Capital Shallowness: A Problem for New Zealand?

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Abstract

There is now substantial evidence that New Zealand's overall rate of economic growth relative to Australia's has been lower in part because of lower levels and slower growth in our labour productivity. This then requires us to explore why the labour productivity is lower in New Zealand. This paper explores the extent to which a lower level of capital per hour worked (or lower capital intensity) is associated with less output per hour worked in New Zealand. We find that the capital intensity in New Zealand has not been increasing as fast as in Australia for nearly 25 years. Between 1995 and 2002, lower capital intensity explains 70 percent of the difference in output per hour worked. Whereas the cost of labour relative to capital has been rising in Australia, it has fallen by 20 percent in New Zealand between 1987 and 2002. The relative price of labour to capital in New Zealand fell to 60 percent of the Australian value in 2002 after being comparable in the late 1980's. It is to be expected that New Zealand enterprises would therefore tend to adopt less capital intensive production methods. Differences in capital intensity could also have arisen because the underlying production technologies are different even if the relative prices of labour and capital in the two economies had been similar. We explore this issue and find a similar response of capital intensity to changes in the wage rate relative to the return on capital for the economies as a whole. However when we exclude the mining sector we find that the responsiveness in New Zealand is about one half that of Australia. Whether there are impediments or greater uncertainty in New Zealand that limit the ability of firms to respond to economic signals as much as their Australian counterparts remain as possible explanations requiring further investigation.

JEL CLASSIFICATION

E22 Capital
E23 Production
E24 Employment
O49 Economic Growth and Aggregate Productivity

KEYWORDS New Zealand; Australia; Capital-labour ratios; relative factor prices

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Capital Shallowness: A Problem for New Zealand?

1 Introduction

While indefinite growth in income cannot be sustained through input accumulation alone, capital deepening nevertheless has a direct impact on the level of output and productivity. Increasing the amount of capital directly influences labour productivity by increasing the quantity and quality of machinery, equipment and infrastructure available to each worker. However, evidence suggests that New Zealand is currently capital shallow compared with other OECD countries. That is, New Zealand appears to have a lower capital to labour ratio than many comparator OECD countries.

The Treasury Working paper by Black, Guy and McLellan (2003) was the catalyst for investigating the contribution of capital intensity to the labour productivity gap. Black et al found that New Zealand has had a lower rate of capital accumulation than Australia. In light of this paper Treasury (2004) took up this issue in Chapter II, laying down several hypotheses for why New Zealand's rate of capital deepening may have lagged behind that in Australia in recent years. This paper is motivated by that discussion, and attempts to shed some light on these hypotheses.

The aim of this paper is to look at some possible explanations as to why New Zealand may have invested less in physical capital compared with other countries. We examine the rate of return to capital in New Zealand and comparator countries. High returns are an indication that investment within a country has been low and (perfectly functioning) international capital markets will begin to adjust by equalising marginal products across countries. The existence of high returns in one country for an extended period of time could be an indication that there are barriers to investing within that country.

While it is true that capital investment depends on the return it is expected to generate, firms will assess this return in relation to the return which may be made on other factors of production. Thus in section 6 we turn to the *relative* prices of labour and capital. We find that New Zealand appears to have a lower ratio of labour-to-capital prices, indicating that it has been cheaper for businesses in New Zealand to hire more workers rather than invest in physical capital. We then examine whether New Zealand also adjusts differently to changes in relative prices by estimating the elasticity of substitution in a CES production function.

The paper is structured as follows: Section 2 discusses the methodology employed to measure the capital stock, and issues surrounding the exclusion of land and inventories in the construction of capital stock measures. Section 3 examines the apparently conflicting evidence of New Zealand's similar rate of investment and lower capital stock growth compared with other OECD countries. Section 4 presents evidence of New Zealand's capital shallowness and its relation to New Zealand's labour productivity growth. Section 5 discusses the impact of high rates of return to capital investment on capital stock growth. Section 6 then examines the effects of the relatively lower price of labour to capital in New Zealand, while the summary and conclusions follow in Section 7.

2 Data

2.1 Measuring the Capital Stock

"The measurement of capital is one of the nastiest jobs economists have set to statisticians."
((Hicks 1981): 204)

Perpetual Inventory Method

While the System of National Accounts (SNA) ensures consistent investment data for international comparisons, there are no such guidelines for producing capital stock series. Therefore we use the Gross Fixed Capital Formation series contained in the OECD national accounts to construct capital stock data.[1] The method used to construct capital stock data from investment flow data is that set out in Caselli (November 2003), using the perpetual inventory equation:

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

where I_t is investment and δ is the depreciation rate. The initial capital stock (K_0) was calculated as:

$$K_0 = \frac{I_0}{g+\delta} \quad (2)$$

where I_0 is the value of the investment series in the first year available (1970 for all OECD countries except Czech, Hungary, Poland, and Slovak), and g is the average geometric growth rate for the investment series between 1970 and 1980. The depreciation rate δ was set to 0.06 following Caselli (November 2003).

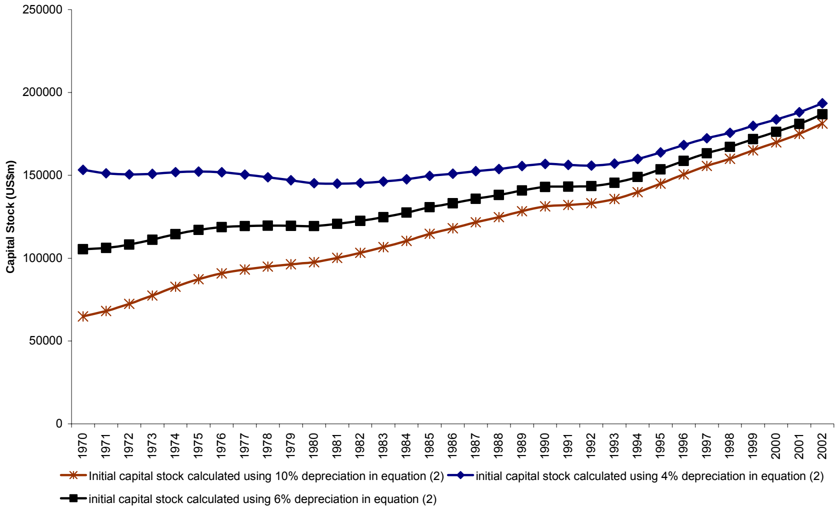
The perpetual inventory method takes into account the continual additions to and subtractions from the stock of capital as new investment and retirement of old capital take place.

Caution must be used when analysing series created using this perpetual inventory method. While observations which occur later in the series will be fairly accurate, values near the beginning of the series should be interpreted with caution, as they are subject to the value assumed for the initial capital stock K_0. Figure 1 shows the evolution of the capital stock for three different initial values.

[1] See Appendix A for a description of the data.

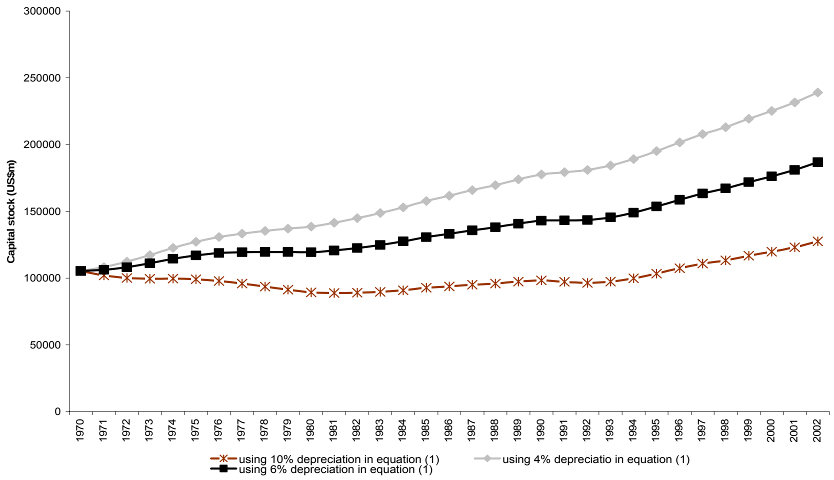
The constructed capital stock series will also be sensitive to the choice of depreciation rate. Figure 2 shows three different capital stock series with the same initial capital stock but different depreciation rates.

Figure 1: Effect of different starting values on the estimated capital stock: 1970-2002



Source: OECD

Figure 2: Effect of different depreciation rates on the estimated capital stock: 1970-2002



Source: OECD

The capital stock used in this paper is based on an initial value of US$105b (for New Zealand in 1995 prices) in 1970 and a depreciation rate of 6%.

Land and Inventories

It has been argued that land and inventories should be included in any measure of the capital stock used in production (see Diewert and Lawrence 1999, Ahmad 2004). The rationale for recognising capital services from inventories is based on the idea that the inventory holder provides security of supply or the ability to provide goods at a later date. Land also provides capital services in that it may be utilised for production at some point in the future.

However, the current SNA has no role for inventories or land as inputs into production. Standard national accounting conventions usually treat the change in inventories as an output but do not include the stock of inventories as an input. Land is not included as an input perhaps because the quantity of land in use is seen to remain relatively constant over time, and hence can be treated as a fixed, unchanging factor in the analysis of production. However, Diewert and Lawrence (2000) state that even though the *quantity* of land is fixed, its price is not, and so neglecting land can have a substantial effect on aggregate input growth.

As New Zealand has no official data on the stock of land, the assumption must be made that the share of land in the total capital stock is similar between New Zealand and other comparator countries. If this assumption is violated (as could well be the case given New Zealand's large agricultural base), the resulting level comparisons will be biased.

In two separate studies, Diewert and Lawrence (1999 and 2000) examine the effect of including land and inventories on the growth of TFP, for New Zealand and Canada respectively. In their 2000 paper, they found that excluding land as a factor of production in Canada increases the average growth rate for capital services and hence decreases TFP growth. When both inventories and land were dropped as factors of production, the average growth rate for real capital services increased further, and further decreased the average TFP growth rate, since inventories have grown much more slowly than other types of capital in Canada.

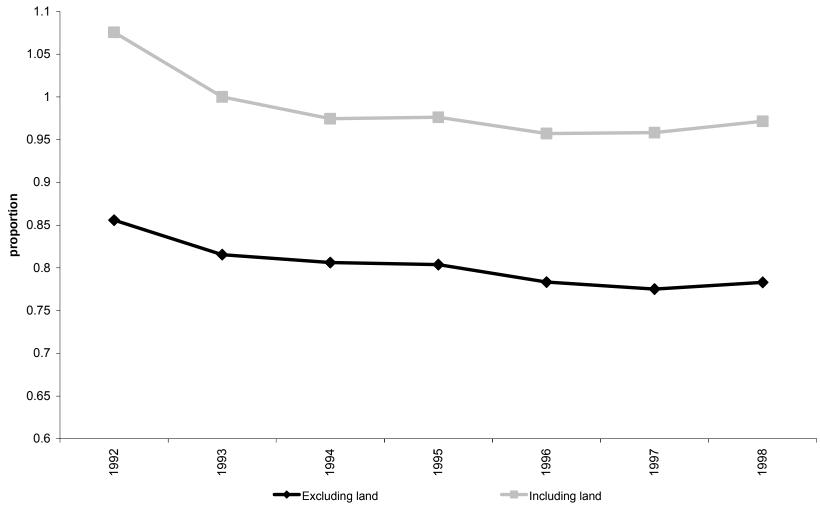
In their 1999 paper, Diewert and Lawrence concluded that the impact of excluding land from the coverage of inputs had a negligible impact on TFP in New Zealand. They argued that this was because land has a relatively small (ex post) user cost and consequently has a small weight in forming the overall index of total inputs. The main reason for land's relatively small user cost was due to the fact that they did not include a depreciation component – they assumed that maintenance activities picked up elsewhere lead to the quality of land being held constant through time. However, they also made this assumption in their 2000 paper for Canada.

The difference in the findings comes down to the different user cost assumptions. They state that depending on what methodology is used to measure user costs, including land can potentially have a significant impact on measured TFP. The effect of including land (whose quantity remains constant over time and therefore provides an offset against other inputs whose quantities are usually increasing through time) is reinforced in their 2000 paper by the user cost approach as rapidly increasing land prices give progressively more weight to the constant quantity of land. In their 1999 paper for New Zealand they use a more "sophisticated" ex post user cost method which largely negates this effect, as the asset specific capital gains term offsets and in some cases exceeds the interest rate term leading to a small user cost value.

The capital stock calculated for this paper excludes both inventories and land. However, as a preliminary investigation, we added the Business and Agricultural Land data from Diewert and Lawrence (1999) to our capital stock data for New Zealand, and data on Rural and Commercial Land for Australia from the Australian Bureau of Statistics (2005). Figure 3 shows the result of doing this for the years for which data were available. When land is added to the capital stock, New Zealand appears to have a similar level to that in Australia (at least up to 1998), although the general downward trend is preserved if moderated. This suggests that the omission of land from the capital stock data may play a large role in concluding that New Zealand is capital-shallow compared with Australia.

