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Productivity growth in New Zealand: economic reform and the convergence hypothesis

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Abstract

The recent productivity experience of the New Zealand economy is examined using a cyclically-adjusted or trend measure of total factor productivity (TFP). On the basis of this measure, the results of estimating a leader-follower convergence relationship suggest that productivity in New Zealand has been converging to US levels through a process of technological diffusion. The evidence also *tentatively* suggests that the size of the steady-state gap in the levels of TFP between New Zealand and the US decreased in the early 1990s. Although the evidence presented here is encouraging, it should be interpreted with considerable caution given that the post-reform sample period is very short and the method used to measure the steady-state levels gap is preliminary.

JEL classification: 040

Summary[1]

This paper examines the productivity performance of the New Zealand economy since the inception of the economic reform programme in the mid-1980s. The reforms have increased the openness of the New Zealand economy to international competitive pressure and the degree to which domestic market forces are able to operate. As a consequence, New Zealand's productivity performance should have improved as competitive pressures encourage domestic firms to adopt superior production technologies from the world's most advanced countries. Consistent with this prediction, the measure of productivity considered here does display a marked improvement at the beginning of the 1990s. If, as the evidence suggests, this improvement is the result of technology diffusion, then the positive impact of opening the economy to competitive forces should be ongoing for a considerable time into the future.

1. Introduction

Until recently, New Zealand's rate of economic growth has been markedly below that of other western industrialised countries.[2] Traditional growth theory predicts that the economic performance of lagging economies should converge towards that of the world's leading economies. This arises because of equalisation in capital intensities, arising from diminishing marginal returns, and convergence in the levels of technology via the diffusion of technological innovation. Empirical tests of the convergence hypothesis suggest that necessary conditions for this result are that tastes and preferences, and the structure of institutions are similar across countries, and that competitive market forces are able to operate. It is reasonable to assume that in New Zealand, tastes and preferences and the structure of institutions are broadly comparable to those of other developed countries. Until recently however, competitive market forces have been a less significant determinant of economic activity in comparison to other developed countries. The period of economic reform since the mid-1980s has enhanced the role of market forces as determinants of economic activity. Accordingly, New Zealand's economic performance should have begun to 'catch-up' to that of the world's leading economies as a result of the reforms.

To examine the growth performance of the New Zealand economy since the mid-1980s, we focus on growth arising from technological advance. The measure of technological proficiency considered is a trend, or cyclically-adjusted, measure of total factor productivity (TFP). Total factor productivity is an index of the efficiency with which an economy combines its capital stock (buildings, machinery and equipment) and its labour supply (workers) to produce final goods and services. Trend TFP abstracts from normal business cycle variations in productivity growth, so that longer-term trends become apparent. On the

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[2] Evans, Grimes, Wilkinson and Teece (1996) find that GNP per capita in New Zealand has fallen from 92 percent of US per capita income in 1938 to around 50 percent at the end of the 1980s. Smith and Grimes (1990) report that per capita income in New Zealand has fallen from around 125 percent of the OECD average in 1950 to only 75 percent in 1985. Other studies confirm New Zealand's recent poor growth performance. For example, Dowrick and Nguyen (1989) find that over the period 1973 to 1985 the growth rate in New Zealand per capita GDP was less than half the OECD average. Hall (1996) comments that 'New Zealand's average growth performance has been the worst of any OECD country … for the overall post-war period' (p 31).

basis of this measure, the results of estimating a leader-follower convergence relationship for the New Zealand economy suggest that technological catch-up has been occurring. Furthermore, the evidence tentatively suggests that the steady-state levels gap in TFP between New Zealand and the US decreased in the early 1990s.

The paper is structured as follows. A brief description of economic growth and convergence theory is contained in section 2. This is used to justify the focus of the paper. In section 3, the principal ways that economic reforms have increased the role of foreign and domestic competitive forces in the New Zealand economy are briefly discussed. A summary of previous empirical work on New Zealand's recent productivity performance is also presented. The empirical method used to estimate trend TFP and test for technological convergence is discussed in section 4. Results are presented in section 5 and section 6 contains a brief summary and conclusion.

2. Theories of economic growth and the convergence hypothesis[3]

The neoclassical growth model in Solow (1956) and Swan (1956) embodied the first notion of the convergence hypothesis. In this model, countries below their steady-state levels of per capita output experience relatively high rates of growth. Output per capita converges towards the steady state because of convergence in capital per worker. Given diminishing marginal returns and perfect capital mobility, capital accumulates until returns are equalised across countries. The steady state levels of per capita income are determined by a constant rate of savings and level of technology, both of which are exogenous. In the steady state, growth in output is driven by population growth so that per capita output is constant.[4]

The empirical observation of persistent growth in per capita income in many economies over the last two hundred years illustrates a key weakness of the prototype neoclassical growth model. Two approaches have been followed to address the issue. Romer (1986) and Lucas (1988) avoid diminishing returns to investment by using a sufficiently broad definition of capital, thus allowing for growth in steady-state per capita income. In Romer (1990) and Aghion and Howitt (1992), theories of investment in research and development coupled with imperfect competition are introduced into growth theory. This results in positive growth in steady-state per capita income while maintaining the neoclassical assumption of diminishing returns to capital.

