple years is known as the annual chain-linked approach and this method updates the price weights used every

[20] Unfortunately this is not a pure experiment as changes to methodology and revisions to component series also contribute to differences in growth rates.

year. For the period 1987 to 2000, the chain-linked real GDP series is derived by calculating the (percentage) change between 1987 and 1988 using 1987 prices to value the quantities in 1987 and 1988. The change between 1988 and 1989 is calculated using 1988 prices to value the quantities in 1988 and 1989 and so on. To obtain a series of real GDP figures based on 1995 prices the following approach is used. For each year a measure of the total change between the year of interest and the year 1995 is obtained by multiplying together the annual changes between consecutive years. For years prior to 1995, the value of 1995 real GDP (which will equal the nominal GDP for 1995 as 1995 prices are being used) is divided by the by the appropriate total change figure. For years post 1995 the 1995 value for real GDP is multiplied by this amount.[21]

Note that the above approach to obtaining a chain-linked series is known as a Laspeyres chain linked approach as for each pair of years the prices of the earlier year are used. If the latest year's prices were used for each pair the resulting index would be a Paasche chain index.

If relative prices change monotonically using chain weights instead of fixed weights tend to result in a growth rate somewhere between that of a fixed Laspeyres or fixed Paasche index. As outlined above, Statistics New Zealand has upgraded New Zealand's National Accounts by moving from fixed to (Laspeyres) chain weights. Theoretically this should increase growth rates prior to 1991/92 as a chain Laspeyres index will produce higher growth rates than a fixed Paasche. The upgrade would also theoretically reduce growth rates after 1991/1992 as a chained Laspeyres index will result in lower growth rates than a fixed Laspeyres index.

Experimental work by Statistics New Zealand based on real (expenditure based) GDP series showed that when moving from a fixed weight method to a Laspeyres chain weighted method for constructing real GDP series the differences in (annual) growth rates are less than 0.3 percentage points although the annual growth rate between the 1994 and 1995 March years was as high as 0.6 percentage points (see Statistics New Zealand (1998) for more details).[22]

The key point to be taken from this section is that there are a number of measurement issues associated with measuring real GDP and consequently with measuring the growth in real GDP per capita. As a result there probably does not exist a definitive or 'true' calculated value for the historical rate of growth in a particular period. Different approaches to measuring or constructing real GDP series have resulted in the various series for real GDP per capita that are available not being identical. Therefore, the average growth rate for a period of interest will tend to vary across series.

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[21] Consider the following example. 1992 GDP measured in 1991 prices is 5% higher than 1991 GDP. 1993 GDP measured in 1992 prices is 4% higher than 1992 GDP. 1994 GDP measured in 1993 prices is 6% higher than 1993 GDP. 1995 GDP measured in 1994 prices is 1% higher than 1994 GDP. Consequently 1995 real GDP is 1.05 x 1.04 x 1.06 x 1.01 = 1.169 times as great as 1991 real GDP. If GDP in 1995 was $100 billion then 1991 real GDP would be $85.54 billion.

[22] Note that the Statistics New Zealand publication interprets the difference between, say, 1.2% and 1.4% as being 2 percentage points. A more common interpretation of a percentage point would be the difference between, say, 2% and 3% and therefore the difference between 1.2% and 1.4% would be regarded as 0.2 percentage points. In this paper I have used this more common interpretation and therefore have amended the percentage point differences presented in the Statistics New Zealand publication accordingly.

5 Measured New Zealand growth rates over time

One point that should be noted when considering New Zealand's average growth rate over a particular sub-period is that the growth rate can be quite sensitive to the endpoints (or time period) chosen. Table 9 shows New Zealand's growth rate based on OECD data for a number of different length sub-periods. To illustrate the sensitivity of the average growth rate for a period, consider the average growth rate for the period 1988 to 1994 (a 6 year window with window endpoint 1994). The average growth rate for this sub-period is 0.63 percent. Compare this to the growth rate for the period 1987 to 1993. The average growth rate for this period was -0.10 percent per annum. These growth rates differ significantly yet the start and end of the six year period under consideration differ by only one year.

Table 9 - New Zealand Growth Rates for Different Window Endpoints and Window Lengths based on OECD data

Window endpoint	Window length										
	5	6	7	8	9	10	11	12	13	14	15
1975	2.32										
1976	1.88	1.93									
1977	0.35	0.85	1.04								
1978	-0.92	0.18	0.64	0.83							
1979	-1.76	-0.82	0.11	0.51	0.70						
1980	-0.92	-1.35	-0.61	0.18	0.53	0.70					
1981	-0.36	-0.30	-0.75	-0.18	0.48	0.76	0.89				
1982	1.20	0.28	0.24	-0.23	0.23	0.77	1.01	1.11			
1983	1.60	1.23	0.44	0.38	-0.05	0.34	0.83	1.04	1.13		
1984	2.45	1.99	1.61	0.87	0.77	0.35	0.67	1.08	1.26	1.33	
1985	2.38	2.10	1.75	1.45	0.81	0.73	0.35	0.64	1.03	1.19	1.26
1986	2.20	2.31	2.08	1.77	1.50	0.92	0.84	0.48	0.74	1.09	1.24
1987	1.43	1.77	1.92	1.77	1.53	1.31	0.80	0.73	0.41	0.66	0.99
1988	1.05	1.10	1.44	1.61	1.51	1.33	1.15	0.69	0.64	0.34	0.58
1989	0.30	0.90	0.97	1.28	1.45	1.38	1.22	1.06	0.65	0.60	0.33
1990	0.04	0.09	0.63	0.72	1.03	1.21	1.16	1.04	0.91	0.53	0.50
1991	-1.26	-0.73	-0.58	-0.02	0.14	0.47	0.68	0.69	0.61	0.52	0.19
1992	-1.17	-1.05	-0.62	-0.50	-0.01	0.13	0.43	0.63	0.64	0.57	0.48
1993	-0.02	-0.10	-0.15	0.11	0.14	0.52	0.59	0.83	0.99	0.97	0.88
1994	0.72	0.63	0.47	0.36	0.53	0.51	0.82	0.87	1.07	1.19	1.16
1995	1.44	1.04	0.91	0.73	0.61	0.74	0.70	0.97	1.00	1.18	1.29
1996	2.64	1.44	1.09	0.98	0.81	0.69	0.80	0.76	1.00	1.03	1.19
1997	2.75	2.30	1.32	1.03	0.93	0.79	0.68	0.78	0.75	0.98	1.00
1998	1.62	2.23	1.91	1.10	0.87	0.80	0.68	0.59	0.69	0.67	0.88
1999	1.67	2.04	2.50	2.19	1.44	1.20	1.10	0.97	0.86	0.94	0.90
2000	1.53	1.71	2.02	2.42	2.16	1.49	1.26	1.17	1.04	0.94	1.00
Max	2.75	2.31	2.50	2.42	2.16	1.49	1.26	1.17	1.26	1.33	1.29