However, the indicator presented in Figure 3 is a very crude approximation; this warrants further investigation which we plan to undertake in future.

Figure 3: New Zealand's capital-labour ratio as a proportion of Australia's when land is excluded and included



Source: OECD, Diewert and Lawrence (1999), and Australian Bureau of Statistics.

Human Capital

Another important aspect of the total capital stock of an economy which is often ignored in capital stock measures is the stock of *human* capital. It is not yet standard practice for official statistical agencies to include human capital in their capital stock measures, although Jorgenson and Fraumeni, as early as 1989, proposed a new system of national accounts for the US in which human capital was included in an extended notion of the total capital stock.

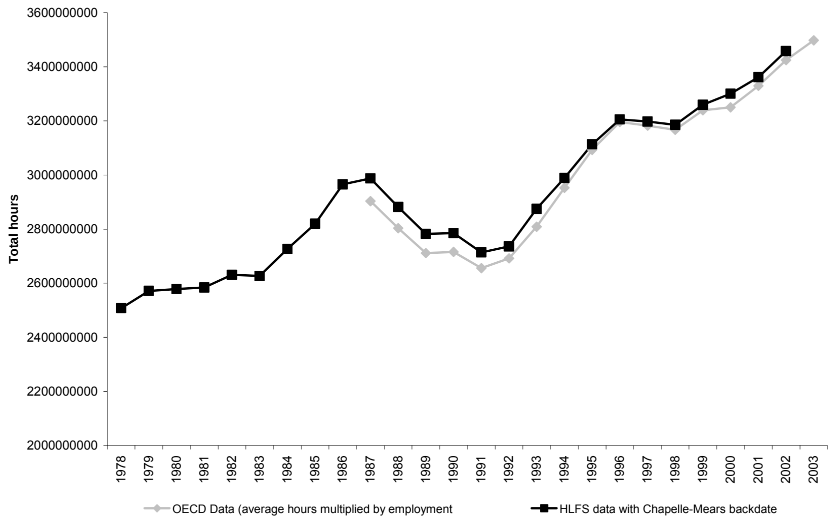
Le, Gibson and Oxley (2002) (using a lifetime labour income method outlined by Jorgenson and Fraumeni, 1989, 1992a, 1992b) made some preliminary comparisons between the physical capital stock within New Zealand and the human capital stock. They found that the value of the human capital stock was approximately twice that of the physical capital stock within New Zealand, and this ratio had been rising from 1986 to 2001. In contrast, using Wei's (2001) estimates, the Australian ratio of human to physical capital appeared to be falling, and was lower than New Zealand's ratio in 1996. This suggests that New Zealand may not be capital-shallow compared to Australia if we were to adopt an extended notion of the capital stock. However, we do not include human capital in our measure of the capital stock in this paper.

2.2 Total Hours Worked

The OECD has data on average hours worked and total employment. We multiplied these two series to form Total Hours Worked, and used this in the measurement of labour productivity and the capital-labour ratio. Alternatively we could have used total employment to calculate labour productivity and the capital-labour ratio, but we preferred to use total hours worked as it allows for changes over time in the hours worked per person employed. For example, if average hours worked per person employed is trending downwards, using a simple measure of persons employed would lead to an overestimate of the quantity of labour input.

The data available from the OECD on average hours worked for New Zealand starts in 1987. We thus used the Household Labour Force Survey (HLFS) series on Total Hours Worked for New Zealand instead of the OECD data, backdated by Chapelle and Mears (1995) to 1978. As shown in Figure 4, the OECD series and the HLFS series are very similar.

Figure 4: Estimates of the total hours worked in New Zealand using different data sources: 1978-2003



Source: OECD and Statistics New Zealand.

In this paper we do not attempt to adjust for quality in the measure of labour input (or in our measure of the capital stock). For examples of these adjustments see the IMF Country Report (2002) and Caselli (November 2003).

3 Rate of Investment and the Growth of Capital: An International Comparison

Over time, the capital stock is built up through the flows of new capital investment. Thus it is useful to examine how much New Zealand has been investing over time compared with other OECD countries. The investment-to-GDP ratio is one way of assessing the various investment levels across countries.

Table 1 shows that New Zealand's investment-to-GDP ratio has been similar to other OECD countries, although below that in Australia. In all three periods New Zealand invested a higher proportion of GDP than the UK and the US, and a similar proportion to the OECD average.

However, the growth of New Zealand's capital stock has been slower than in these same comparator countries (except for the UK in the first two periods). This can be explained by the initial ratios of capital stock to GDP. In 1990 the ratio of capital stock to GDP was 2.6 compared to the OECD average of 2.3. This initially higher capital to GDP ratio in New Zealand combined with a relatively similar level of investment to GDP resulted in a lower rate of capital growth in New Zealand over the 1990s compared with the OECD average.

Table 1: International comparisons of the investment to output ratio (I/Y), the growth of capital, and the initial capital to output ratio (K/Y)

	1970-1979		1980-1989			1990-2002			
	I/Y	Growth of K	I/Y	Initial K/Y	Growth of K	I/Y	Initial K/Y	Growth of K	End K/Y
Australia	22%	2.8%	23%	2.50	3.4%	23%	2.6	3.6%	2.6
NZ	19%	1.4%	19%	2.7	1.9%	20%	2.6	2.3%	2.4
UK	17%	0.7%	16%	2.4	1.3%	18%	2.2	2.4%	2.1
USA	16%	4.2%	17%	1.8	3.5%	19%	1.8	4.1%	2.1
OECD Average	21%	2.9%	20%	2.4	2.6%	21%	2.3	3.1%	2.5

The OECD average is an unweighted average, and all series are in constant 1995 prices.

The initial K/Y ratios are the centred average of 3 periods, while the end ratios are the average of the years 2001 and 2002.

While New Zealand's ratio of *total* investment to GDP is similar to that in Australia and the OECD, New Zealand's *business* investment to GDP is somewhat lower (as shown in the OECD Economic Survey of New Zealand 2003 and the Economic Development Indicators 2005).

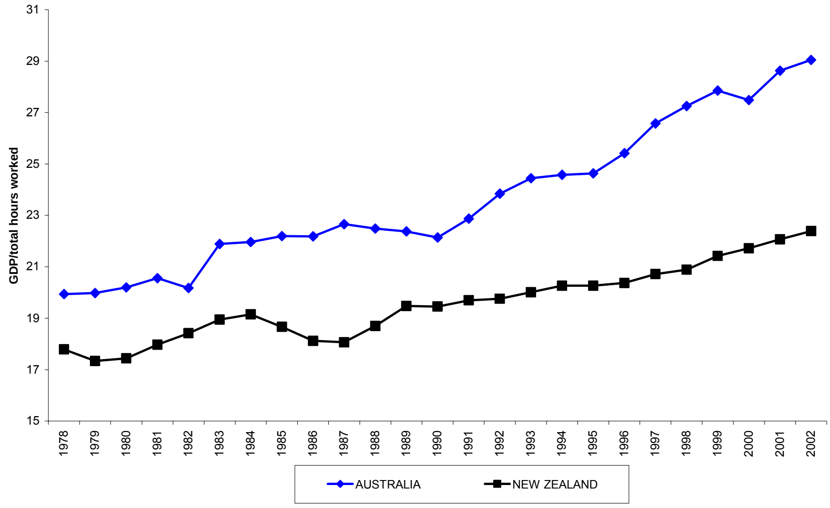
4 Labour Productivity and Capital Intensity

This section analyses the level and growth of labour productivity and the role played by the amount of capital per hour worked. We refer to this latter concept as capital intensity.

4.1 Labour productivity

It has previously been shown that New Zealand has a lower level of labour productivity compared with Australia (see Ministry of Economic Development and Treasury 2005). Figure 5 indicates that this lower level of labour productivity has prevailed since at least 1978; furthermore the gap appears to have widened in the later years of the series.

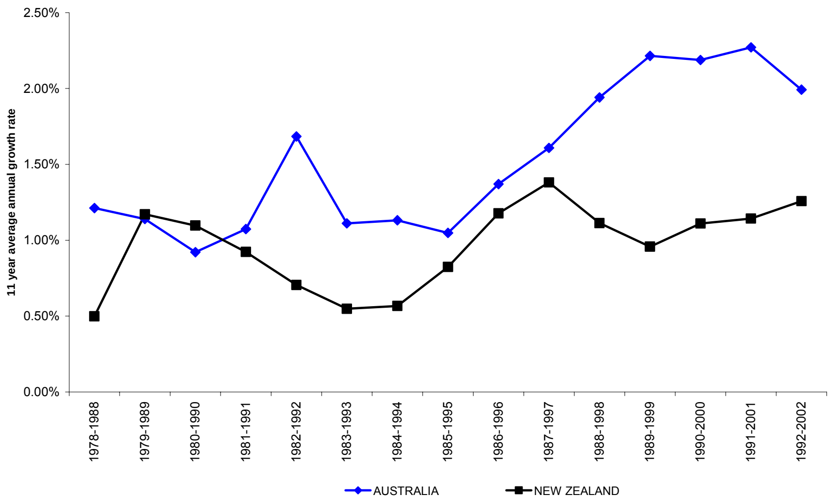
Figure 5: Labour productivity levels in New Zealand and Australia: 1978-2002



Source: OECD

This widening of the gap in the level of labour productivity relative to Australia reflects the fact that the average growth rate of labour productivity in New Zealand has been lower than in Australia since the 1980s. The eleven year moving average growth rates of labour productivity for the two countries are plotted in Figure 6.

Figure 6: Annual average growth rates of labour productivity in New Zealand and Australia: 1978-2002: 11 year moving averages



Source: OECD

4.2 Capital intensity

A critical determinant of the level of labour productivity is capital intensity or the amount of capital per hour worked. Consider the following identity:

$$\frac{Y}{L} = \frac{Y}{K} \times \frac{K}{L} \tag{3}$$

where Y/L is labour productivity or output per unit of labour, Y/K is capital productivity or output per unit of capital, and K/L is the capital-labour ratio or capital intensity. Thus labour productivity is made up of capital productivity, or how efficiently capital is being used within the economy, multiplied by the capital-labour ratio, or how much capital each worker has to work with.

As Table 2 shows, New Zealand's low labour productivity level compared with Australia is not due to the fact that workers are using capital less efficiently than workers in Australia; the level of Y/K in New Zealand is virtually identical to that in Australia in all three periods shown. Rather, the difference in labour productivity with Australia arises from the lower capital-labour ratio in New Zealand; i.e., on average each worker has less physical capital to work with in New Zealand.

In contrast the lower labour productivity in New Zealand compared to the UK and the US is due to the combined effects of both lower capital productivity and a lower capital-labour ratio in New Zealand.

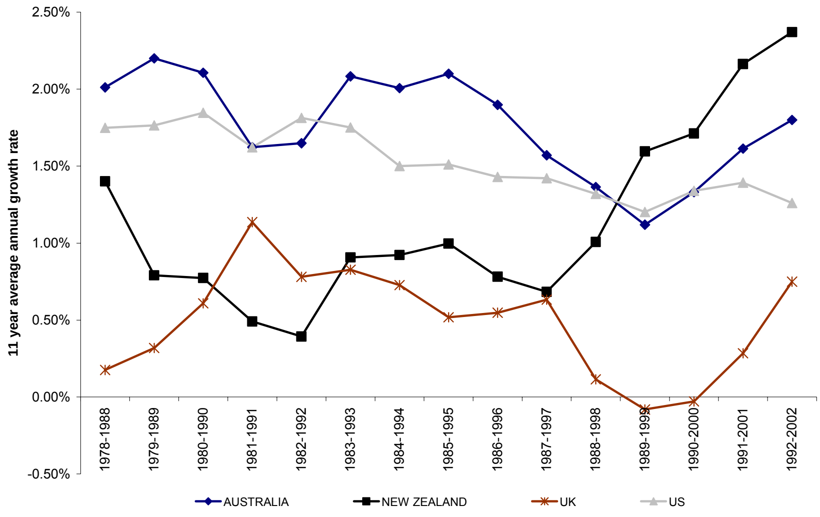
Table 2: Simple Decomposition of Labour Productivity

	1970-1979			1980-1989			1990-2002		
	Y/L	Y/K	K/L	Y/L	Y/K	K/L	Y/L	Y/K	K/L
Australia		0.40		22	0.39	55	26	0.40	65
NZ		0.38		18	0.39	47	21	0.40	52
UK	16	0.40	41	21	0.44	47	26	0.46	56
US	24	0.60	41	27	0.55	50	33	0.52	63

New Zealand's Labour data is obtained from the HLFS (backdated by Chappell-Mears).