In contrast to the neoclassical growth model, Romer (1993) emphasises 'idea gaps' as an explanation for cross-country differences in the levels of income per capita. In this framework, countries will be relatively poor if they do not have access to the ideas necessary to generate economic value. Convergence in output per capita occurs through a process of technology diffusion between countries.[5]

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[3] For a detailed discussion of the evolution of growth theory and theories of convergence, see Barro and Sala-i-Martin (1995).

[4] In Cass (1965) and Koopmans (1965), the theory of consumer choice in Ramsey (1928) is built on to endogenise the savings rate in the neoclassical model. This results in the predicted speed of convergence becoming a function of the time path of the savings rate. However, the equilibrium continues to be characterised by no per capita output growth.

[5] 'Technology' in this sense is Harrod neutral or labour augmenting.

The convergence hypothesis has been extensively tested. Although not all studies are in complete agreement, there is a substantial amount of evidence in support of convergence.[6] In Baumol (1986), growth in output per hour worked in major industrialised countries over the 1870 to 1979 period shows remarkable support for the convergence hypothesis. Barro and Sala-i-Martin (1992a, 1992b and 1995) also find strong evidence of convergence in output per person across different states of the United States, Japanese prefectures, and regions in eight European countries.

When tests of the convergence hypothesis are extended to include a wider and more heterogeneous group of countries, unconditional convergence can no longer be observed.[7] Baumol (1986) argues that three 'convergence clubs' exist: western industrialised countries, centrally planned economies, and less developed countries.[8] Barro and Sala-i-Martin (1995) find that information on tastes and preferences, institutional structure and the extent to which market forces are able to operate is required before convergence can be observed across a large group of heterogeneous countries. Within the context of growth theory, this additional conditioning information proxies for the country-specific steady-state level of output per capita.

A number of studies have tried to assess the relative significance of capital accumulation and technological diffusion as sources of observed convergence behaviour. owrick and Nguyen (1989) find that total factor productivity is converging in all but the poorest countries, implying that technological diffusion is a key factor underpinning convergence in income per capita. Klenow and Rodriguez-Clare (1997) argue cogently that differences in productivity are the primary cause of cross-country dispersion in income per capita, also implying that convergence occurs as a result of technology diffusion. In addition, the work of Heliwell and Chung (1991), Sachs and Warner (1995) and Edwards (1996) shows that competitive pressure arising from an economy's openness to the rest of the world is a fundamental market force that speeds the diffusion of technical progress, thus driving convergence across a large group of countries. However, the empirical analysis in Wolff (1991), Bernard and Jones (1996), and Bianchi et al. (1997) shows that the accumulation of capital can also be an important force underlying growth and convergence.

In what follows, we focus on technological diffusion as a source of convergence behaviour in the New Zealand economy by analysing trend TFP. This choice is motivated by the work of Romer (1993) and the previous empirical work discussed above. In the New Zealand context, this focus is also consistent with the results of Smith and Grimes (1990) and Hall (1996) who find that New Zealand's relatively poor output growth performance over the post-war period is primarily the result of weak growth in TFP. This provides further support for the assertion that in the case of New Zealand, convergence in output per capita will be driven by convergence in TFP.

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[6] Note, however, that this literature is by no means conclusive. See Klenow and Rodriguez-Clare (1997) and Bernard and Durlauf (1995) for discussion of the problems inherent in empirical tests of the convergence hypothesis.

[7] Unconditional convergence simply means that poorer countries will grow more quickly than richer countries. Accordingly, tests of unconditional convergence do not allow for different steady-state income paths across countries.

[8] Quah (1994 and 1996) examines the data in a slightly different fashion and illustrates that there is support for Baumol's notion of convergence clubs, with a high growth and low growth club that appear to be diverging. Quah also finds that transition between clubs appears to be very unlikely.

3. The increased role of foreign and domestic market forces in New Zealand

A comprehensive overview of New Zealand's economic reforms can be found in Evans, Grimes, Wilkinson and Teece (1996) and Silverstone, Bollard and Lattimore (1996). From the perspective of the convergence theory discussed above, the most relevant aspects of the reforms are the opening of the domestic economy to international competitive forces and the fostering of a domestic economic environment operating on the basis of competitive market structures. As discussed in Evans et al, increasing the degree to which foreign and domestic market forces are able to operate in the New Zealand economy has been a principal aspect of the reform experience.

The openness of the New Zealand economy to foreign sector competitive forces has been greatly increased in the post-reform period by the removal of foreign exchange controls and quotas, and reductions in tariffs and foreign ownership restrictions. Conway (1998) uses an empirical model (SVAR) to assess the openness of the New Zealand economy. Results indicate that in general, foreign sector shocks have become a substantially more important source of domestic macroeconomic variability since the beginning of the reform period.

Within the domestic economy, an array of policy initiatives was implemented to improve the extent to which the New Zealand economy operates on the basis of competitive market principles. The Employment Contracts Act, reductions in the size of the public sector through privatisation, the conversion of public departments into state-owned enterprises operating with a profit incentive, decreases in welfare benefits and large falls in government-funded industry assistance have all enhanced the role of the market place as a basis for economic activity.