Growth Rates calculated using average annual change method.

Example: the growth rates with window endpoint 1999 and window length 8 is calculated using real GDP data for the years 1991 through to 1999.

Highlighted figures show the highest average growth rate for each window length. For example if one focuses on growth rates for sub periods that are 7 years long, the highest growth rate for any period of this length was 2.5% and this relates to the period 1992 to 1999.

Alternatively, this same point can be illustrated when the endpoint is fixed and the length of the sub-period differs by a single year. For example the average growth rate for the period 1991 to 1997 was 2.30 percent. Extending this period back just one year results in a growth rate for the period 1990 to 1997 of 1.32 percent. This is nearly a whole percentage point lower. These differences are a result of the variability of the annual growth rates. Due to this variability it is often desirable to measure trend growth, which loosely put implies measuring growth rates between two years that are similarly placed during the growth cycle, for example, peak to peak. The objective of this paper is, however, to document New Zealand's historical growth performance over time and not to determine New Zealand's trend (or potential) growth rate.

Table 10 gives the ranking of the New Zealand growth rate for each cell in Table 9 within the 26 OECD countries included in the OECD dataset used for this paper. For each possible sub-period shown in the table, the average growth rates of the other 25 OECD countries have been calculated and New Zealand's ranking within these growth rates computed. As Table 10 shows New Zealand's growth rate for most sub-periods has been towards the bottom of the OECD (lowest possible ranking is 26). Periods where performance has been in the top half are rare and not sustained for long periods of time.

Table 10- New Zealand's growth rate ranking in the OECD for a number of different sub-periods based on OECD data

Window endpoint	Window length										
	5	6	7	8	9	10	11	12	13	14	15
1975	17										
1976	23	22									
1977	25	25	25								
1978	26	25	25	25							
1979	26	26	26	26	26						
1980	26	26	26	26	26	26					
1981	25	26	26	26	26	26	26				
1982	16	25	26	26	26	25	25	25			
1983	10*	18	25	26	26	25	25	25	25		
1984	4*	9*	17	22	26	26	25	25	25	25	
1985	6*	5*	11*	21	23	26	26	26	25	25	25
1986	11*	7*	7*	12*	20	25	26	26	25	25	25
1987	22	20	13*	15	20	22	25	26	26	25	25
1988	24	24	23	22	22	23	24	25	26	26	26
1989	25	25	24	24	23	24	24	24	26	26	26
1990	25	25	25	25	24	24	24	24	25	26	26
1991	26	26	26	26	25	25	24	24	25	26	26
1992	25	26	26	26	26	25	25	24	24	25	26
1993	22	23	26	26	26	25	24	23	21	23	24
1994	20	21	23	26	25	25	25	24	22	20	21
1995	9*	18	19	20	23	24	25	23	22	21	20
1996	7*	12*	18	20	20	24	24	24	24	23	21
1997	9*	9*	16	20	22	23	25	24	25	24	23
1998	22	15	14	22	24	25	26	26	25	25	25
1999	22	19	11*	12*	19	24	25	24	25	24	24
2000	24	23	20	14	14	20	25	25	25	25	25
Best	4	5	7	12	14	20	24	23	21	20	20

Possible rankings range from 1 (highest growth rate for the period in the OECD) to 26 (lowest growth rate for the period in the OECD). Highlighted cells show New Zealand's highest ranking in each column.

* indicates that the growth rate ranking is sufficiently high to be categorised as being in the top half of the OECD.

Bearing in mind the sensitivity of NZ growth rates to the sample period, the results shown in Tables 9 and 10 may highlight signs of improved performance by the NZ economy over the last decade. In Table 9, the decade with the highest growth rate out of any decade long period in the table was the most recent decade ending in 2000. However, while this period also resulted in New Zealand's highest growth ranking out of all decade long periods, the rate of growth achieved was still insufficient to register New Zealand in the top half of OECD growth rates.

It should be noted that exactly the same growth rates are obtained when using OECD data from publications such as *National Accounts of OECD Countries* (OECD, 2002) regardless of whether real GDP per capita is converted into a common currency using exchange rates or PPPs. This is because the OECD converts all the observations in a country's real GDP per capita series (expressed in the country's national currency) using the exchange rate or PPP rate for a single year.[23] A transformation that involves either multiplying or dividing all observations in a series by some constant has no impact on the growth rate of the transformed series.

Tables equivalent to Tables 9 and 10 based on the PWT, Maddison and Haugh's calibrated real GDP data sources are provided in Appendix D. Nuxoll (1994) raises a concern that data construction techniques used in constructing series such as those contained in the PWTs may have inadvertently introduced a spurious correlation between growth rates and income. Nuxoll argues that (based on what he calls the Gerschenkron proposition) any income index using fixed prices to measure growth rates would tend to understate the growth rates for less developed countries and overstate the growth rates for more developed countries relative to the national income accounts.