New Zealand's lower capital-labour ratio compared with Australia, the UK and the US is consistent with the fact that New Zealand's capital stock has not been growing as fast as in these other OECD countries (see Table 1). At the same time New Zealand's labour input (measured as total hours worked) has on average been growing faster over the 1990s than in Australia, the UK and the US, as shown in Figure 7.

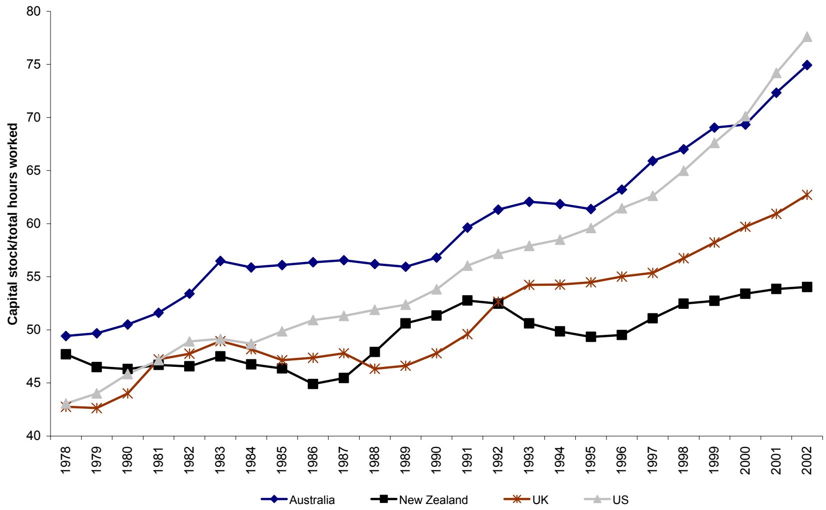
Figure 7: Annual average growth rates of hours worked: 1980-2002: 11 year moving averages



Source: OECD and Statistics New Zealand

Figure 8 shows the impact of the slower growth of capital and faster growth of labour in New Zealand on New Zealand's capital intensity over time compared with selected other OECD countries. New Zealand has had a lower level of the capital-labour ratio than Australia, US and the UK since 1992. While in each of these other countries the capital intensity continued to grow throughout the 1990s, in the case of New Zealand the level of capital intensity in 2002 was no higher than that which it had been in 1991.

Figure 8: Capital Intensity (capital per hour worked): 1978 - 2002



Source: OECD and Statistics New Zealand

Figure 9 shows New Zealand's capital-labour ratio as a proportion of Australia's capital-labour ratio from 1978 to 2002. New Zealand's capital intensity has been declining relative to that in Australia throughout the period. The only exception was during the years 1986-1990. This period corresponds to a time when Australia engineered a reduction in real wages through the Prices and Income Accords and the centralised bargaining process. It was also around the end of the 1980s that Australia's labour markets started to become more flexible and decentralised.

Figure 9: Capital intensity in New Zealand relative to Australia: 1978 - 2002

Source: OECD and Statistics New Zealand

One possibility which may explain part of the divergence in capital stocks between New Zealand and Australia is uncertainty. Macroeconomic instability weakens business confidence and can make long-term planning difficult. If investment is irreversible (that is, once a machine is put in place it has no alternative use), firms may be less likely to invest when output growth is unstable. Also, a highly volatile exchange rate may increase the risk to businesses of buying and selling in international markets. GDP growth and Real Effective Exchange Rate volatility for New Zealand and Australia are presented in Table 3. These indications show that the New Zealand economy continues to be more volatile than the Australian economy.

Table 3: GDP Growth and Exchange Rate Volatility in New Zealand and Australia

	Real Effective Exchange Rate (standard deviations)		Real GDP Growth (standard deviations)	
	Australia	New Zealand	Australia	New Zealand
1984-1994	100	74	100	150
1994-2003	52	78	63	100

Australia = 100 in 1984-1994.

Another source of uncertainty may arise from the regulatory environment. This includes legislation such as the Resource Management Act 1991 (RMA), which creates several unintended obstacles to private investment. Businesses are concerned with the current consents process, which is costly, lacks certainty and takes a long time to complete for large projects (Macquire Research 2004). However, based on an index of economic freedom (Miles, Feulner and O'Grady 2005) New Zealand's ranking at 5th in 2004 compared with Australia's 10th place ranking may well indicate that the overall business climate is not a major deterrent in New Zealand.

4.3 The gap in the *growth* of labour productivity

An alternative approach is to assess the contribution of the capital-labour ratio to the differences in the growth rate of labour productivity. Following Jorgenson, Gollop and Fraumeni (1987) we can express the growth in labour productivity as a function of the growth in multi-factor productivity and the growth of capital intensity as follows:

$$\Delta \ln(Y/L)_t = \Delta \ln MFP_t + \alpha \Delta \ln(K/L)_t \quad (4)$$

where the term on the LHS of the equation is the change from year t-1 to year t of the log of labour productivity; the first term on the RHS is the change in the log of multifactor productivity (from t-1 to t); and $\Delta \ln(K/L)_t$ is the change in the log of the capital-labour ratio from t-1 to t. The parameter α is the average income share of capital in years t-1 and t.

Although this Solow-type growth accounting framework has its limitations,[2] this methodology remains an important tool in productivity analysis, as it permits disentangling

[2] The growth accounting framework is not a theory of growth in that it does not tell us what drives productivity growth, or input accumulation, or if there is any interaction between input accumulation and productivity growth; but it can help identify broad areas for focus.

the relative contribution to output from the accumulation of factors of production and the efficiency in their utilisation (MFP).

Using equation (4),[3] we analyse the contribution of capital accumulation to labour productivity growth in New Zealand and Australia (see Table 4).

Table 4: Contributions to Labour Productivity Growth

	New Zealand		Australia		Australia minus New Zealand	
	1987-1994	1995-2002	1987-1994	1995-2002	1987-1994	1995-2002
Growth in Labour Productivity	1.7%	1.4%	1.2%	2.4%	-0.5%	1.0%
Made up of:						
MFP	1.1%	0.8%	0.7%	1.1%	-0.4%	0.3%
Capital intensity	0.6%	0.6%	0.5%	1.3%	-0.1%	0.7%

Table 4 shows that 70% of the difference in labour productivity growth between New Zealand and Australia is due to the capital-labour ratio rather than MFP.[4] This is consistent with the finding by the IMF (2002) that around three-quarters of the gap in labour productivity is accounted for by the relatively lower capital intensity in New Zealand. From these findings, a case can be made that understanding why New Zealand's labour productivity lags that of Australia depends critically on further insights as to why the capital intensity is lower. We explore this issue in Sections 5 and 6 of this paper.

4.4 The gap in the *level* of labour productivity

Using the growth accounting framework, we can also estimate the contribution of the capital intensity *level* gap to the New Zealand-Australia labour productivity level gap.

Table 5 gives this decomposition of levels based on the following relationship[5]:

$$\ln\left(\frac{(Y/L)_{NZ}}{(Y/L)_{Aus}}\right) = \ln\left(\frac{MFP_{NZ}}{MFP_{Aus}}\right) + \bar{\alpha}\ln\left(\frac{(K/L)_{NZ}}{(K/L)_{Aus}}\right) \quad (5)$$

where $\bar{\alpha}$ is the average labour income share of both New Zealand and Australia, and the MFP gap is calculated as the residual.

[3] With MFP calculated as the residual.
[4] Care should be exercised in interpreting the residual (MFP) as a measure of the technological endowment of a country. Other factors are also included, such as changes in managerial practices, model misspecification and measurement problems
[5] See Nishimizu and Jorgenson (1995).

Table 5: Contributions to the gap in the level of labour productivity between New Zealand and Australia in 2002

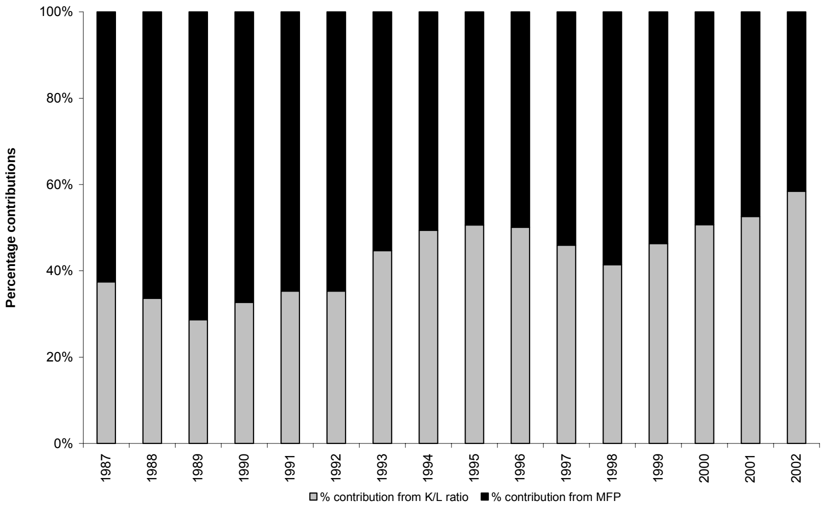
		2002
Relative labour productivity in New Zealand	(Australia=100)	77
Relative MFP in New Zealand	(Australia=100)	83
Relative capital intensity in New Zealand	(Australia=100)	72
New Zealand-Australia Gap in Labour Productivity[a]		-0.26
Made up of (%)		
MFP		42
Capital Intensity		58

a: This value is the logarithm of labour productivity (Y/L) for New Zealand ratio minus the logarithm of labour productivity in Australia, both measured for 2002. The negative sign reflects the fact that Australian labour productivity was some 25% higher than that in New Zealand in that year.

Table 5 shows that New Zealand's labour productivity level was only 77 percent of Australia's labour productivity level in 2002. From equation (5) above, this equates to a labour productivity gap of 26%. Of this, 58% can be explained by the lower capital intensity in New Zealand relative to Australia. The same decomposition was applied to all years from 1987 to 2002 and the results are plotted in Figure 10.

These results rely on our measurement of the capital stock which, as we discuss earlier, is sensitive to the initial value and depreciation rate used. However, not only does the IMF (2002) report similar results, when we calculate equation (5) using a series obtained from the OECD (discussed in more detail in section 6.6), we find that an even larger percentage of the labour productivity gap in 2002 can be explained by the lower capital intensity in New Zealand (73%).

Figure 10: Contributions to the labour productivity gap between New Zealand and Australia: 1987- 2002



Source: OECD and Statistics New Zealand

4.5 Decomposing the output gap

An alternative approach is to decompose the output gap between New Zealand and Australia. In this way we can isolate the contributions from both capital and labour (as opposed to the capital-labour ratio). To do this, we re-write equation (5) as:

$$\ln\left(\frac{Y_{NZ}}{Y_{Aus}}\right) = \ln\left(\frac{MFP_{NZ}}{MFP_{Aus}}\right) + \bar{\alpha}\ln\left(\frac{L_{NZ}}{L_{Aus}}\right) + (1-\bar{\alpha})\ln\left(\frac{K_{NZ}}{K_{Aus}}\right) \quad (6)$$

Table 6 shows the percentage contributions to the output gap from capital, labour and MFP based on equation (6) from 1987 to 2002.

Table 6: Percentage contributions to the output gap between New Zealand and Australia: 1987 -2002

Year	Contribution from K	Contribution from L	Contribution from MFP
1987	39	53	8
1988	38	55	7
1989	39	56	5
1990	41	54	5
1991	42	52	5
1992	42	51	7
1993	44	50	6
1994	45	50	5
1995	46	49	5
1996	46	48	6
1997	45	48	7
1998	45	47	8
1999	45	47	8
2000	46	47	6
2001	47	46	7
2002	48	46	6

Note: These results were calculated using equation 6. Figures may not add up to 100 due to rounding.