It is therefore reasonable to conclude that economic reform has increased the degree to which foreign and domestic competitive market forces are able to operate in the New Zealand economy. Assuming that the tastes and preferences of New Zealanders and the structure of institutions in the economy are broadly comparable to those of other developed countries, the discussion in section 2 suggests that New Zealand's steady-state productivity path should have experienced an upward shift as a result of economic reform. Accordingly, productivity growth in New Zealand should have improved relative to the pre-reform period *and* relative to productivity growth in the world's most technologically advanced countries.

Previous empirical studies of the effects of economic reform on productivity growth in New Zealand have produced mixed results. Table 1 reports estimates of annual growth in TFP from various studies. Hall (1996 and 1997) and the OECD (1993) both find that annual growth in TFP actually fell from the mid-1980s. In contrast, Färe, Grosskopf and Margaritis (1996) conclude that "the economic reforms had an overall positive impact on the productivity growth performance of the New Zealand market sector" (p 96). Furthermore, they attribute this improvement in productivity performance to the international diffusion of technology. Philpott (1995) also finds that TFP growth increased after the mid-1980s.

Table 1
Annual TFP growth rates in New Zealand

	'Pre-Reform'		'Post-Reform'	
OECD (1993)	1975-84	0.2	1985-91	-0.6
Philpott (1995)	1975-85	0.1	1985-94	1.4
Färe, Grosskopf and Margaritis (1996)	1972-84	0.7	1985-94	2.4
Hall (1996)	1978-85	1.2	1983-93	0.4
Hall (1997)	1978-85	1.2	1985-95	0.9

Without undertaking a detailed comparison, it is not possible to identify conclusively the source of these disparate results. However, variation arising from different sample periods is likely to be substantial because of the cyclical characteristics of the New Zealand economy, given that the above measures of TFP are not cyclically adjusted.

Hall (1996) points out that analysis of New Zealand's recent TFP growth performance should take into consideration the role of the aggregate business cycle. In this respect, the post-reform TFP growth figures reported above must be interpreted with caution because they may be biased by the cyclical characteristics of the New Zealand economy over the sample period. To mitigate this problem, Hall also reports TFP growth rates in a business cycle (trough-peak-trough) context. However, the lack of a complete business cycle in the post-reform period means that this approach did not allow a definitive conclusion about the influence of reform on New Zealand's TFP growth to be made. Hall (1996, p 65) concludes:

> "There is as yet no clear (cyclically corrected) evidence that TFP growth rates have been better recently than for periods prior to the mid-1980s. There is, however, a reasonable possibility that full cycle figures for the currently incomplete business cycle could register better news for both TFP and labour input growth."

4. Data and empirical method

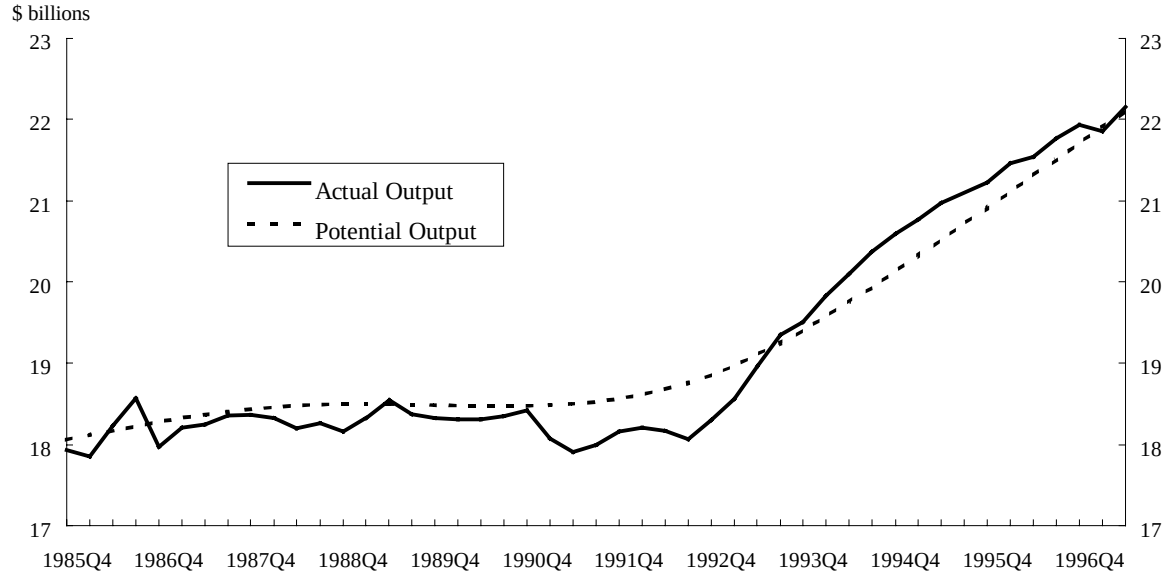
In a study of income convergence in OECD countries, Dowrick and Nguyen (1989) employ an alternative approach to account for cyclical bias in macroeconomic data. They extract trend measures from relevant macroeconomic aggregates using a time-series filter and conduct their analysis using these trends. This is the approach adopted here. We derive a trend, or cyclically-adjusted, measure of TFP for the New Zealand economy based on the following time series:

- potential output (y_p),
- a trend measure of employment (τ_{emp}),
- the capital stock (k).