The PWT draw heavily on the work of the International Comparison Project (ICP). The ICP estimates real expenditure in a large number of countries based on what are termed "international prices". International prices are constructed using the Geary-Khamis formula for international prices.[24] This results in the international price of a good depending little on the prices in low-income countries, countries with small populations or low or relatively small demand for the good.

The ICP only produces expenditure estimates of real GDP for a few years and consequently to construct the annual series that appear in the PWT, Summers and Heston extrapolate estimates for real consumption, investment, government spending and net foreign balance for a large number of years. These estimates are based on international prices. "The estimates for real consumption, investment, government spending, and net foreign balance were combined with the growth rates for the same series in existing World Bank national-accounts data. This amounts to assuming that these series measured in terms of international prices grow at the same rate as these series measured in domestic prices. The result is a series of estimates for each year, all measured in terms of international dollars." (Nuxoll, 1994)

Consequently, real total GDP measures from the PWT and national accounts estimates differ because of the price weights used. The PWT use international prices whereas national accounts uses domestic prices. If this results in the share in GDP of consumption, investment, government or net foreign balance differing between the PWT and the national accounts, the growth rates obtained from the different sources will differ.

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[23] For example, the real GDP series for New Zealand expressed in 1995 prices and exchange rates (US dollars) is obtained by converting each value in a real GDP per capita series expressed in 1995 prices and valued in New Zealand by dividing by the 1995 exchange rate with the US dollar. Likewise, the real GDP series for New Zealand expressed in 1995 prices and PPPs (US dollars) is obtained by converting each value in a real GDP per capita series expressed in 1995 prices and valued in New Zealand by dividing by the 1995 PPP with the US dollar. Note, OECD publications express the exchange rate for the New Zealand and US dollars in terms of the number of New Zealand dollars a US dollar will buy. In New Zealand exchange rates tend to be expressed terms of the number of units of a foreign currency one New Zealand dollar will buy.

[24] For more details see Geary(1958) and Khamis (1967).

Nuxoll (1994) notes that international prices are a synthetic set of average prices across countries, so they are not drawn directly from one country. He also states that prices in Hungary are the closest to the international prices used in the ICP and PWTs. Nuxoll's research ultimately finds that "Current versions of the Penn World Table do not systematically distort the data, because of the very high level of aggregation. Nonetheless, the growth rates in Penn World Tables do differ from national accounts." (Nuxoll, 1994). Nuxoll goes on to argue that the use of real GDP series measured in domestic prices is more reliable than using series expressed in international prices, because domestic prices characterise the trade-offs faced by people in the country. An awareness of the sorts of problems associated with the use of different price weights is, however, still desirable for empirical work.

6 Conclusion

This paper has examined issues associated with measuring economic growth and the international ranking of countries by real GDP per capita. Section 2 illustrated that New Zealand's international ranking depends to some extent on the data source used. While each data source produced a picture of a falling ranking over time, different data sources do influence the timing of falls and consequently may support different theories as to the major events contributing to such falls.

Section 3 examined the differences between various approaches to measuring the average growth rate over a period. The weighting system underlying growth rates estimated by OLS can lead to results that differ significantly from other techniques. The OLS technique is not appropriate when the log of real GDP per capita series contains a unit root. All the New Zealand series used in this paper contained a unit root, suggesting that the use of the OLS approach is inappropriate when using New Zealand data. At the very least it is important that people disclose the technique used in constructing a growth rate.

Section 4 focused on the impact of different data construction techniques on measured growth rates. It highlighted that knowledge of how data has been constructed is important as data construction can potentially have important implications for the measurement of real GDP and its associated growth rates. Changes in construction techniques over time do hinder the consistency of growth rate measures across time for New Zealand. This is also likely to be the case for most other countries, making international comparisons difficult. Large amounts of effort and resources have been expended in trying to make the construction of GDP measures as consistent as possible across countries. While this effort is extremely valuable, rankings of countries should still be treated with caution. This is particularly so when GDP per capita is being used as a proxy for living standards across countries.

Section 5 illustrated that New Zealand's average growth rate for a period can be very sensitive to the endpoints used. This needs to be borne in mind when statements are made comparing the average growth rate for one period to another. To be credible, the analysis behind such statements needs to consider whether the comparison changes significantly when relatively minor changes are made to the time periods for which the growth rates are being compared. The tables included in section 5 and the appendices provide an accessible documentation of New Zealand's historical growth performance as suggested by several different real GDP per capita series.

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Appendix A:

A.1 Weighting Scheme of the OLS Growth Rate Estimator

As explained in Section 3.1 one way of estimating a growth rate is to estimate the model:

$$\ln Y_t = \alpha + \beta t + \varepsilon_t$$

The OLS estimator for β can be written as:

$$\hat{\beta} = \sum_{t=1}^{T} w_t \ln Y_t \qquad \text{(A.1.1)}$$

where $w_t = \frac{t - \bar{t}}{\sum_{t=1}^{T}(t-\bar{t})^2}$ and $\bar{t} = \frac{1}{T}\sum_{t=1}^{T} t = \frac{1}{T}\frac{T(T+1)}{2} = \frac{1}{2}(T+1)$