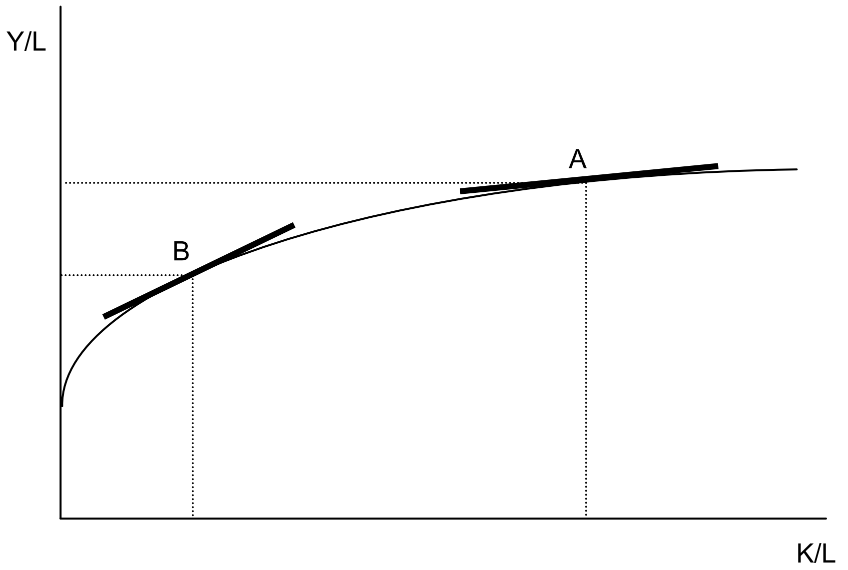
While from 1987 until 2000 the contribution to the output gap between New Zealand and Australia from labour has outweighed the contribution from capital, the contribution from labour has been decreasing since 1990. Thus in 2001 and 2002 the difference in capital stocks between New Zealand and Australia accounted for more (marginally) of the difference in the relative outputs.

5 Returns to Capital

5.1 Theoretical Considerations

In a basic model of economic growth where capital is perfectly mobile, capital will flow to countries with the highest rates of return. With the assumption of diminishing returns to capital, these countries will be the ones which are relatively capital shallow. This can be shown with the help of Figure 11. If we assume that New Zealand and Australia have identical production functions, then New Zealand, with a lower capital-labour ratio than Australia, will lie at some point B. At this point it can be seen that there is a higher return to capital; that is, the slope of the tangential line at point B is higher than at point A.[6]

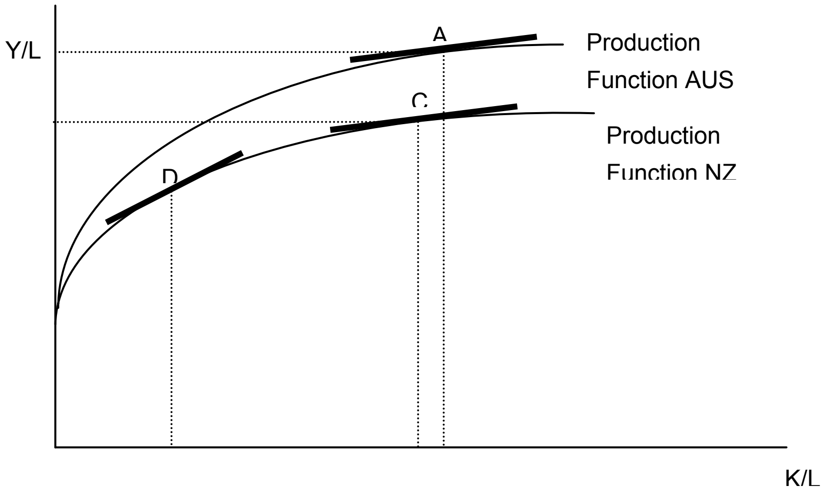
Figure 11: Differences in capital intensity: the case of identical production functions



Alternatively, the different capital intensities might arise from differences in the underlying production functions, despite both countries facing the same relative prices for labour and capital. This case is illustrated in Figure 12. A country lying at any point along the lower production function has a lower multifactor productivity level, as any given amount of capital per unit of labour will produce less output per unit of labour. In this case, both countries may have the same return to capital (points A and C), but the country at point C has a relatively low capital-labour ratio due to its relatively low MFP. Alternatively, the country with a lower MFP level may also have a higher return to capital, thus lying at point D in the diagram. In this case there could be a "wedge" that impedes capital flows to the country at point D.

[6] In this Solow-Swan framework, the country at point B will also have either a higher labour supply growth rate or a higher capital depreciation rate (or both) in equilibrium. See Solow (1956) for details.

Figure 12: Differences in capital intensity: the case of different production functions



5.2 Empirical Evidence

Our previous investigation suggests that New Zealand may have a somewhat lower level of MFP compared to Australia (see Table 5). Therefore, the question which remains is whether New Zealand is at point C or point D in Figure 12. Both points C and D correspond to a lower capital intensity in New Zealand compared to Australia.

As a first step in this section we estimate the returns to capital in New Zealand and several other OECD countries by looking at the real operating surplus (converted to US dollars using PPPs) divided by the capital stock. Ideally, we would like to assess the rate of return which firms use when deciding whether to invest. That is, we want to look at an *ex ante* (expected) marginal return to capital investment. However, the Operating surplus divided by the capital stock is a *realised* rate of return and as such is only a proxy for the expected return. Also, the operating surplus divided by the capital stock is a measure of the average return, rather than the marginal return which arguably governs decisions to undertake additional capital investment. In a Cobb-Douglas production function, the average and marginal returns are the same so this is not an issue. In the case of the constant elasticity of substitution production function, the average return is directly related to the marginal return[7]; thus the measure of operating surplus to the capital stock provides us with a reasonably good proxy of the return to capital which firms are facing.

Figure 13 shows the rate of return to capital in New Zealand, Australia, the UK, and the US, together with the OECD average. Until the early 1990s, New Zealand had a relatively similar rate of return to that of Australia, the UK, the US and the OECD average. Since 1993 New Zealand has had a higher rate than Australia, the UK and the OECD average, and since 1999 higher than the US as well.[8] This suggests that New Zealand may lie at the point D in Figure 12 when compared with Australia.

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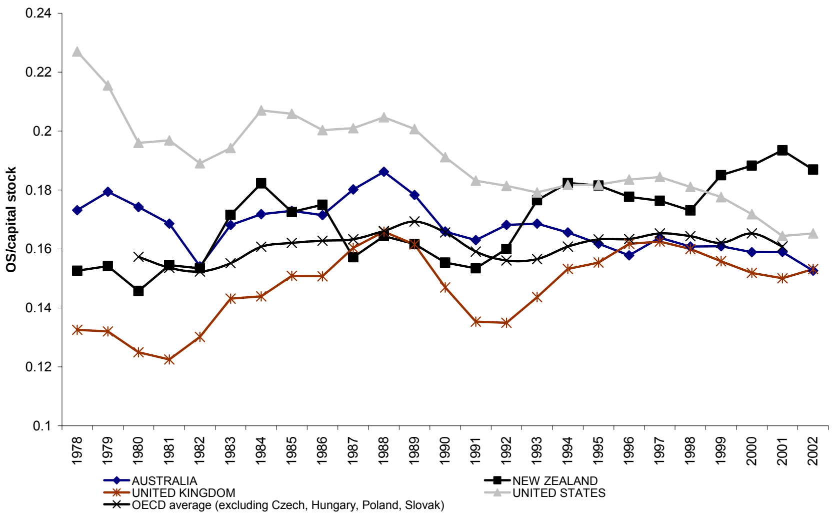
[7] The marginal revenue of capital in a CES production function is equal to $\frac{1}{\alpha^{\rho}}\left(\frac{OS}{K}\right)^{1/\sigma}$ where $\frac{OS}{K}$ is the average return.

[8] Rates of return that are computed neglecting inventories will be overstated, according to Diewert and Lawrence (1999), since the opportunity cost of capital due to holding inventories at the beginning of the period is neglected.

Figure 13: Average annual rates of return to capital for selected countries: 1978 -2002



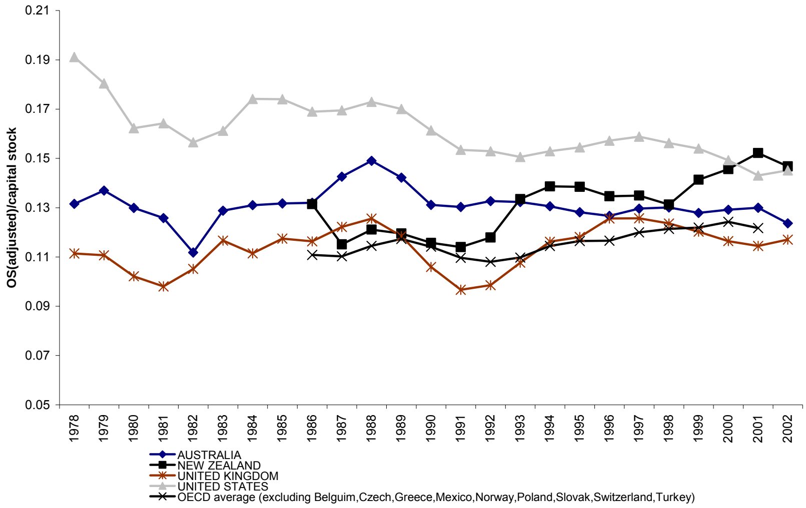
Source: OECD

5.3 Adjusting for Sole-Proprietors

The 1993 System of National Accounts treats the labour income of the self-employed as capital income. As a consequence it is included in the measure of Operating Surplus instead of more logically as Compensation of Employees. Thus our estimates of rates of returns (calculated as Operating Surplus divided by the capital stock) will be overestimated. In this section we use a method proposed by Gollin (2002) to adjust our estimated rates of return to account for sole-proprietors' income, and assess if this has much impact on the conclusions drawn in the previous section.

Figure 14 shows the adjusted rates of return for New Zealand and selected OECD countries. It is only possible to make the adjustment for New Zealand from 1987. However the adjusted rates of return show a similar pattern to those seen for the unadjusted rates, in that the real rate of return on capital in New Zealand appears to have been rising over the 1990s to end the period as the highest among the selected countries. Thus our conjecture from the previous section (that New Zealand may lie at point D in Figure 12 when compared with Australia) still holds when we adjust the Operating Surplus for sole-proprietors' income.

Figure 14: Annual average rates of return adjusted for the income of sole proprietors: 1978 - 2002



Source: OECD

However, these results must be treated cautiously. If we instead compare New Zealand to the US, New Zealand has a similar rate of return but a much lower capital-labour ratio. However, returns are only one part of the story – the capital-labour ratio depends not only on the price of capital but also on the price of labour (discussed in the next section). Thus we are concerned with the *relative* price of capital to labour, and in particular the difference in New Zealand's relative prices compared to those in Australia.

6 Relative Prices of Labour and Capital

"An important part of the New Zealand story is a decline in real labour costs over 1992-96, following the implementation of the ECA. In conjunction with welfare reform, this induced an employment expansion and held back growth in labour productivity".

(Parham and Roberts 2004)

6.1 Comparative Statics

We have observed that New Zealand is apparently "capital-shallow" in comparison with Australia; i.e., New Zealand has a lower capital-labour ratio. We have also shown that New Zealand appears to have a higher return to capital. However, the capital-labour ratio not only depends on the price of capital, but also on the price of labour. This can be illustrated as follows.

Suppose that New Zealand and Australia operate on a similar underlying production function which is depicted as the common unit isoquant in Figure 15. The two countries do not lie at the same position on the production function because they are subject to different relative prices. New Zealand, as drawn, has a lower price of labour relative to capital and thus lies further to the right along the production function, implying that the capital-labour ratio in New Zealand is lower than in Australia (where the capital-labour ratio is the slope of the ray from the origin to the point on the unit isoquant). In this case the lower capital intensity in New Zealand can be attributed to the fact that labour is cheaper in New Zealand relative to the price of capital. This is consistent with the finding that the real return on capital is higher in New Zealand.

If, instead, the two countries faced the same relative prices of labour and capital, as illustrated in Figure 16, New Zealand may have a lower capital-labour ratio than Australia because the two countries lie on different production functions. Of course in reality the differences in the capital intensities could refect both differences in relative factor prices and differences in the underlying production functions; i.e. some combination of the two extreme cases illustrated in Figures 15 and 16.