We use the actual capital stock instead of a trend measure because the actual capital stock series does not display a great deal of variability at business cycle frequencies. The resulting measure of trend TFP abstracts from business cycle fluctuations and allows New Zealand's recent TFP growth performance to be evaluated in a cyclically adjusted context.

Potential output is calculated using a multi-variate (MV) filtering technique documented in Conway and Hunt (1997). This is a semi-structural estimation technique in which information derived from broad macroeconomic relationships is incorporated into a time-series filter in a fairly general way. Specifically, the Hodrick-Prescott (HP) (1997) filter is augmented with information from a Phillips curve, an Okun's Law relationship and survey data on capacity utilisation. This strategy is designed to improve the accuracy with which the filter identifies supply (trend) and demand (cyclical) disturbances in New Zealand real output data. The MV filter estimate of potential output and the actual output series are displayed in figure 1.

Figure 1: Actual and potential output



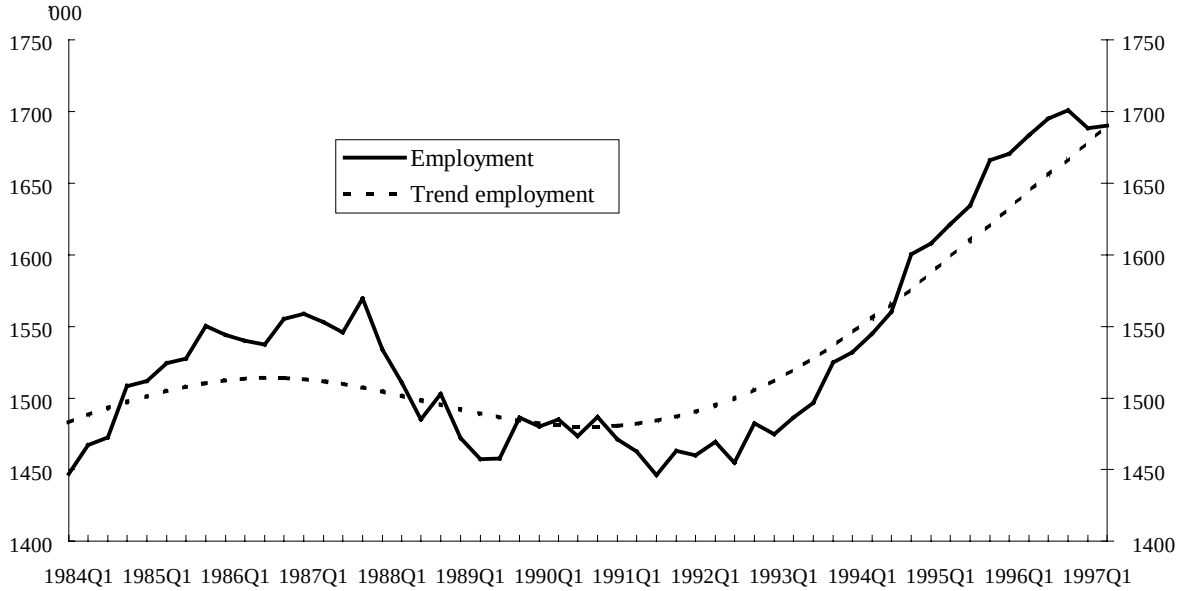
The trend level of employment (τ_{emp}) is defined as:

$$\tau_{emp} = \tau_{1f} * \left(1 - \tau_{ump}\right) \qquad (1)$$

τ_{1f} and τ_{ump} are trend measures of the labour force and unemployment rate respectively. τ_{1f} is calculated as the HP trend of the actual labour force. The value of the smoothness parameter (λ) in the HP minimisation problem is set equal to 1600. The trend rate of unemployment, τ_{ump}, is estimated as the HP trend of the actual unemployment series. The value of the smoothness parameter is set equal to 1600 in all periods except 1991Q1, in which it equals zero. This allows for a break in the trend rate of unemployment, coinciding with the inception of the Employment Contracts Act (1991).[9] The trend and actual rate of employment are displayed in Figure 2.

[9] See Conway and Hunt (1997) for details.