Now $\sum_{t=1}^{T}(t-\bar{t}) = \sum_{t=1}^{T} t - T\bar{t} = T\bar{t} - T\bar{t} = 0$ which implies:

$$\sum_{t=1}^{T} w_t = 0 \qquad \text{(A.1.2)}$$

We can therefore rewrite (A.1.1) as:

$$\hat{\beta} = \sum_{t=1}^{T} w_t \ln Y_t - \sum_{t=1}^{T} w_t \ln Y_1 = \sum_{t=1}^{T} w_t (\ln Y_t - \ln Y_1) = \sum_{t=2}^{T} w_t (\ln Y_t - \ln Y_1) \qquad \text{(A.1.3)}$$

by noting that $\sum_{t=1}^{T} w_t \ln Y_1 = \ln Y_1 \sum_{t=1}^{T} w_t = 0$ due to (A.1.2) and $\ln Y_1 - \ln Y_1 = 0$

The next step is to note that:

$$\ln Y_t - \ln Y_1 = (\ln Y_t - \ln Y_{t-1}) + (\ln Y_{t-1} - \ln Y_{t-2}) + (\ln Y_{t-2} - \ln Y_{t-3}) + \ldots + (\ln Y_3 - \ln Y_2) + (\ln Y_2 - \ln Y_1)$$

note that the last term in a bracket cancels with the first term in the following bracket so:

$\ln Y_t - \ln Y_1 = \sum_{s=2}^{t} (\ln Y_s - \ln Y_{s-1})$ substituting this into (A.1.3) gives:

$$\hat{\beta} = \sum_{t=2}^{T} w_t \sum_{s=2}^{t} (\ln Y_s - \ln Y_{s-1}) = \sum_{s=2}^{T} (\sum_{t=s}^{T} w_t) \Delta \ln Y_s = \sum_{s=2}^{T} k_s \Delta \ln Y_s \qquad \text{(A.1.4)}$$

where $k_s = \sum_{t=s}^{T} w_t$, ie a set of weights.

Using the definition of w_t we get:

$$k_s = \frac{\sum_{t=s}^{T}(t-\bar{t})}{\sum_{t=1}^{T}(t-\bar{t})^2} = \frac{\sum_{t=0}^{T-s}(t+s-\bar{t})}{\sum_{t=1}^{T}(t-\bar{t})^2} \qquad \text{(A.1.5)}$$

By making use of $\sum_{t=1}^{T} t^2 = \frac{T(T+1)(2T+1)}{6}$ and $\bar{t} = \frac{1}{2}(T+1)$ it can be shown that:

$$k_s = \frac{6(T-s+1)(s-1)}{T(T+1)(T-1)} \text{ where } s = 2,3,...,T \qquad \text{(A.1.6)}$$

Therefore:

$$\hat{\beta} = \sum_{s=2}^{T} \frac{6(T-s+1)(s-1)}{T(T+1)(T-1)} \Delta \ln Y_s \qquad \text{(A.1.7)}$$

A.2 Obtaining the growth rate estimator in a log-difference model

The OLS estimator for the model $\Delta \ln Y_t = \beta + \varepsilon_t$ can be found as follows:

$$\varepsilon_t = \Delta \ln Y_t - \beta \qquad \text{(A.2.1)}$$

Therefore:

$$\sum_{t=2}^{T} \varepsilon_t^2 = \sum (\Delta \ln Y_t - \beta)^2 \qquad \text{(A.2.2)}$$

Differentiating with respect to β gives:

$$\frac{\partial \sum_{t=2}^{T} \varepsilon_t^2}{\partial \beta} = -2\sum_{t=2}^{T}(\Delta \ln Y_t - \beta) \qquad \text{(A.2.3)}$$

Minimisation requires setting (A.2.3) to zero. Therefore:

$$\sum_{t=2}^{T}(\Delta \ln Y_t - \beta) = 0 \qquad \text{(A.2.4)}$$

Thus:

$$\sum_{t=2}^{T} \beta = \sum_{t=2}^{T}(\Delta \ln Y_t) \qquad \text{(A.2.5)}$$

and so:

$$\hat{\beta} = \frac{1}{T-1}\sum_{t=2}^{T}(\Delta \ln Y_t) \qquad \text{(A.2.6)}$$

A.3 The geometric Average Growth Rate

Solving the compound growth formula for the growth rate r is one possible way of calculating the average annual growth rate over a period. Outlined below is why this solution for r is known as a geometric average growth rate. We begin with the compound growth rate formula:

$$Y_T = Y_1(1+r)^{T-1} \qquad \text{(A.3.1)}$$

which can be rewritten as:

$$(1+r)^{T-1} = \frac{Y_T}{Y_1} \qquad \text{(A.3.2)}$$

This is equivalent to:

$$(1+r)^{T-1} = \prod_{t=2}^{T}\frac{Y_t}{Y_{t-1}} \text{ as } \frac{Y_t}{Y_1} = \frac{Y_2}{Y_1}\frac{Y_3}{Y_2}\frac{Y_4}{Y_3}\cdots\frac{Y_{t-1}}{Y_{t-2}}\frac{Y_t}{Y_{t-1}} \qquad \text{(A.3.3)}$$

Note: the numerator in each fraction cancels with the denominator in the following fraction, except at the endpoints.

Therefore by adding and subtracting Y_{t-1} to the numerator:

$$(1+r)^{T-1} = \prod_{t=2}^{T}\frac{Y_t - Y_{t-1} + Y_{t-1}}{Y_{t-1}} \qquad \text{(A.3.4)}$$

so that:

$$(1+r)^{T-1} = \prod_{t=2}^{T}\left(1+\frac{Y_t - Y_{t-1}}{Y_{t-1}}\right) \qquad \text{(A.3.5)}$$

$$1+r = \left[\prod_{t=2}^{T}\left(1+\frac{Y_t - Y_{t-1}}{Y_{t-1}}\right)\right]^{\frac{1}{T-1}} \qquad \text{(A.3.6)}$$