Figure 15: Differences in capital intensity arising from different relative factor prices

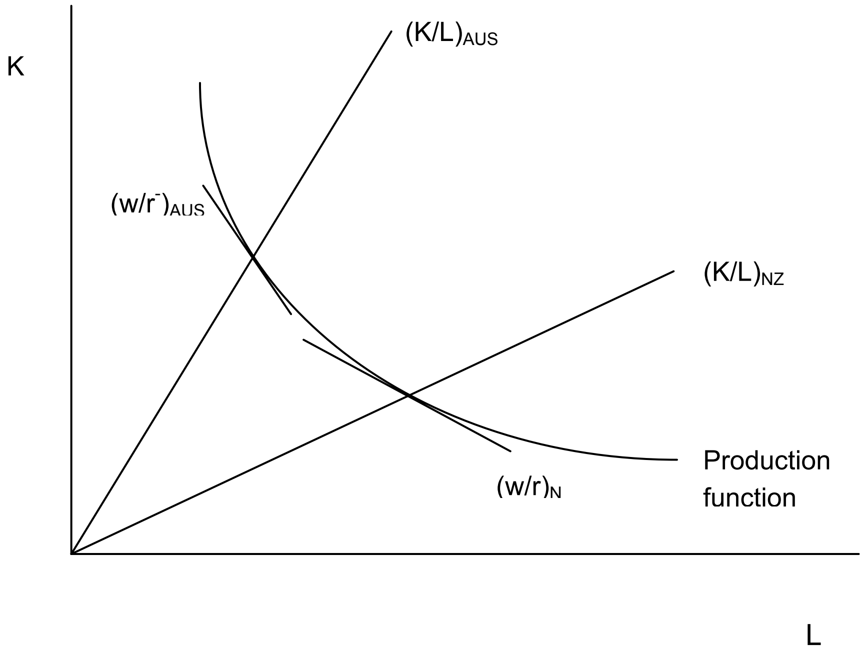
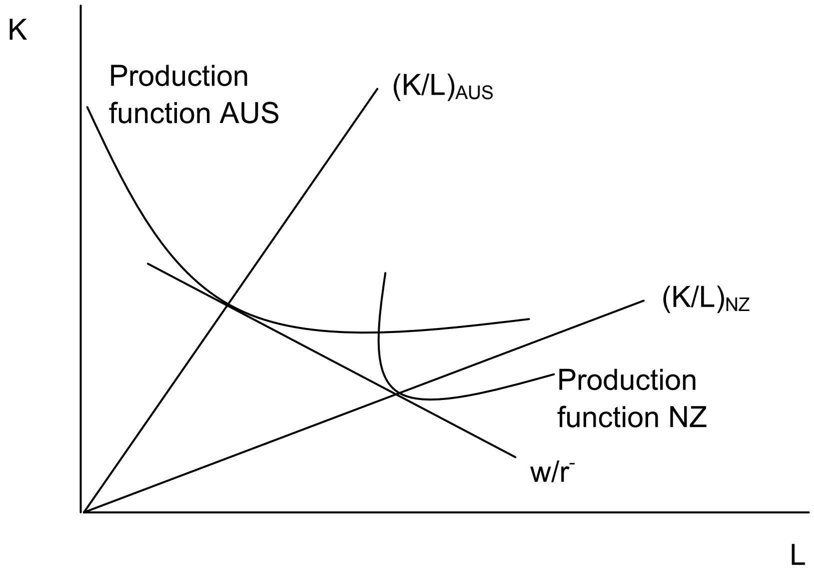


Figure 16: Differences in capital intensity arising from different production functions



Margo (2004) reports on current work using the above framework to analyse the capital intensity of manufacturing in the south of the United States after the Civil War.

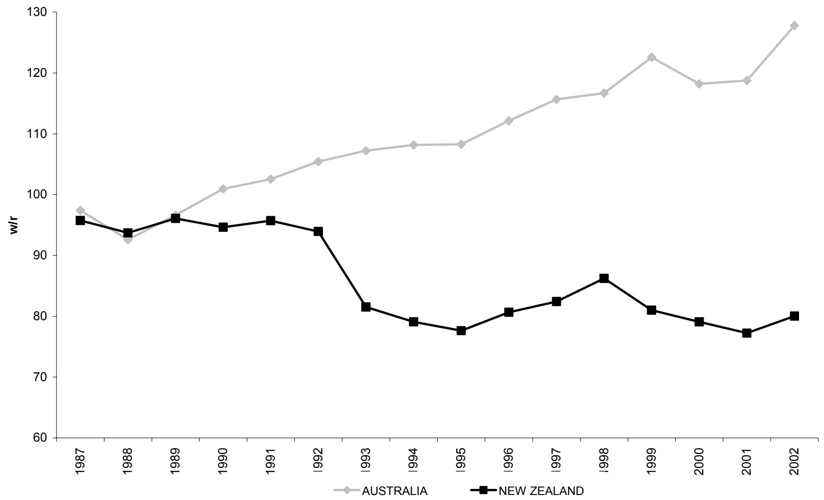
> In ongoing work with my Vanderbilt colleague William Hutchinson, I examine changes in the wage-rental ratios in the South relative to the North after the War. Although wages fell in the South, interest rates rose, resulting in a sharp decline in the cost of labor compared to the cost of capital. Simple economic theory predicts that the capital intensity should have decreased in the South in response to this change in relative factor prices. Using establishment data from the 1850-80 censuses… our preliminary results suggest that manufacturing labor productivity fell in the South and… [this] can be accounted for fully by the reduction in relative capital intensity.

It should be noted that the models depicted in Figures 15 and 16 are comparative static models; i.e., they compare one equilibrium position with another after allowing for full adjustment to relative price changes. They are silent on the question of the time path of any adjustments. We address the question of short versus long-run adjustments in Section 6.4.

6.2 Evidence on relative factor prices

What does the evidence suggest about the relative price of labour to capital? New Zealand appears to have a consistently lower price of labour relative to capital than Australia, as shown in Figure 17. Furthermore, this gap has persisted for over a decade and has widened over time. This would in part explain both the observed lower capital intensity in New Zealand, and the fact that the capital intensity has continued to fall relative to Australia (see Figure 9). The IMF (2002) concluded that the existence of different capital intensities between New Zealand and Australia reflects different relative factor costs. They also concluded that the difference in the relative factor prices is due mainly to the higher relative wage growth in Australia.

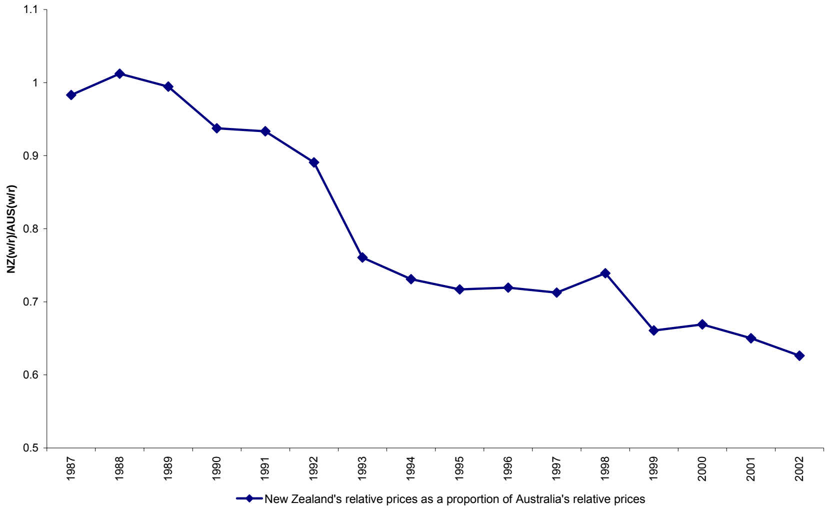
Figure 17: The relative price of labour to capital in Australia and New Zealand: 1987 -2002



Source: OECD and Statistics New Zealand

Another way to view the relative factor prices is to plot the ratio of the factor prices in New Zealand relative to Australia. This is done in Figure 18 where we see that while the relative prices were comparable at the end of the 1980s, by 2002 the ratio in New Zealand had fallen to about 60 percent of the comparable level in Australia. In short, labour has continued to become cheaper relative to capital in New Zealand, encouraging firms to use more labour relative to capital than in Australia, and arguably leading to a lower capital intensity in New Zealand.

Figure 18: Ratio of the factor prices in New Zealand Relative to Australia



Source: OECD and Statistics New Zealand

To what extent is the difference in relative prices being driven by the lower wage growth in New Zealand? Table 7 shows that, in 2002, the gap in relative prices between New Zealand and Australia was mainly due to a lower wage rate in New Zealand (63%), with 37% of the difference due to a higher return to capital in New Zealand. Black et al (2003) also point out that, along with the implementation of the ECA which was at least in part responsible for lower real wage growth in New Zealand relative to Australia after 1991, lower skilled workers finding employment in the 1990s could have contributed to the lower labour productivity growth in New Zealand relative to Australia. This in turn would imply lower real wage growth in New Zealand compared with real wage growth in Australia.

Table 7: The contributions to the gap in relative prices between New Zealand and Australia

		2002
Relative w/r in New Zealand	(Australia=100)	63
Relative wage rate in New Zealand	(Australia=100)	74
Relative return to capital in New Zealand	(Australia=100)	119
New Zealand-Australia Gap in w/r[a]		-0.47
Made up of (%):		
w		63
r		37

a: This value is the logarithm of relative prices (w/r) ratio for New Zealand minus the logarithm of relative prices in Australia, both measured for 2002. The negative sign reflects the fact that the Australian relative price ratio was some 47% higher than in New Zealand in that year.

To this point we have explored differences in the capital intensity that might have arisen due to differences in relative factor prices. However as shown in Figure 12, differences in the capital-labour ratio could also reflect differences in the underlying production function.

A key parameter that characterises a production function is the elasticity of substitution between labour and capital. This parameter describes how the capital intensity responds to changes in the relative price of labour to capital. For example if the real wage rises relative to the cost of capital, do we observe firms moving to a more capital intensive form of production by substituting capital for labour? The elasticity of substitution is defined as:

$$\sigma = [\Delta \ln(K/L)]/[\Delta \ln(w/r)] \qquad (7)$$

where w/r is the relative price of the factors with w the real wage rate and r being the cost of capital. We test for differences in the elasticity of substitution in the following section.

It should be noted that the concept embodied in the term r is typically defined as the post tax cost of capital. Ideally we want a measure that is relevant to those taking the decisions on the mix of capital and labour to employ. As investment in capital is undertaken with a horizon spanning several years, then arguably an appropriate measure would be the expected return to capital. In this study we have used estimates of the realised return to capital as the proxy for the variable r. This measure will incorporate unanticipated variations due to changes in economic conditions not foreseen at the time the initial investment was made. In the long run one would expect these unanticipated elements to cancel out. Using our proxy for the cost of capital (operating surplus divided by the capital stock), Australia's real cost of capital in 1999 was 91% of New Zealand's real cost of capital. This is broadly in line with that estimated by Lally (2000) combining the real cost of debt capital with the (estimated) real cost of equity capital; he found that the real cost of capital in Australia was 93% of New Zealand's real cost of capital.

6.3 Do the Underlying Production Functions Differ?

The Cobb-Douglas functional form is the most widely known and perhaps still the most widely used model to represent the production structure in economic theory. However, it has sometimes proved inadequate in empirical studies. Diewert and Lawrence (1999) conclude that "The Cobb-Douglas functional form is simply not flexible enough to model adequately trends in the New Zealand economy." The simple Cobb-Douglas production structure is inflexible in two separate ways: (a) it imposes an elasticity of one between each pair of inputs and (b) it does not allow for differential rates of technical progress across inputs and outputs (Diewert and Lawrence, 1999). Szeto (2001) tested empirically the hypothesis that New Zealand has a unitary elasticity of substitution. He found that the Cobb-Douglas production structure is not empirically valid for the New Zealand economy, and subsequently estimated an elasticity of substitution of approximately 0.5.

As our concern here is to estimate the elasticity of substitution and in particular to explore if the value for New Zealand differs from that in Australia, we need to adopt an approach that does not constrain the value to be the same in both countries. To this end we have used a Constant Elasticity of Substitution (CES) form of the production function. In this case, the degree of substitutability between the inputs is always the same, regardless of the level of output or input proportions, but is not constrained to be equal to unity as in the case of a Cobb-Douglas production function.

The CES production function may be written in the form[9]:

$$Y_t = A\left[\alpha\left(e^{\lambda t}L_t\right)^{-\rho} + (1-\alpha)\left(e^{\mu t}K_t\right)^{-\rho}\right]^{\frac{-1}{\rho}} \quad (8)$$

where Y is output, A is a measure of exogenous technical progress, L is labour input, K is capital input, λ and μ are the rates of labour and capital augmenting technical progress, α is the share of labour used in production, and the elasticity of substitution (σ) is equal to $\frac{1}{\rho+1}$.

Including labour and capital augmenting technical progress allows us to control for the "identification problem in CES production function analysis" (Johnson 1972). The identification problem arises because the biased efficiency growth and the elasticity of substitution are both varying simultaneously over time, and one must be held constant to isolate or "identify" the other. By defining efficiency units in terms of relative productivity (as in equation 8), the shift in the isoquant is now normalised, and the marginal rate of substitution between the factors remains the same for constant ratios of the factors measured in efficiency units. Efficiency growth is now embodied in the factors of production. This allows us to define an equation for estimating the elasticity of substitution.

Taking the firm's cost minimisation problem (equating marginal products to real factor costs) and assuming that firms take factor prices as given, we get the following relationship:

$$\frac{K}{L} = \left[\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{w}{r}\right)e^{\rho t(\lambda-\mu)}\right]^{\frac{1}{\rho+1}} \quad (9)$$

Taking logs we get the following linear equation:

$$\ln\left(\frac{K}{L}\right)_t = \beta_0 + \sigma\ln\left(\frac{w}{r}\right)_t + \beta_1 t \quad (10)$$

where $\beta_0 = \sigma\ln\left(\frac{1-\alpha}{\alpha}\right)$ and $\beta_1 = (1-\sigma)(\lambda-\mu)$.