Figure 2: New Zealand employment: trend and actual

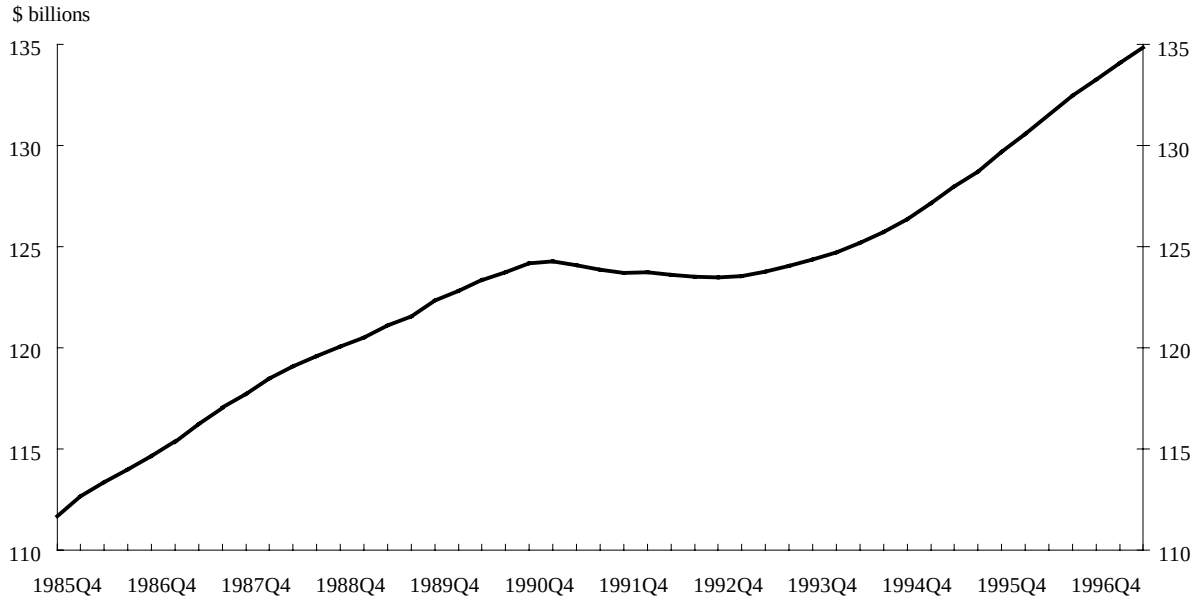


The capital stock is calculated using the perpetual inventory method. In this technique, initial starting-point estimates of the capital stock are brought forward through time using data on investment flows and assumed depreciation rates. The capital stock series begins in 1983Q1. Initial starting point estimates are based on the capital stock series contained in Sieper (1996).[10] The total capital stock is disaggregated into the following components: buildings and construction, computer equipment, and other machinery. These components are assumed to depreciate at 3.4 percent, 25 percent, and 14 percent per annum respectively.[11] The estimate of the capital stock is shown in Figure 3.

[10] The starting point estimates taken from Sieper (1996) are adjusted to remove non-market capital. The ratio of investment by market and non-market entities is used as a proxy for the share of market and non-market capital in the total capital stock figure.

[11] In Section 5 we examine the sensitivity of results to these assumptions.

Figure 3: New Zealand capital stock



Using these measures, trend New Zealand TFP (NZTFP) is calculated on the basis of a Cobb-Douglas production function, that is

$$NZTFP = \frac{y_p}{(k^{\alpha} \times \tau_{emp}^{1-\alpha})} \qquad (2)$$

This specification incorporates the neoclassical assumptions of diminishing marginal returns to each factor with overall constant returns to scale. The value of the capital share parameter, α, is set equal to 0.35.[12] To compare New Zealand's recent productivity performance with that of the world's technological leader, we calculate an analogous measure of trend TFP for the United States economy (USTFP).[13]

To test the hypothesis of convergence in New Zealand's trend TFP we use a model of technology diffusion presented in Barro and Sala-i-Martin (1995). An empirical implication of this model is that the growth rate of income per capita in the follower country is influenced by the *growth rate* of income per capita in the leader country, the *levels gap* in per capita income between the leader and follower countries, and a *steady-state levels gap* between the two countries. Specifically:

$$\gamma_i \approx \gamma_1 - \beta \log(y_i) + \beta \log(y_1) + \beta \log\left[(y_i/y_1)^*\right] \qquad (3)$$

where y_1 and y_i are output per capita in the leader and follower country respectively and γ_1 and γ_i are the associated growth rates. The equilibrium levels gap is denoted $(y_i/y_1)^*$.

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[12] This is the value of α in the core model of the Reserve Bank's *Forecasting and Policy System* (FPS). See Black et al (1997) for details.

[13] Potential output in the US economy is also calculated using a multi-variate filtering technique. All of the data used to construct trend TFP in the New Zealand and US economies is detailed in the Data Appendix.

As discussed in section 2, the focus of this paper is technological diffusion. Accordingly, in applying this model to the New Zealand and United States economies we use trend TFP rather than income per worker. As is pointed out by Barro and Sala-i-Martin, the variables y_1 and y_i are in fact intended to represent the level of technology in the leader and follower country respectively.

Barro and Sala-i-Martin also point out that cyclical macroeconomic fluctuations make it difficult to measure the underlying level of technology from available data. Using a trend measure of TFP that abstracts from business cycle fluctuations mitigates this difficulty. To capture the steady-state levels gap between New Zealand's and the United States' trend TFPs (y_i/y_1), a constant is included in the regression.

Accordingly, the following equation is estimated:

$$\Delta NZTFP_t = \Delta USTFP_{t-4} + \beta(\log(USTFP_{t-4}) - \log(NZTFP_{t-4})) + \psi_t + \varepsilon_t \qquad (4)$$

Δ is the first difference operator, ψ is a constant and ε is residual error. ΔUSTFP and the levels gap between New Zealand and US TFP are lagged four quarters on the assumption that technology does not diffuse instantaneously. A positive and significant value of β implies that growth in NZTFP is positively influenced by the size of the levels gap in trend TFP between New Zealand and the US, indicating technological catch-up. The magnitude of the steady-state levels gap is derived by dividing ψ by the coefficient β, ie $\log [(y_i/y_1)^*] = \psi / \beta$, consistent with equation (3) above.[14]

As is apparent from equation (4), testing the hypothesis of catch-up in NZTFP requires a measure of the trend TFP levels gap between the New Zealand and the United States economies. Rendering the levels of macroeconomic time series comparable across countries is not a straightforward exercise. Studies of income convergence generally rely on constant international price measures of per capita GDP taken from the International Comparison Project and the Penn World Tables. Although this approach is an improvement over simple exchange rate-based comparisons, it is still subject to cogent criticism.[15] To construct the levels gap in trend TFP between New Zealand and the United States we simply deflate our starting-point values for potential output and the capital stock in New Zealand using a measure of bilateral purchasing power parity between the United States and New Zealand.[16] We then extend these series using growth rates analogous to those in the unadjusted series. We make no adjustment to New Zealand's trend level of employment.