A.4 Proof that Log Difference Regression and Geometric Growth Rates are Equal

The log difference regression estimate of the growth rate can be found using the following expression:

$$r_{LD} = e^{\frac{1}{T-1}\sum_{t=2}^{T}\Delta \ln Y_t} - 1 \qquad \text{(A.4.1)}$$

now $\frac{1}{T-1}\sum_{t=2}^{T}\Delta \ln Y_t = \frac{1}{T-1}\sum_{t=2}^{T}(\ln Y_t - \ln Y_{t-1}) = \frac{1}{T-1}\sum_{t=2}^{T}\ln\left(\frac{Y_t}{Y_{t-1}}\right)$ as $\ln(A) - \ln(B) = \ln\left(\frac{A}{B}\right)$

and $\frac{1}{T-1}\sum_{t=2}^{T}\ln\left(\frac{Y_t}{Y_{t-1}}\right) = \ln\left(\prod_{t=2}^{T}(\frac{Y_t}{Y_{t-1}})\right)^{\frac{1}{T-1}}$ (by using the rules $\ln(A) + \ln(B) = \ln(AB)$ and $A\ln(B) = \ln(B^A)$). Consequently (A.4.1) can be rewritten as:

$$r_{LD} = e^{\ln\left(\prod_{t=2}^{T}(\frac{Y_t}{Y_{t-1}})\right)^{\frac{1}{T-1}}} - 1 \qquad \text{(A.4.2)}$$

which can be simplified further to:

$$r_{LD} = \left(\prod_{t=2}^{T}\frac{Y_t}{Y_{t-1}}\right)^{\frac{1}{T-1}} - 1 \qquad \text{(A.4.3)}$$

Noting that $\prod_{t=2}^{T}\frac{Y_t}{Y_{t-1}} = \frac{Y_2}{Y_1}\frac{Y_3}{Y_2}\frac{Y_4}{Y_3}\ldots\frac{Y_{t-1}}{Y_{t-2}}\frac{Y_t}{Y_{t-1}}$ and observing that the numerator in each fraction cancels with the denominator in the following fraction, except at the endpoints, we get:

$$r_{LD} = \left(\frac{Y_T}{Y_1}\right)^{\frac{1}{T-1}} - 1 = r_{GEO} \qquad \text{(A.4.4)}$$

Appendix B - New Zealand real GDP per capita series

year	OECD ($US)	OECD (PPP)	calibrated	Maddison	PWT5.6	prelim. PWT6.0
1950				8453	6667	9313
1951				7651	6263	8762
1952				7792	6074	8578
1953				7850	6068	8529
1954				8734	6811	9471
1955				8714	6878	9628
1956				8981	6772	9503
1957				9030	7010	9796
1958				9168	6926	9720
1959				9614	7040	9883
1960				9444	7960	11152
1961				9767	8066	11561
1962				9744	8154	11465
1963				10149	8387	11976
1964				10430	8677	12365
1965				10901	9032	13001
1966				11381	9121	13550
1967				10683	8704	12591
1968				10565	8624	12398
1969				11546	9122	13437
1970	12920.52	13419.60		11221	9392	13226
1971	13203.61	13713.62		11622	9726	13728
1972	13646.05	14173.15		11916	10004	14101
1973	14423.30	14980.42		12513	10631	14972
1974	14980.18	15558.81		12991	11088	15626
1975	14458.50	15016.98		12613	10526	14804
1976	14456.98	15015.40		12801	10631	15036
1977	13834.62	14369.00		12130	10045	14232
1978	13743.54	14274.40	20472.08	12175	10036	14217
1979	13695.07	14224.06	20907.00	12388	10342	14632
1980	13791.31	14324.02	20989.02	12449	10362	14647
1981	14181.31	14729.08	21872.27	13000	10815	15291
1982	14672.97	15239.73	21795.25	13135	10896	15427
1983	14873.91	15448.43	22191.76	13315	11004	15644
1984	15454.24	16051.18	23175.52	13834	11446	16310
1985	15506.79	16105.76	23303.26	13881	11443	16320
1986	15807.41	16417.99	23793.83	14151	11704	16609
1987	15743.12	16351.21	23714.43	14093	11688	16483
1988	15660.44	16265.35	23661.37	13995	11501	16211
1989	15687.00	16292.93	23620.69	14040	11762	16283
1990	15530.34	16130.22	23330.11	13825	11513	15931
1991	14822.98	15395.53	22760.87	13162	11054	15457
1992	14828.62	15401.40	22586.06	13140	11363	15520
1993	15607.28	16210.13	23767.08	13640		16345
1994	16214.20	16840.50	24692.40	14253		17056
1995	16635.06	17277.61	25335.85	14593		16265
1996	16871.59	17523.28	25693.41	14838		16407
1997	16971.85	17627.41	25852.54	14971		16519
1998	16904.23	17557.18	25754.24	14779		
1999	17600.50	18280.34	26803.92			
2000	17937.70	18630.57				

Appendix C – New Zealand average annual change growth rates from different data sources