6.4 Allowing for dynamic effects

While equation (10) represents a long-run equilibria position, it may well be the case that there are lags in reaching a new equilibrium level of the capital intensity following a change in factor prices. We would not expect firms to be able to adjust instantaneously when the price of labour changed relative to the cost of capital. It is likely therefore, that the ability to change in the short run as depicted by the elasticity of substitution, would be less than the adjustment we would observe in the long-run. Therefore, we allow for lags in adjustment by estimating the following regression equation for both New Zealand and Australia:

[9] This form assumes that there are constant returns to scale in production.

$$\ln\left(\frac{K}{L}\right)_t = \beta_0 + \beta_1 \ln\left(\frac{w}{r}\right)_t + \beta_2 t + \beta_3 \ln\left(\frac{K}{L}\right)_{t-1} + \varepsilon_t \quad (11)$$

This specification is useful because both the long-run and short-run estimates of the elasticity of substitution are easily extracted.[10] The short-run elasticity is given by the estimate of β_1 while the long-run elasticity is calculated as $\left[\frac{\beta_1}{1-\beta_3}\right]$.

An important issue when dealing with macroeconomic time series is the problem of spurious regression. If the time series used in the analysis are non-stationary, the results of the estimation could be spurious as the classical t and F tests are based on the assumption that the variables are stationary.

Szeto (2001) notes that there are three approaches to the problem of spurious regression. The first approach is to difference the data before estimating. The second approach is to add the lags of the dependent variable. Finally one may consider the cointegration approach.[11] In our specification we include the lag of the dependent variable so as to estimate the long-run elasticity of substitution. Therefore we estimate the model in levels rather than in differences. We present unit root tests in Appendix 2, and also test the sensitivity of our results by running the relationship in first differences, as well as in an Error Correction (cointegration) framework.

The results of estimating equation (11) with annual data from 1987 to 2002 are given in Table 8. The short run elasticities are similar in magnitude for the two countries, at 0.30 for Australia and 0.31 for New Zealand. However, in contrast to that for New Zealand, Australia's short-run elasticity is not statistically different from zero.

Table 8: Estimates of the short and long-run elasticity of substitution between capital and labour for Australia and New Zealand

Dependent variable: ln (K/L)	Australia		New Zealand	
	Coefficient Estimate	t-ratio	Coefficient Estimate	t-ratio
Log of relative prices (β_1)	0.30	1.58	0.31***	4.28
Time Trend (β_2)	0.003	0.58	0.007***	3.90
Log of lagged capital-labour ratio (β_3)	0.62***	3.10	0.61***	5.88
Long-run elasticity of substitution $\left[\frac{\beta_1}{1-\beta_3}\right]$	0.78*	-1.40a	0.79***	-3.40a
Adjusted R-squared	0.97		0.91	
Breusch-Godfrey (order 1)	6.82***		0.47	

*= sig. at 10% level, **=sig. at 5% level, ***=sig. at 1% level

a: These t-ratios were calculated using the Delta method and indicate whether the long-run elasticities are statistically different from one.

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[10] Balistreri et al (2002) also note that this estimation procedure generates efficient estimates in the presence of disturbances that exhibit first order serial correlation.

[11] Non-stationary variables may be used in a regression if they prove to be cointegrated.

The long-run elasticities are also very similar. The results presented in Table 8 indicate that for a 10 percent change in relative prices, both Australia's and New Zealand's capital-labour ratios will adjust by 8 percent in the long run. Both long-run estimates are significantly different from one, indicating that the Cobb-Douglas specification (with a unitary elasticity of substitution) may not be appropriate for both countries.

The results in Table 8 were generated using data for the period 1987 to 2002. This allowed for the adjustment to be made for the earnings of sole-proprietors. The same model was re-run using unadjusted relative prices for the period 1978 to 2002. The results of this estimation are given in ***Appendix Table 1***. Both the short-run and long-run estimates of the elasticity of substitution are very similar for both New Zealand and Australia, and the long-run estimates are both significantly lower than unity.

Both countries have implemented a series of economic reforms which one might have expected would have enhanced the responsiveness of the productive sector to changes in its operating environment. In a world of highly regulated labour and capital markets with limited access to foreign capital, it would seem plausible that the capacity of firms to adjust to changes in the economic environment would be more constrained. They would have greater difficulty in obtaining finance and restructuring their labour force in order to take advantage of new circumstances.

On the other hand, a deregulated environment introduces new sources of uncertainty, and it is entirely conceivable that economic agents will hesitate to make significant new investments until they feel sufficiently certain about the future expected payoffs. This could mean that initially it would take longer for a change in relative factor prices to trigger new capital investment or hiring; or alternatively that the same changes in relative factor prices would generate a smaller response in the capital intensity.[12]

Ultimately, the effect of the economic reforms on the responsiveness of firms, as measured by the elasticity of substitution of capital for labour, becomes an empirical question. In order to test whether the responsiveness has in fact varied over time, we re-estimated equation (11) by adding a term for the interaction between time and the relative factor price as follows:

$$\ln\left(\frac{K}{L}\right)_t = \beta_0 + \beta_1 \ln\left(\frac{w}{r}\right)_t + \beta_2 t + \beta_3 \ln\left(\frac{K}{L}\right)_{t-1} + \beta_4\left(t * \ln\left(\frac{w}{r}\right)_t\right) + \varepsilon_t \qquad (12)$$

The results for this estimation are summarised in Table 9. It is found that the coefficient on the interaction term is not significant for New Zealand or Australia, suggesting that the responsiveness in both countries is not changing over time. Naturally one should exercise caution when interpreting this result. We have no basis for extrapolating beyond the sample period to argue that the elasticity of substitution will continue to remain constant in both countries. Also, we cannot make any judgement as to whether the elasticity has been changing prior to 1987 (the beginning of our sample period).

[12] We are grateful to Bob Buckle for his guidance on this question and for drawing our attention to Goodson (1995) who showed that uncertainty had a negative effect on investment in New Zealand when tested over the period 1966 to 1991.

Table 9: Estimates of the short run elasticity of substitution allowing for variation over time.

Dependent variable: ln (K/L)	Australia		New Zealand	
	Coefficient Estimate	t-ratio	Coefficient Estimate	t-ratio
Log of relative prices (β_1)	0.19	0.99	0.30**	2.61
Time trend (β_2)	-0.07	-1.29	-0.005	-0.07
Log of lagged capital-labour ratio (β_3)	0.43	1.80	0.60***	4.96
Long-run elasticity of substitution $\left[\frac{\beta_1}{1-\beta_3}\right]$	0.33***	-6.76[a]	0.74**	-2.64[a]
Interaction time trend term (t*log of relative prices) (β_4)	0.02	1.35	0.003	0.17
Adjusted R-squared	0.97		0.90	
Breusch-Godfrey (order 1)	5.68**		0.57	

Note: Based on equation 12.

*= sig. at 10% level, **=sig. at 5% level, ***=sig. at 1% level

a: These t-ratios were calculated using the Delta method and indicate whether the long-run elasticities are statistically different from one.

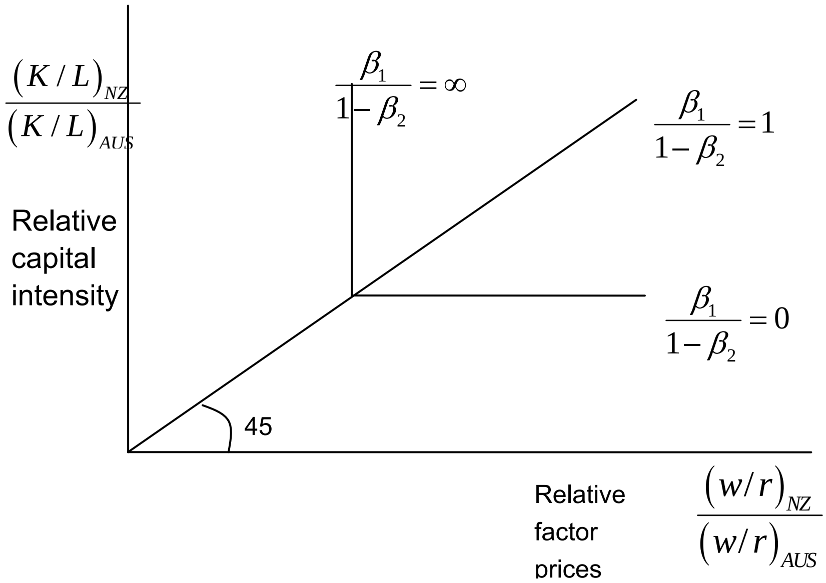
6.5 Assessing the contribution from relative prices on the capital-labour ratio gap between New Zealand and Australia

We also follow Rao, Tang and Wang (2003) and re-estimate equation (11) as New Zealand relative to Australia:

$$\ln\left(\frac{(K/L)_{NZ}}{(K/L)_{AUS}}\right)_t = \beta_0 + \beta_1 \ln\left(\frac{(w/r)_{NZ}}{(w/r)_{AUS}}\right)_t + \beta_2 \ln\left(\frac{(K/L)_{NZ}}{(K/L)_{AUS}}\right)_{t-1} + \varepsilon_t \quad (13)$$

This equation may be interpreted with the help of Figure 19 below.

Figure 19: Responsiveness of capital intensity in New Zealand relative to Australia



If the long-run coefficient ($\frac{\beta_1}{1-\beta_2}$) is equal to one, this implies that for any change in the relative prices in New Zealand relative to the prices in Australia, the gap in the capital-labour ratio will increase or decrease by the same amount. For example, if wages in New Zealand increase by 10% relative to wages in Australia (holding the price of capital constant in both countries), the gap between the capital-labour ratios will decrease by 10% (that is, the capital-labour ratio in New Zealand will increase relative to the capital-labour ratio in Australia).

The significant coefficients presented in Table 10 suggest that the capital intensity gap between New Zealand and Australia will in part be determined by the gap in the relative prices between the two countries. As the relative factor prices in New Zealand increase relative to Australia (a movement to the right along the horizontal axis in Figure 19), there will be a less than proportionate change in the capital intensity relative to Australia. This follows from the estimated long-run coefficient of 0.5 (Table 10). This finding is consistent with the fact that differences in the *trends* of the relative prices in New Zealand and Australia played a significant role in the widening of the capital intensity gap between the two countries. As the price of labour decreased in New Zealand relative to that in Australia, the capital intensity gap increased (see Figures 9 and 18).

Table 10: Response of capital intensity in New Zealand relative to Australia.

Dependent Variable: Relative capital-labour ratio	Coefficient Estimate	t-ratio
Short Run Real price of labour relative to capital in New Zealand relative to Australia (β_1)	0.19***	4.77
Lagged relative capital-labour ratio (β_2)	0.62***	5.29
Long Run Real price of labour relative to capital in New Zealand relative to Australia $\left[\frac{\beta_1}{1-\beta_2}\right]$	0.50	-
Adjusted R-squared	0.91	
Breusch-Godfrey (order 1)	0.70	

*= sig. at 10% level, **=sig. at 5% level, ***=sig. at 1% level

Note: We also ran this equation with a time trend included, and got similar results with an insignificant time trend coefficient. Therefore we do not present these results in the paper.

6.6 Adjustments to the definition of capital

It could be argued that the growth of the capital stock in the housing sector does not necessarily respond to changes in relative factor prices in a manner similar to that in other sectors of the economy. For this reason, we removed housing capital from the estimate of the total capital stock for both New Zealand and Australia. The purpose of this adjustment is to test whether our earlier findings are robust with respect to changes in the description of the capital stock. The results of re-estimating equation 11 with the revised capital stock excluding housing capital are shown in Table 11.

The effect has been to widen the gap between the estimated long-run elasticities of substitution for New Zealand and Australia. The value for New Zealand has fallen from 0.79 to 0.54, whereas for Australia the estimated long-run elasticity increased from 0.78 to 0.94 and becomes insignificantly different from unity. This suggests that the production sector in New Zealand does not respond as fast to changes in the relative price ratio as does the production sector in Australia; for a 10% change in relative prices the capital-labour ratio in the production sector adjusts by 10% in Australia but only by about 5.5% in New Zealand. However, when we re-ran our estimation using an error correction framework, Australia's long-run elasticity estimate is 0.58 and significantly smaller than unity. Also, in both specifications, an F-test of the coefficients on interactions of a dummy variable with the log of relative prices and the log of the lagged capital labour ratio in a pooled regression (combining New Zealand and Australian data with the dummy equal to one if the observation is for Australia) failed to reject the hypothesis that both coefficients in the derivation of the long-run elasticity estimate are statistically different from New Zealand's, indicating that the Australian and New Zealand long-run elasticity estimates are not statistically different.