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[14] This technique for calculating the steady-state levels gap is clearly not ideal. In future work we hope to construct proxies for the steady-state levels gap to be included in equation (4).

[15] In a recent contribution Dowrick and Quiggin (1997) point out that this approach does not yield true quantity indices and may result in systematic substitution bias. They also show that the use of purchasing power parity measures that are based on international price indices using the more advanced economies prices tend to *underestimate* the strength of convergence.

[16] The starting point for these series is 1985Q4. For this quarter the measure of bilateral PPP between the US and New Zealand, taken from the OECD Main Economic Indicators (via Datastream) is 1.59.

Results

The log levels of trend TFP in New Zealand and the United States are presented in Figure (4). The sample period is from 1985Q4 to 1997Q2. Consistent with prior expectations, trend TFP in the United States is substantially higher than in New Zealand.

Figure 4: New Zealand and US trend TFP levels

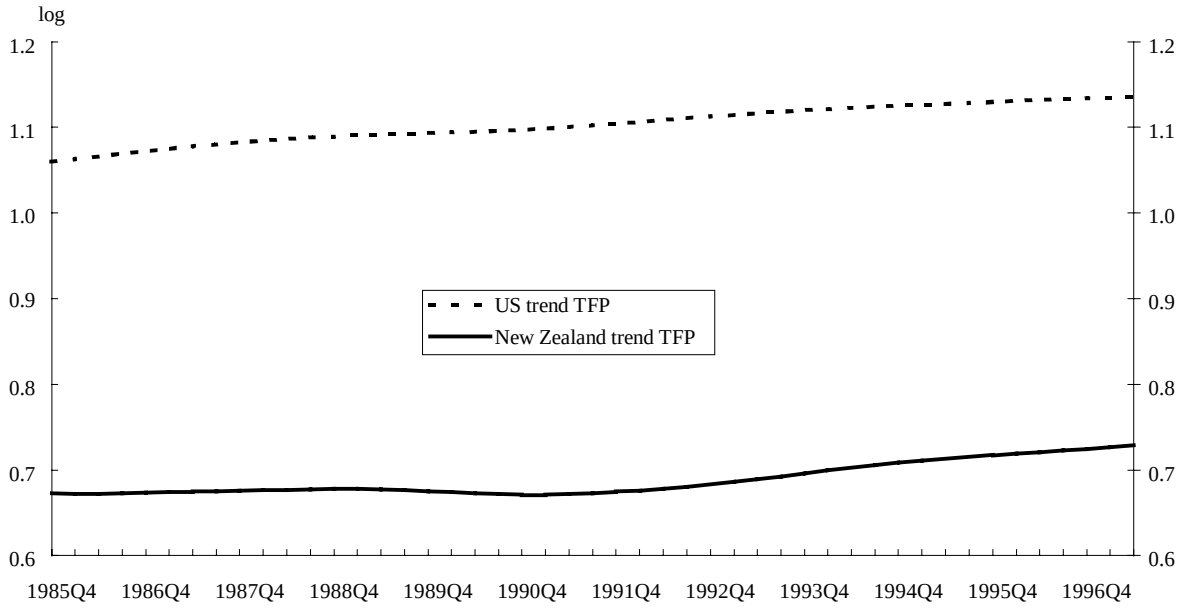
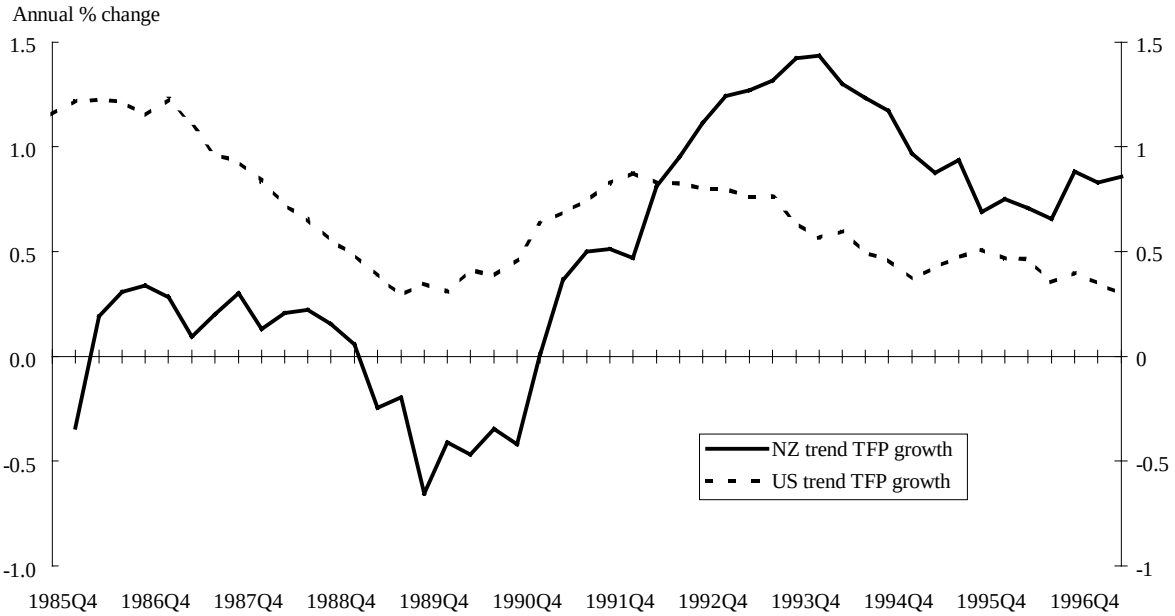