Period	Calibrated	Maddison 2001	OECD	PWT5.6	Prelim. PWT6.0
1950 - 1960		1.24			
1951 - 1961		2.53			
1952 - 1962		2.32			
1953 - 1963		2.66		3.40	3.55
1954 - 1964		1.81		2.52	2.77
1955 - 1965		2.29		2.83	3.12
1956 - 1966		2.42		3.08	3.67
1957 - 1967		1.75		2.28	2.66
1958 - 1968		1.49		2.30	2.58
1959 - 1969		1.93		2.72	3.25
1960 - 1970		1.83		1.71	1.81
1961 - 1971		1.84		1.93	1.82
1962 - 1972		2.12		2.10	2.18
1963 - 1973		2.20		2.45	2.35
1964 - 1974		2.31		2.53	2.46
1965 - 1975		1.57		1.61	1.42
1966 - 1976		1.27		1.62	1.16
1967 - 1977		1.36		1.52	1.33
1968 - 1978		1.51		1.60	1.47
1969 - 1979		0.76		1.33	0.93
1970 - 1980		1.09	0.70	1.06	1.09
1971 - 1981		1.17	0.76	1.14	1.15
1972 - 1982		1.02	0.77	0.93	0.97
1973 - 1983		0.66	0.34	0.40	0.49
1974 - 1984		0.67	0.35	0.37	0.48
1975 - 1985		0.99	0.73	0.87	1.01
1976 - 1986		1.04	0.92	1.00	1.04
1977 - 1987		1.52	1.31	1.54	1.49
1978 - 1988	1.59	1.42	1.33	1.39	1.34
1979 - 1989	1.30	1.27	1.38	1.31	1.09
1980 - 1990	1.11	1.07	1.21	1.08	0.87
1981 - 1991	0.57	0.15	0.47		0.13
1982 - 1992	0.25	0.03	0.13		0.08
1983 - 1993	0.78	0.27	0.52		0.47
1984 - 1994	0.59	0.33	0.51		0.48
1985 - 1995	0.76	0.54	0.74		0.01
1986 - 1996	0.80	0.51	0.69		-0.08
1987 - 1997	0.90	0.64	0.79		0.06
1988 - 1998	0.82	0.58	0.80		
1989 - 1999	1.15		1.20		
1990 - 2000	1.57		1.49		

Appendix D – New Zealand growth rates and growth rate rankings from alternative data sources

Table D1 - New Zealand Growth Rates for Different Window Endpoints and Window Lengths based on PWT data

Window endpoint	Window length (years)										
	5	6	7	8	9	10	11	12	13	14	15
1958	2.80										
1959	0.68	2.61									
1960	3.10	2.75	4.10								
1961	3.67	2.80	2.54	3.76							
1962	3.19	3.24	2.56	2.36	3.46						
1963	4.00	3.13	3.19	2.60	2.42	3.40					
1964	4.36	3.91	3.18	3.22	2.69	2.52	3.41				
1965	2.57	4.32	3.93	3.29	3.32	2.83	2.66	3.46			
1966	2.50	2.30	3.84	3.57	3.04	3.08	2.66	2.52	3.27		
1967	1.36	1.32	1.32	2.79	2.66	2.28	2.39	2.06	1.98	2.71	
1968	0.61	0.98	1.00	1.04	2.38	2.30	1.99	2.11	1.83	1.77	2.47
1969	1.07	1.47	1.67	1.60	1.57	2.72	2.62	2.30	2.39	2.11	2.04
1970	0.85	1.39	1.68	1.83	1.75	1.71	2.74	2.65	2.35	2.43	2.17
1971	1.36	1.30	1.70	1.92	2.02	1.93	1.87	2.81	2.72	2.44	2.51
1972	2.85	1.61	1.52	1.84	2.02	2.10	2.01	1.96	2.81	2.73	2.47
1973	4.28	3.42	2.28	2.11	2.33	2.45	2.48	2.37	2.29	3.06	2.96
1974	3.99	4.29	3.54	2.53	2.36	2.53	2.61	2.63	2.52	2.43	3.14
1975	2.38	2.48	2.95	2.47	1.68	1.61	1.84	1.97	2.04	1.97	1.93
1976	1.87	2.15	2.27	2.71	2.30	1.62	1.56	1.77	1.90	1.97	1.91
1977	0.20	0.64	1.06	1.29	1.79	1.52	0.97	0.97	1.21	1.37	1.47
1978	-1.07	0.15	0.54	0.91	1.14	1.60	1.37	0.88	0.89	1.12	1.27
1979	-1.32	-0.39	0.56	0.85	1.15	1.33	1.74	1.51	1.05	1.04	1.25
1980	-0.27	-1.07	-0.30	0.52	0.78	1.06	1.23	1.61	1.41	0.99	0.99
1981	0.40	0.50	-0.29	0.28	0.95	1.14	1.36	1.49	1.82	1.62	1.21
1982	1.65	0.46	0.54	-0.16	0.33	0.93	1.10	1.31	1.43	1.74	1.57
1983	1.87	1.54	0.54	0.59	-0.04	0.40	0.93	1.09	1.28	1.40	1.69
1984	2.06	2.23	1.90	0.97	0.97	0.37	0.73	1.19	1.32	1.48	1.58
1985	2.02	1.72	1.91	1.66	0.86	0.87	0.33	0.66	1.10	1.22	1.38
1986	1.60	2.06	1.80	1.95	1.73	1.00	1.00	0.50	0.79	1.18	1.29
1987	1.43	1.31	1.75	1.55	1.72	1.54	0.90	0.91	0.45	0.72	1.09
1988	0.91	0.92	0.90	1.33	1.20	1.39	1.25	0.69	0.71	0.30	0.57
1989	0.56	1.13	1.11	1.07	1.44	1.31	1.47	1.34	0.81	0.83	0.43
1990	0.14	0.11	0.67	0.71	0.71	1.08	1.00	1.17	1.07	0.60	0.63
Max	4.36	4.32	4.10	3.76	3.46	3.40	3.41	3.46	3.27	3.06	3.14

Table D2- New Zealand's growth rate ranking in the OECD for a number of different sub-periods based on PWT data