It has often been argued (see IMF, 2002, extension of that report) that the different industrial structures of New Zealand and Australia could play a role in the capital intensity gap between the two countries. In particular, the Australian economy is thought to have a relatively capital intensive mining and quarrying sector that accounts for a proportionately larger share of the Australian economy than the corresponding sector does in New Zealand. Also, the agriculture, fishing and forestry sector represents a larger proportion of the New Zealand economy than the Australian economy. In addition, New Zealand agriculture may be less capital intensive than is the broad-acre cropping and grazing that characterises much Australian agriculture.

To test whether the presence of the Mining sector, and in turn the Agriculture, Forestry and Fishing sector, has an impact on our results, we reran equation 11 excluding this sector,[13] and then excluding both sectors. Table 11 compares the results of our base case to the estimation when we exclude mining, and when we exclude both mining and agriculture, forestry and fishing. New Zealand's long-run elasticity remains significantly lower than unity for both equations. However, the results show that the long-run elasticity of substitution in Australia becomes higher than the corresponding elasticity of substitution for New Zealand when Mining is excluded. Australia's long-run elasticity becomes significantly *greater than* 1 when Mining is excluded, but is once again significantly lower than unity when both Mining and Agriculture are excluded. These results may indicate that the agricultural sector in Australia is very elastic in comparison with other sectors in Australia, and outweighs the inelastic nature of the mining sector. However, when we ran our model in an error correction framework, we found that the long-run elasticity for Australia when both sectors were excluded was 1.58, statistically *greater* than unity. Also, an F-test from the pooled regression (of the coefficients on the interaction terms of the dummy variable with the two parameters included in the long-run elasticity computation) - in both the form of equation 11 and in an error correction framework - failed to reject the null hypothesis that both coefficients are not statistically different from zero. This result indicates that while Australia's long-run elasticity may be greater than New Zealand's when Mining is excluded, they are not statistically different when both mining and agriculture are excluded.

This evidence conflicts with the conclusions drawn by Diewert and Lawrence (2003), who found that excluding the Mining and Quarrying sector, although leading to a marginal increase in New Zealand's capital intensity relative to Australia, was unlikely to lead to significant differences. They concluded the same thing when the Agriculture, Forestry and Fishing sector was excluded.

[13] The relative prices for the regressions excluding the Mining and Quarrying Sector are unadjusted for sole-proprietors income as data on self-employment is unavailable by sector.

Table 11: Estimation of the elasticities of substitution when Residential Housing or the Mining and Quarrying Sector or both the Mining and Quarrying and the Agriculture, Forestry and Fishing Sectors are excluded.

Dependent Variable: ln(K/L)	Excluding Housing		Excluding Mining		Excluding Mining and Agriculture, Forestry and Fishing	
	Australia	New Zealand	Australia	New Zealand	Australia	New Zealand
Log of relative prices (β_1)	0.30*	0.27***	0.57**	0.34***	0.33	0.33***
	(1.91)	(4.33)	(2.42)	(8.18)	(1.74)	(7.23)
Time Trend (β_2)	0.003	0.009***	-0.004	0.006***	0.003	0.006***
	(0.61)	(4.13)	(-0.53)	(6.66)	(0.35)	(5.76)
Log of lagged capital-labour ratio (β_3)	0.68***	0.50***	0.59**	0.45***	0.54*	0.42***
	(3.61)	(4.71)	(2.36)	(5.46)	(1.95)	(4.50)
Long-run elasticity of substitution $\frac{\beta_1}{1-\beta_3}$	0.94	0.54***	1.39**	0.62***	0.72*	0.57***
	(-0.35)[a]	(-14.47)[a]	(2.04)[a]	(-14.88)[a]	(-1.73)[a]	(-16.87)[a]
Adjusted R-squared	0.98	0.96	0.97	0.93	0.98	0.89
Breusch-Godfrey (order 1)	5.48**	0.96	3.09*	1.99	3.66*	2.49

The t-ratios are given in parentheses below the coefficient estimates.

*= sig. at 10% level, **=sig. at 5% level, ***=sig. at 1% level

a: These t-ratios were calculated using the Delta method and indicate whether the long-run elasticities are statistically different from one.

A final test of robustness with respect to changes in the definition or measurement of the capital stock was made by re-estimating the basic model (equation 11) using a series obtained from the OECD.[14] These data comprise direct estimates of the capital stock in contrast to the estimates based on the Perpetual Inventory Method that we have adopted in this paper. The one main difference is that we used a flat 6% depreciation rate for all types of assets, whereas the new OECD capital stock uses different depreciation rates for different asset types. By using the same depreciation rate for all assets, we may be overstating the actual size of the Australian capital stock compared to New Zealand, as (in particular) Australia has more ICT capital than New Zealand, which arguably has a higher depreciation rate compared to other asset types. Thus by re-estimating our equation using the new OECD capital stock estimates, we are analysing how much of an effect the use of a constant depreciation rate has on our results.

The results are summarised in Table 12. As the OECD data excludes housing capital the relevant long-run comparisons are given by 0.94 for Australia and 0.54 for New Zealand (using the perpetual inventory method) and 0.67 for Australia and 0.93 for New Zealand based on the OECD capital stock data. Clearly this implies that the New Zealand economy (in particular the production sector) is rather more responsive to changes in the relative factor prices than given by the original estimates, while the

[14] Paul Schreyer, pers. comm..

Australian economy is considerably less responsive. In fact, our long-run estimate for New Zealand changes from being statistically different from one when we use our original data, to being *not* significantly different from one when we use the OECD capital stock data (and vice versa for Australia). This suggests that our assumption of a constant depreciation rate across asset types may have a significant effect on our results. However, when we ran our model in an error correction framework using this new data, we found New Zealand's long-run elasticity to be significantly lower than unity (although still higher than the long-run estimate for Australia).

Table 12: Estimates of the short and long-run elasticity of substitution between capital and labour for New Zealand using the new OECD capital stock data

Dependent Variable: ln(K/L)	Base Case Excluding Housing		Using new OECD capital stock	
	Australia	New Zealand	Australia	New Zealand (adjusted)[b]
Log of relative prices (β_1)	0.30*	0.27***	0.42***	0.39***
	(1.91)	(4.33)	(3.85)	(5.01)
Time Trend (β_2)	0.003	0.009***	0.004	0.009***
	(0.61)	(4.13)	(1.15)	(4.35)
Log of lagged capital-labour ratio (β_3)	0.68***	0.50***	0.37**	0.58***
	(3.61)	(4.71)	(2.39)	(6.33)
Long-run elasticity of substitution $\frac{\beta_1}{1-\beta_3}$	0.94	0.54***	0.67***	0.93
	(-0.35)[a]	(-14.47)[a]	(-5.49)[a]	(-1.19)[a]
Adjusted R-squared	0.98	0.96	0.98	0.96
Breusch-Godfrey (order 1)	5.48**	0.96	4.16**	0.49

*= sig. at 10% level, **=sig. at 5% level, ***=sig. at 1% level

a: These t-ratios were calculated using the Delta method and indicate whether the long-run elasticities are statistically different from one.

b: An adjustment was made in the OECD capital stock data for New Zealand by replacing an apparent outlier in 1992 with the average values for 1991 and 1993.

7 Summary and Conclusions

This paper has addressed the level and growth of capital intensity in New Zealand. In particular the paper focuses on comparisons with Australia. Capital intensity is defined as the amount of capital per hour worked. The motivation for this arises from the observation that output per hour worked is lower in New Zealand than a number of other OECD countries. What explains this lower level of labour productivity? There are two proximate candidates: the amount of capital per hour worked (the capital intensity) and the overall level of efficiency of resource use as measured by multifactor productivity.

Over time the stock of capital per hour worked grows as the result of new investment (relative to the depreciation rate and growth in the labour supply). Each year some share of the total output of the economy is devoted to investment rather than current consumption. In New Zealand we find that that share (the ratio of investment to total output) has been comparable to the average for OECD countries over the last three decades. However, over the 1990s, starting from a relatively higher level of capital per unit of output, the rate of growth of the capital stock has been well below that for Australia and the USA, and on average 0.8 percent per annum below the average growth of capital in the OECD.

In the period 1990 to 2002, the amount of capital per hour worked grew very modestly in New Zealand; in contrast capital per hour worked rose by about 25 percent in Australia. In 1978, New Zealand and Australian workers had about the same amount of capital per hour worked. By 2002, capital intensity in Australia was over 50 percent greater than in New Zealand.

As a result it is not surprising that we find that between 1995 and 2002 some 70 percent of the difference in the growth of labour productivity is explained by a lower rate of growth of capital intensity in New Zealand. The remaining 30 percent is due to lower growth in multifactor productivity in New Zealand. In summary, our slower growth in labour productivity compared to Australia appears in recent years to have been associated with a slower growth in capital intensity. The net result is that the gap between the capital intensity in New Zealand and that of Australia has continued to widen for nearly three decades.

Why is the level of capital intensity lower in New Zealand and why has it grown more slowly? These are central questions addressed in the paper. One possible explanation for the lower capital intensity might be that returns on capital are lower in New Zealand which discourages new investment. However, we find in fact that the return on capital in New Zealand has been growing and by 2002 exceeded the level in the OECD and in Australia by some 15 to 20 percent. It is not immediately obvious why the rate of return in New Zealand should continue to exceed that in Australia given open capital markets. One possible source may lie in a higher risk premium in New Zealand, although the evidence for this is not overwhelming.

Firms select the mix of labour and capital in part based on the relative prices of these factors. If the capital intensity is observed to be low (as in New Zealand), it could be associated with a lower relative price of labour to capital. In a country where labour is relatively abundant and wages low while capital is scarce and commands a high return we would expect to observe a lower level of capital intensity. In New Zealand the price of labour relative to Australia was very comparable in the late 1980s. By 2002 it had fallen to about 60% of the level in Australia. With labour relatively cheaper in relation to capital than in Australia, it appears that New Zealand firms have opted for a lower level of capital intensity.

Even in a world where both countries faced the same relative factor prices, we might still observe differences in the capital intensity due to differences in the underlying production systems. We explored this by estimating the elasticity of substitution between labour and capital; this measure indicates the responsiveness of the capital- labour mix to changes in relative factor prices. As labour becomes more expensive relative to capital do firms tend to substitute more capital for labour?

The results confirm that in both Australia and New Zealand, this type of substitution does in fact occur. Our estimates are all significant and fall in the range of estimates from international studies: see for example Claro (2002) and Balistreri et al. (2002). Our initial results using the total capital stock (excluding land, inventories, and human capital) suggest that the long-run responsiveness of the capital-intensity to the relative price of labour to capital is very similar for the two economies. When we adjust the capital stock to exclude housing, the Australian long-run elasticity estimate becomes larger than New Zealand's. However, a preliminary test suggests that the long-run elasticities in the two countries when housing is excluded are not statistically different. There is also no evidence that the long-run elasticities are different in the two countries when both the mining and agricultural sectors are excluded. However, when we adjust the capital stock to exclude only the mining sector, we find that the elasticity of substitution in New Zealand is on average less than one half of that in Australia. In other words for any given rise (fall) in the relative cost of labour, Australian firms which are not in the mining sector appear to make a much greater swing toward more (less) capital intensive forms of production. They alter their long run mix of inputs much more than do firms outside of the mining sector in New Zealand.

Has this degree of responsiveness been changing over time? It is possible that following the reforms there has been a period of learning and adjustment to a new economic environment. This would suggest that the rate at which the capital intensity responds to price signals might have increased over time. At the same time reforms create uncertainty and this could lead to a hesitation to make new investments until the future payoffs seemed more certain. This would tend to dampen any increase in responsiveness. To test the effect we allowed the response parameter to vary over time. However there was no evidence that the response is different between the two economies.

Three major limitations of the study should be noted. In the first place we have used data for either the whole economy or by excluding certain sectors for what we might call the "comparable core" sectors. It may be that there are differences in the responsiveness of the capital intensity to changes in relative factor prices across different industries within the core economy. The cross-country results for some 40 industries presented by Claro (2002) show a range from 0.6 to 2.1, whereas our aggregate long run estimates for New Zealand and Australia span a more limited range between 0.5 and 1.4.

Second, we have assumed that the relative prices of factors are given to the economy. In fact in the long run both the prices of the factors and the mix will be simultaneously determined. We tested for the direction of causation; do factor prices cause changes in the mix of capital and labour or is the direction of causation the other way around. The results were inconclusive.

Finally, it is evident that differences in the measurement of the capital stock are critical. Changes in the coverage and method of computing estimates of the capital stock do alter the conclusions. Whether New Zealand is really capital shallow relative to Australia may well hinge on whether land and inventories and human capital are adequately measured and incorporated in a more comprehensive concept of capital.