Figure 5 displays the growth rates of trend TFP in New Zealand and the United States. One of the most notable features of the graph is the increase in the growth rate of trend TFP in the New Zealand economy at the beginning of the 1990s. From 1985Q4 until 1991Q2, trend TFP growth in New Zealand averages just above zero percent per annum. Over the same period, annual growth in trend TFP in the United States averages 0.75 percent. From 1991Q3 until 1997Q2, the average annual growth rate in New Zealand's trend TFP increases to around 1 percent. The analogous figure in the US over this period is 0.6 percent.

Figure 5: New Zealand and the United States trend TFP growth



These results suggests that the economic reforms only began to have a noticeable positive impact on trend productivity in New Zealand in late 1991. This result is plausible because economic reform was by no means an instantaneous process. It is therefore reasonable to expect that productivity growth improved through time as the reform program unfolded.[17] Further, firms in New Zealand are unlikely to have immediately adjusted their behaviour in response to economic reform, implying further lags in subsequent productivity growth improvement. The dislocation of productive resources that would arise during this transition period is also likely to have had a negative impact on estimated productivity growth in the short-run.

To determine whether the impact of the reforms has altered the size of the steady-state levels gap in trend TFP between New Zealand and the US, we include a dummy variable (ϕ) in equation (4). It has the following values:

$$\phi_t = \begin{cases} 0 & for \;\; 1985Q4 \leq \;\; t \;\; \leq 1991Q2 \\ 1 & for \;\; 1991Q3 \leq \;\; t \;\; \leq 1997Q2 \end{cases}$$

In this way, the test regression can be used to provide an estimate of the change in the steady-state levels gap that occurred after 1991Q2. That is, for the period 1991Q3 to 1997Q2, the steady-state levels gap is calculated as $\log [(y_i/y_1)^*] = (\psi + \phi) / \beta$.

To test the sensitivity of the regression results to the uncertainty surrounding the estimate of the capital stock,[18] we calculate measures of trend TFP in New Zealand using several alternative capital stock estimates. We change the starting-point (SP) estimates of the capital

[17] For a chronology of economic reform in New Zealand see Bollard, Lattimore and Silverstone (1996) and Evans et al (1996) (among others).

[18] See Chapple (1994) for a discussion on the pitfalls inherent in using a perpetual inventory model to calculate the capital stock in New Zealand.

stock by +/- 10 percent and the depreciation rates (depn) by +/- 10 percent. Graphs of the resulting estimates of growth in NZTFP are contained in Appendix A2.

The results of estimating the test regression under the various assumptions about the capital stock are reported in Table 2. The size of the implied steady-state gaps in trend TFP between New Zealand and the United States before and after 1991Q2 are also reported. When trend TFP in New Zealand is calculated using the benchmark measure of the capital stock, β is positive and significant. This result provides some evidence of catch-up in trend TFP in the New Zealand economy. The estimated values of ψ and ϕ are both significant and indicate that the steady-state levels gap in trend TFP between New Zealand and the United States decreases by 20 percent after 1991Q2. Some care should be taken when interpreting these estimates as the econometric technique used to capture the shift implicitly assumes that it was a discrete shift that occurred in one quarter. However, the shift in the steady-state gap would undoubtedly have been a continuous process, occurring over many years (and possibly still underway).

The results of Ljung-Box Q tests suggest that the residuals of the test regressions are serially correlated. This is not altogether surprising given the simplicity of the model and the method used to capture the change in the steady state levels gap.

To provide an illustrative simulation, we assume that in the future USTFP will grow at an annual rate of 0.8125 percent.[19] The results of simulating into the future the first regression reported in Table 2 on the basis of this assumption suggest that the growth rate of NZTFP will converge to the growth rate of USTFP sometime towards the middle of the next century.[20] Over all of the intervening period, the growth rate of NZTFP will be greater than that of USTFP. For example, over the ten year period 1997Q2 to 2007Q1, the growth rate of NZTFP averages roughly 0.2 of a percentage point more than the growth rate of USTFP.