Window endpoint	Window length (years)										
	5	6	7	8	9	10	11	12	13	14	15
1958	15										
1959	25	15									
1960	11*	16	7*								
1961	10*	14	17	11*							
1962	13	12*	16	20	12*						
1963	15	14	14	16	19	13					
1964	15	15	18	14	19	19	15				
1965	22	12*	15	16	12*	17	19	14			
1966	22	23	14	17	17	15	18	21	15		
1967	24	24	24	21	22	23	21	23	24	18	
1968	25	24	24	24	24	23	24	24	24	24	21
1969	24	25	24	24	25	21	21	22	20	22	25
1970	25	25	25	25	25	25	21	22	21	21	23
1971	25	25	25	25	25	25	25	22	21	22	21
1972	22	25	25	25	25	25	25	25	22	22	22
1973	14	19	25	25	25	25	25	25	25	20	21
1974	14	11*	18	22	23	22	23	22	24	24	21
1975	15	19	19	21	23	24	24	24	23	23	25
1976	22	18	19	19	22	24	24	24	24	24	24
1977	24	24	24	24	21	24	25	25	25	25	25
1978	25	24	24	24	24	24	24	25	25	25	25
1979	25	25	24	24	24	24	24	24	25	25	25
1980	25	25	25	25	25	25	25	24	25	25	25
1981	23	23	25	25	23	24	22	22	19	25	25
1982	11*	22	23	25	24	22	23	21	21	20	23
1983	8*	12*	22	23	25	24	24	24	24	23	21
1984	5*	6*	10*	22	23	23	23	23	24	24	23
1985	9*	10*	11*	15	22	23	24	24	24	24	24
1986	13	9*	9*	10*	13	21	23	25	24	24	24
1987	21	20	14	16	15	17	24	24	25	25	24
1988	24	24	24	20	22	21	22	25	25	25	25
1989	24	24	24	24	23	23	21	22	25	25	25
1990	25	25	25	24	24	24	24	24	25	25	25
Best	5	6	7	10	12	13	15	14	15	18	21

Possible rankings range from 1 (highest growth rate for the period in the OECD) to 25 (lowest growth rate for the period in the OECD).

* indicates that the growth rate ranking is sufficiently high to be categorised as being in the top half of the OECD.

Table D3 - New Zealand Growth Rates for Different Window Endpoints and Window Lengths based on Maddison 2001 data

Window endpoint	Window length										
	5	6	7	8	9	10	11	12	13	14	15
1955	0.83										
1956	3.34	1.20									
1957	3.08	2.87	1.11								
1958	3.23	2.82	2.68	1.16							
1959	1.95	3.51	3.11	2.95	1.57						
1960	1.65	1.33	2.75	2.50	2.43	1.24					
1961	1.72	1.94	1.63	2.84	2.60	2.53	1.44				
1962	1.56	1.39	1.63	1.40	2.49	2.32	2.28	1.30			
1963	2.09	1.99	1.79	1.95	1.71	2.66	2.49	2.43	1.52		
1964	1.67	2.20	2.10	1.91	2.04	1.81	2.67	2.51	2.46	1.61	
1965	2.93	2.14	2.53	2.41	2.20	2.29	2.06	2.82	2.66	2.61	1.80
1966	3.12	3.17	2.47	2.77	2.63	2.42	2.48	2.25	2.95	2.79	2.73
1967	1.94	1.58	1.84	1.39	1.78	1.75	1.64	1.76	1.61	2.30	2.19
1968	0.89	1.43	1.20	1.47	1.11	1.49	1.49	1.41	1.54	1.41	2.07
1969	2.19	2.29	2.56	2.21	2.34	1.93	2.20	2.14	2.02	2.09	1.94
1970	0.73	1.36	1.56	1.88	1.65	1.83	1.50	1.78	1.76	1.67	1.77
1971	0.56	1.20	1.68	1.81	2.07	1.84	1.99	1.67	1.92	1.89	1.80
1972	2.29	0.89	1.39	1.78	1.89	2.12	1.90	2.03	1.74	1.96	1.93
1973	3.52	2.75	1.48	1.84	2.14	2.20	2.38	2.16	2.26	1.97	2.16
1974	2.42	3.57	2.90	1.77	2.06	2.31	2.35	2.50	2.29	2.37	2.10
1975	2.40	1.53	2.64	2.17	1.25	1.57	1.83	1.91	2.08	1.92	2.02
1976	1.99	2.25	1.53	2.50	2.10	1.27	1.56	1.81	1.88	2.04	1.89
1977	0.43	0.78	1.18	0.68	1.64	1.36	0.68	0.99	1.26	1.37	1.56
1978	-0.49	0.42	0.72	1.08	0.65	1.51	1.27	0.66	0.94	1.20	1.30
1979	-0.91	-0.12	0.61	0.85	1.15	0.76	1.53	1.31	0.74	1.00	1.24
1980	-0.23	-0.67	-0.03	0.60	0.81	1.09	0.73	1.45	1.25	0.72	0.97
1981	0.36	0.55	0.05	0.52	1.02	1.17	1.39	1.04	1.68	1.48	0.97
1982	1.62	0.47	0.62	0.18	0.58	1.02	1.16	1.36	1.04	1.63	1.45
1983	1.82	1.57	0.60	0.71	0.31	0.66	1.06	1.18	1.36	1.06	1.61
1984	2.25	2.16	1.91	1.01	1.07	0.67	0.95	1.29	1.39	1.54	1.25
1985	2.21	1.93	1.90	1.71	0.94	0.99	0.64	0.90	1.22	1.31	1.46
1986	1.72	2.17	1.93	1.91	1.74	1.04	1.08	0.75	0.98	1.27	1.36
1987	1.43	1.36	1.80	1.64	1.65	1.52	0.91	0.96	0.66	0.88	1.16
1988	1.02	1.07	1.07	1.49	1.38	1.42	1.32	0.77	0.83	0.56	0.78
1989	0.30	0.90	0.97	0.98	1.36	1.27	1.32	1.24	0.74	0.79	0.55
1990	-0.07	-0.01	0.55	0.65	0.70	1.07	1.02	1.08	1.02	0.58	0.64
1991	-1.42	-0.86	-0.69	-0.12	0.05	0.15	0.54	0.53	0.63	0.61	0.22
1992	-1.37	-1.21	-0.76	-0.62	-0.12	0.03	0.12	0.48	0.48	0.57	0.56
1993	-0.47	-0.51	-0.50	-0.19	-0.13	0.27	0.37	0.43	0.73	0.72	0.79
1994	0.36	0.35	0.20	0.13	0.33	0.33	0.65	0.71	0.74	1.00	0.97
1995	1.14	0.70	0.64	0.48	0.38	0.54	0.52	0.80	0.84	0.86	1.09
1996	2.44	1.23	0.84	0.77	0.61	0.51	0.64	0.61	0.87	0.90	0.91
1997	2.65	2.18	1.19	0.85	0.79	0.64	0.54	0.66	0.64	0.87	0.90
1998	1.63	2.00	1.69	0.88	0.61	0.58	0.46	0.39	0.51	0.50	0.73
max	3.52	3.57	3.11	2.95	2.63	2.66	2.67	2.82	2.95	2.79	2.73