Two unanswered questions remain: why has the gap between the capital intensity in New Zealand and Australia continued to widen? At one level, the immediate answer to this question appears to be that the relative price gap has continued to widen. But this of course then merely raises the next question: why have relative prices moved in this way? Essentially these questions remain as topics for further research. Subtle differences in the regulatory environment, labour and capital markets, and taxation regimes may contribute but this remains to be further explored.

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Appendix 1

Appendix Table 1: Results using relative prices unadjusted for sole-proprietors income, with the sample period from 1978-2002

Dependent variable: ln (K/L)	Australia		New Zealand	
	Coefficient Estimate	t-ratio	Coefficien t Estimate	t-ratio
Log of relative prices (β_1)	0.18***	3.59	0.15**	2.57
Time Trend (β_2)	0.005**	2.26	0.005***	3.64
Log of lagged capital-labour ratio (β_3)	0.62***	4.34	0.64***	5.02
Long-run elasticity of substitution $\left[\frac{\beta_1}{1-\beta_3}\right]$	0.47***	-14.75[a]	0.42***	-14.58[a]
Adjusted R-squared	0.98		0.90	
Breusch-Godfrey (order 1)	3.16*		6.18**	

a: These t-ratios were calculated using the Delta method and indicate whether the long-run elasticities are statistically different from one.

Appendix 2

We test the sensitivity of our results by also running the relationship in first differences (see equation 14 below), from which we can obtain an estimate of the short-run elasticity of substitution (β_1). The results are presented below, and give estimates for the short-run elasticities which are similar to the estimates obtained using equation (11), confirming the results found by equation (11) (although for Australia the short-run elasticity when the mining sector is excluded drops from 0.57 to 0.20 and from 0.33 to 0.09 when both mining and agriculture, forestry and fishing are excluded).

$$\Delta \ln\left(\frac{K}{L}\right)_t = \alpha_0 + \alpha_1 \Delta \ln\left(\frac{w}{r}\right)_t + \varepsilon_t \qquad (14)$$

Appendix Table 2: Results of Regression in First Differences

Dependent Variable: $\Delta \ln\left(\frac{K}{L}\right)$	Base Case		Excluding Housing		Excluding Mining	
	Australia	New Zealand	Australia	New Zealand	Australia	New Zealand
First difference of the Log of relative prices (α_1)	0.21* (1.98)	0.25*** (3.43)	0.27* (2.14)	0.19*** (3.58)	0.20 (0.31)	0.28*** (3.90)
Adjusted R-squared	0.16	0.65	0.20	0.68	-0.09	0.66

*= sig. at 10% level, **=sig. at 5% level, ***=sig. at 1% level

All of the New Zealand estimated equations have been corrected for autocorrelation, as well as the Australian estimated equation excluding mining.

Appendix Table 3: Results of Regression in First Differences

Dependent Variable: $\Delta \ln\left(\frac{K}{L}\right)$	Excluding Mining and Agriculture, Forestry and Fishing		Using new OECD capital stock	
	Australia	New Zealand	Australia	New Zealand
First difference of the Log of relative prices (α_1)	0.09 (0.46)	0.24*** (3.37)	0.42*** (3.35)	0.36*** (4.47)
Adjusted R-squared	-0.15	0.56	0.42	0.62

The Canadian equation has been corrected for Autocorrelation, as well as the Australian and New Zealand equations excluding Mining and Agriculture, Forestry and Fishing, and the New Zealand equation using the new OECD capital stock data.

We also estimated the short-run and long-run elasticities using an error correction framework. This framework requires that the variables be cointegrated. The unit root tests (see below) indicate that the variables cannot be cointegrated for both New Zealand and Australia. However, the unit root test has been found to have very low power in small samples. Thus we estimated the error correction models as a further robustness check (see equation 15 below). The results are presented below, and again give similar results for the short-run elasticities. The long-run elasticities are also very similar. Exceptions are the model for Australia when housing is excluded, and the model for New Zealand using the new OECD capital stock. The long-run elasticity for Australia when housing is excluded was 0.94 and not statistically different from one; in the error correction model this decreases to 0.58 and becomes significantly smaller than unity. When the error correction model is run for New Zealand using the new OECD capital stock data, the long-run elasticity estimate becomes statistically smaller than unity (previously the estimate was 0.93 and not significantly different from one).

$$\Delta \ln\left(\frac{K}{L}\right)_t = \alpha_0 + \alpha_1 \Delta \ln\left(\frac{w}{r}\right)_t + \lambda\left[\ln\left(\frac{K}{L}\right)_{t-1} - \beta_1 \ln\left(\frac{w}{r}\right)_{t-1} - \beta_2 t\right] + u_t \qquad (15)$$

Appendix Table 4: Error Correction Estimation Results

Dependent Variable: $\Delta \ln\left(\frac{K}{L}\right)$	Base Case		Excluding Housing		Excluding Mining	
	Australia	New Zealand	Australia	New Zealand	Australia	New Zealand
First difference of the Log of relative prices (α_1) (short-run elasticity)	0.30 (1.45)	0.33*** (5.80)	0.28 (1.55)	0.27*** (4.70)	0.54** (3.08)	0.30*** (4.87)
Lagged log of the capital-labour ratio (λ)	-0.38 (-1.54)	-0.56*** (-5.87)	-0.31 (-1.31)	-0.63*** (-4.34)	-0.52** (-2.76)	-0.66*** (-4.43)
Lagged log of relative prices ($\lambda\beta_1$)	0.29 (1.41)	0.35*** (5.61)	0.18 (0.68)	0.28*** (3.55)	1.14** (4.37)	0.39*** (5.49)
Time Trend ($\lambda\beta_2$)	0.003 (0.53)	0.008*** (4.71)	0.004 (0.71)	0.01**** (3.57)	-0.01* (-2.21)	0.007*** (4.15)
Long-run elasticity ($\frac{-\lambda\beta_1}{\lambda}$)	0.76* (-1.46)[a]	0.63*** (-15.14)[a]	0.58** (-1.93)[a]	0.44*** (-25.92)[a]	2.19*** (5.22)[a]	0.59*** (-18.94)[a]
Adjusted R-squared	0.28	0.87	0.30	0.78	0.66	0.87

a: These t-ratios were calculated using the Delta method and indicate whether the long-run elasticities are statistically different from one.

Appendix Table 5: Error Correction Estimation Results

Dependent Variable: $\Delta \ln\left(\frac{K}{L}\right)$	Excluding Mining and Agriculture, Forestry and Fishing		Using the new OECD capital stock	
	Australia	New Zealand	Australia	New Zealand (smoothed)
First difference of the Log of relative prices (α_1) (short-run elasticity)	0.28* (1.90)	0.30*** (4.80)	0.38** (2.71)	0.38*** (6.10)
Lagged log of the capital-labour ratio (λ)	-0.50** (-2.36)	-0.68*** (-4.30)	-0.76** (-2.72)	-0.58*** (-6.40)
Lagged log of relative prices ($\lambda\beta_1$)	0.79*** (3.65)	0.38*** (4.89)	0.44** (2.59)	0.44*** (6.09)
Time Trend ($\lambda\beta_2$)	-0.008 (-0.97)	0.007*** (3.86)	0.007 (1.32)	0.01*** (5.29)
Long-run elasticity ($\frac{-\lambda\beta_1}{\lambda}$)	1.58*** (2.83)[a]	0.56*** (-19.93)[a]	0.58*** (-7.44)[a]	0.76*** (-9.80)[a]
Adjusted R-squared	0.58	0.84	0.63	0.89

a: These t-ratios were calculated using the Delta method and indicate whether the long-run elasticities are statistically different from one.

The unit root test used in this study is the Augmented Dickey-Fuller t test. The optimal lag length has been chosen using Schwarz criterion.

All variables were tested first to ascertain whether a trend should be included in the unit root test. If we did not reject the unit root null hypothesis, we took the first difference of the series and reran the test excluding a time trend.

New Zealand's capital-labour ratio and capital-labour ratio excluding mining were both stationary, as well as Australia's adjusted relative price series excluding housing. All other series were found to be I(1), except Australia's adjusted relative price series and New Zealand's unadjusted relative price series excluding mining, which were both I(2).

Appendix Table 6: Unit Root Tests (levels)

	Australia		New Zealand	
	Lag Order	t-statistic	Lag Order	t-statistic
Log(K/L)	0	4.44	1	-3.37*
Log(w/r) (adjusted)	4	-3.07	0	-1.13
Log(K/L) excluding housing	0	4.66	1	1.74
Log(w/r) (adjusted, excluding housing OS)	4	-4.78***	2	-2.92
Log(K/L) excluding mining	4	0.86	3	-4.75***
Log(w/r) (unadjusted, excluding mining OS and COE)	0	-0.07	4	-1.25
Log(K/L) excluding mining and agriculture	4	2.10	4	-0.24
Log(w/r) (unadjusted, excluding mining and agriculture OS and COE)	0	0.16	4	-1.45
Log(K/L) using new OECD capital stock	4	1.11	0	-1.50
Log(w/r) (adjusted, using new OECD capital stock)	1	-1.69	0	-0.24

*= sig. at 10% level, **=sig. at 5% level, ***=sig. at 1% level

Appendix Table 7: Unit Root Tests (first differences)

	Australia		New Zealand	
	Lag Order	t-statistic	Lag Order	t-statistic
Log(K/L)	0	-5.92***	-	-
Log(w/r) (adjusted)	4	-1.54	0	-2.84*
Log(K/L) excluding housing	0	-3.44**	0	-2.92*
Log(w/r) (adjusted, excluding housing OS)	-	-	0	-2.74*
Log(K/L) excluding mining	0	-2.93*	-	-
Log(w/r) (unadjusted, excluding mining OS and COE)	0	-4.84***	0	-2.39
Log(K/L) excluding mining and agriculture	0	-3.01**	3	-4.37***
Log(w/r) (unadjusted, excluding mining and agriculture OS and COE)	0	-4.12***	0	-3.01**
Log(K/L) using new OECD capital stock	3	-5.19***	0	-3.56**
Log(w/r) (adjusted, using new OECD capital stock)	0	-4.69***	0	-3.38**

*= sig. at 10% level, **=sig. at 5% level, ***=sig. at 1% level

Appendix Table 8: Unit Root Tests (Second differences)

	Lag Order	t-statistic
Australia Log(w/r) (adjusted)	3	-3.24**
NZ Log(w/r) (unadjusted, excluding mining OS and COE)	4	-4.79***

*= sig. at 10% level, **=sig. at 5% level, ***=sig. at 1% level

Appendix 3

The Gross Fixed Capital Formation (GFKF) series were obtained from the OECD national accounts. Data in the national accounts are on a calendar year basis for all OECD countries except Australia and New Zealand. Australian national account data is based on a June year, whereas New Zealand national account data is based on a March year.

The GDP data obtained from OLISnet were directly downloadable in real 1995 prices and US$ (converted using 1995 Purchasing Power Parities). The Gross Fixed Capital Formation data were available in real 1995 prices, from which we converted to US$ using 1995 Purchasing Power Parities (PPPs) available from the OECD website.

The hours data used for New Zealand from the Household Labour Force Survey (HLFS) (backdated by Chapelle-Mears) is quarterly average weekly hours worked. We multiplied the weekly hour's data by 13 for each quarter and then summed over the four quarters to form annual total hours worked.

The housing GFKF series were obtained from the OECD national accounts and the mining and agriculture, forestry and fishing GFKF series were obtained from Statistics New Zealand and the Australian Bureau of Statistics. For the initial values of the housing GFKF, the Mining GFKF, and the Agriculture, Forestry and Fishing GFKF we have assumed the growth rate to be the same as for total GFKF for the two years prior to 1972 (as the housing GFKF only begins in 1972 for both Australia and New Zealand and the Mining and Agricultural GFKF series only begin in 1972 for New Zealand). For the mining GFKF and agricultural GFKF we only had data in current prices, so we deflated these series by the implicit total GFKF price indices (as the OECD has total GFKF in both current and constant prices in the national accounts). The new OECD capital stock data were also converted to real 1995 prices using this implicit GFKF price deflator. As the mining GFKF and agricultural GFKF series both stop in 2001 (for New Zealand), we assumed the growth rate to be the same as for total GFKF in 2002.

The Compensation of Employees (COE) and Operating Surplus (OS) data were obtained from the OECD national accounts. The COE, OS, and total hours worked data for the mining sector, the agriculture, forestry and fishing sector, and the OS of owner-occupied dwellings were obtained from Statistics New Zealand and the Australian Bureau of Statistics. All COE and OS data (total, mining, agriculture and housing) were converted to real using the CPI for each country, and to US$ using 1995 PPPs.

An estimate of the labour income of sole-proprietors was calculated by multiplying the number of self-employed persons (obtained from the OECD labour force statistics) by an imputed wage rate; the imputed wage rate being Total COE divided by the total number of persons employed less the number of self-employed persons.