Table D4- New Zealand's growth rate ranking in the OECD for a number of different sub-periods based on Maddison 2001 data

Window endpoint	Window length										
	5	6	7	8	9	10	11	12	13	14	15
1955	24										
1956	13	23									
1957	14	15	24								
1958	11*	12*	13	24							
1959	19	10*	10*	12*	24						
1960	20	24	15	19	18	24					
1961	19	19	20	16	18	17	23				
1962	22	22	21	23	17	20	20	24			
1963	21	20	22	22	24	17	19	20	24		
1964	24	22	22	23	21	24	17	20	20	24	
1965	22	23	22	22	22	20	24	17	18	18	24
1966	21	19	23	22	21	21	20	24	18	18	19
1967	24	24	24	24	24	24	24	24	24	22	24
1968	24	24	24	24	24	24	24	24	24	24	24
1969	23	24	23	24	23	24	24	24	24	24	24
1970	24	24	24	24	24	24	24	24	24	24	24
1971	24	24	24	24	24	24	24	24	24	24	24
1972	23	24	24	24	24	24	24	24	24	24	24
1973	14	23	24	24	24	24	24	24	24	24	24
1974	20	11*	20	24	24	23	24	23	23	23	24
1975	15	21	18	21	24	24	23	24	23	24	24
1976	23	18	23	20	22	24	24	23	23	23	23
1977	23	23	23	24	23	24	24	24	24	24	24
1978	23	23	23	23	24	23	24	24	24	24	24
1979	24	24	23	23	23	24	23	24	24	24	24
1980	24	24	24	24	24	24	24	24	24	24	24
1981	22	24	24	24	23	23	23	24	22	24	24
1982	12*	22	24	23	23	23	23	23	24	21	24
1983	9*	10	22	24	23	23	23	23	22	24	22
1984	6*	7*	9*	21	23	23	22	23	23	22	23
1985	8*	6*	8*	15	22	23	24	23	23	23	23
1986	14	10*	7*	11*	15	23	23	23	23	23	23
1987	19	20	15	15	17	18	24	24	23	23	23
1988	23	23	22	19	20	21	21	24	24	24	23
1989	23	23	23	23	21	22	23	23	24	24	24
1990	23	23	23	23	23	23	23	23	24	24	24
1991	23	24	24	24	23	23	23	23	24	24	24
1992	24	23	24	24	24	23	23	23	24	24	24
1993	21	24	23	24	24	24	23	23	23	23	24
1994	19	20	22	23	24	24	23	23	22	20	21
1995	15	17	19	23	22	22	23	23	23	22	21
1996	7*	15	16	20	22	22	22	23	22	22	22
1997	9*	9*	17	19	21	23	22	22	23	23	22
1998	18	13	13	22	23	23	24	23	24	24	23
best	6	6	7	11	15	17	17	17	18	18	19

Possible rankings range from 1 (highest growth rate for the period in the OECD) to 24 (lowest growth rate for the period in the OECD).

* indicates that the growth rate ranking is sufficiently high to be categorised as being in the top half of the OECD.

Table D5 - New Zealand Growth Rates for Different Window Endpoints and Window Lengths based on Haugh's Calibrated data

Window endpoint	Window length (years)										
	5	6	7	8	9	10	11	12	13	14	15
1983	1.64										
1984	2.10	2.10									
1985	2.13	1.84	1.88								
1986	1.71	2.13	1.88	1.91							
1987	1.71	1.37	1.78	1.60	1.66						
1988	1.31	1.39	1.14	1.53	1.40	1.47					
1989	0.39	1.06	1.17	0.98	1.34	1.24	1.32				
1990	0.03	0.12	0.73	0.87	0.73	1.08	1.02	1.11			
1991	-0.88	-0.38	-0.25	0.34	0.50	0.42	0.76	0.73	0.84		
1992	-0.97	-0.86	-0.44	-0.31	0.21	0.37	0.31	0.63	0.61	0.72	
1993	0.12	0.07	0.01	0.27	0.30	0.72	0.82	0.72	0.99	0.94	1.02
1994	0.94	0.75	0.61	0.49	0.67	0.66	1.00	1.07	0.96	1.19	1.14
1995	1.70	1.21	1.02	0.86	0.73	0.87	0.84	1.14	1.19	1.08	1.29
1996	2.47	1.66	1.24	1.07	0.92	0.80	0.92	0.89	1.16	1.21	1.10
1997	2.75	2.17	1.51	1.17	1.02	0.89	0.78	0.89	0.87	1.12	1.17
1998	1.63	2.23	1.80	1.27	0.99	0.88	0.78	0.68	0.79	0.78	1.02
1999	1.67	2.04	2.49	2.09	1.58	1.30	1.17	1.05	0.95	1.03	1.00
2000	1.43	1.67	2.04	2.49	2.09	1.58	1.30	1.17	1.05	0.95	1.03
Max	2.75	2.23	2.49	2.49	2.09	1.58	1.32	1.17	1.19	1.21	1.29