To place these results in perspective, we assess their implications for projected growth in potential output in the New Zealand economy. Our estimates of future trend employment and capital are taken from the projection database of the Reserve Bank's *Forecasting and Policy System* (FPS). In the context of a Cobb-Douglas production function with a constant capital share parameter (α) of 0.35, the simulated path for NZTFP implies that growth in potential output will average just over 3 percent for the period 1998 to 2002. Although these estimates are based on a number of strong assumptions, they do show that if the improvement in New Zealand's trend TFP growth is the result of convergence dynamics, then the positive impact of opening the economy to competitive market forces should continue well into the future.

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[19] This figure is based on the assumptions of 2.25 percent annual growth in United States potential output and 1 percent annual growth in equilibrium labour input. In a Cobb-Douglas production function with a constant capital to (potential) output ratio and a capital share (α) of 0.35, these figures imply annual growth in trend TFP of 0.8125 percent.

[20] Absolute convergence in growth rates does not occur. However, by 2050Q1 the rate of growth in NZTFP is only 0.002 percentage points greater than the growth rate of USTFP.

Table 2: Regression results

Capital Stock Series	β	sig	ψ	sig	ϕ	sig	R^2	Steady-state levels gap 1986q1 - 1991q2	Steady-state levels gap 1991q3 - 1997q2
Benchmark	0.025	0.01	-0.012	0	0.002	0	0.89	0.487	0.390
SP +10 %	0.015	0.15	-0.008	0.07	0.003	0	0.87	0.539	0.370
SP -10%	0.034	0	-0.015	0	0.002	0	0.90	0.455	0.388
Depn +10%	0.021	0.04	-0.010	0.01	0.003	0	0.88	0.480	0.360
Depn -10%	0.029	0	-0.014	0	0.002	0	0.90	0.495	0.416

The other regression results reported in Table 2 indicate that, in some instances, the strength of the evidence supporting convergence in NZTFP to USTFP is sensitive to the capital stock measure. Although the estimate of β is always positive, its become notably less significant when the starting point of the capital stock is increased by 10 percent. Similarly, the estimates of ψ become less significant in this regression. In light of the small sample and the discrete technique used to capture the equilibrium shift, this degree of fragility should not be surprising. In all instances the estimated values of ψ and ϕ imply that the steady-state gap in equilibrium TFP between New Zealand and the United States is smaller after 1991Q2. The estimated reductions in the steady-state gap range from 14 to 31 percent.

6. Conclusions

his paper examines New Zealand's recent productivity performance using a cyclically-adjusted measure of total factor productivity (TFP). The convergence hypothesis suggests that New Zealand's productivity performance should have improved as a result of economic reform given that competitive pressures would have encouraged domestic firms to adopt improved production technologies from the world's most advanced countries. Results indicate that the growth rate of trend TFP in the New Zealand economy does in fact experience an upward shift at the end of 1991.

The results of estimating a leader-follower convergence relationship suggest that growth in trend TFP in New Zealand is influenced by the size of the levels gap in trend TFP between New Zealand and the United States, indicating technological catch-up. Further, the size of the steady-state levels gap in trend TFP between New Zealand and the United States appears to have become smaller after 1991Q2. However, these results are somewhat sensitive to how New Zealand's capital stock is estimated. This sensitivity is not altogether surprising given the short length of the sample period and the technique used to capture the shift in the steady-state levels gap. In future work we hope to develop improved techniques for assessing the size of the steady-state levels gap in trend TFP between New Zealand and the United States. This will allow more precise inferences about the speed of convergence to be drawn. Nonetheless, the results do provide some encouraging evidence that is consistent with the convergence hypothesis. If the improvement in New Zealand's trend TFP growth is the result of convergence dynamics, then the positive impact of economic reform should continue for a considerable time into the future.

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Data Appendix

New Zealand data:

τ_{lf}	trend labour force:	HP trend of HLFS official labour force
τ_{ump}	trend unemployment:	HP trend of HLFS official unemployment rate
Y_p	Potential Output:	see Conway and Hunt (1997)

1985Q4	18034.46	1988Q4	18473.7	1991Q4	18537.3	1994Q4	20081.96
1986Q1	18090.35	1989Q1	18474.76	1992Q1	18587.65	1995Q1	20267.57
1986Q2	18145.94	1989Q2	18471.32	1992Q2	18652.19	1995Q2	20454.65
1986Q3	18200.35	1989Q3	18464.62	1992Q3	18732.71	1995Q3	20642.72
1986Q4	18252.07	1989Q4	18456.6	1992Q4	18830.31	1995Q4	20831.74
1987Q1	18299.42	1990Q1	18449.16	1993Q1	18944.9	1996Q1	21021.79
1987Q2	18342.13	1990Q2	18443.95	1993Q2	19075.55	1996Q2	21212.98
1987Q3	18379.7	1990Q3	18442.33	1993Q3	19220.5	1996Q3	21405.63
1987Q4	18411.33	1990Q4	18445.56	1993Q4	19377.58	1996Q4	21600.01
1988Q1	18436.53	1991Q1	18455.02	1994Q1	19544.5	1997Q1	21796.45
1988Q2	18455.15	1991Q2	18472.43	1994Q2	19718.88	1997Q2	21995.31
1988Q3	18467.4	1991Q3	18499.4	1994Q3	19898.62		

k	capital stock:	calculated using perpetual inventory model

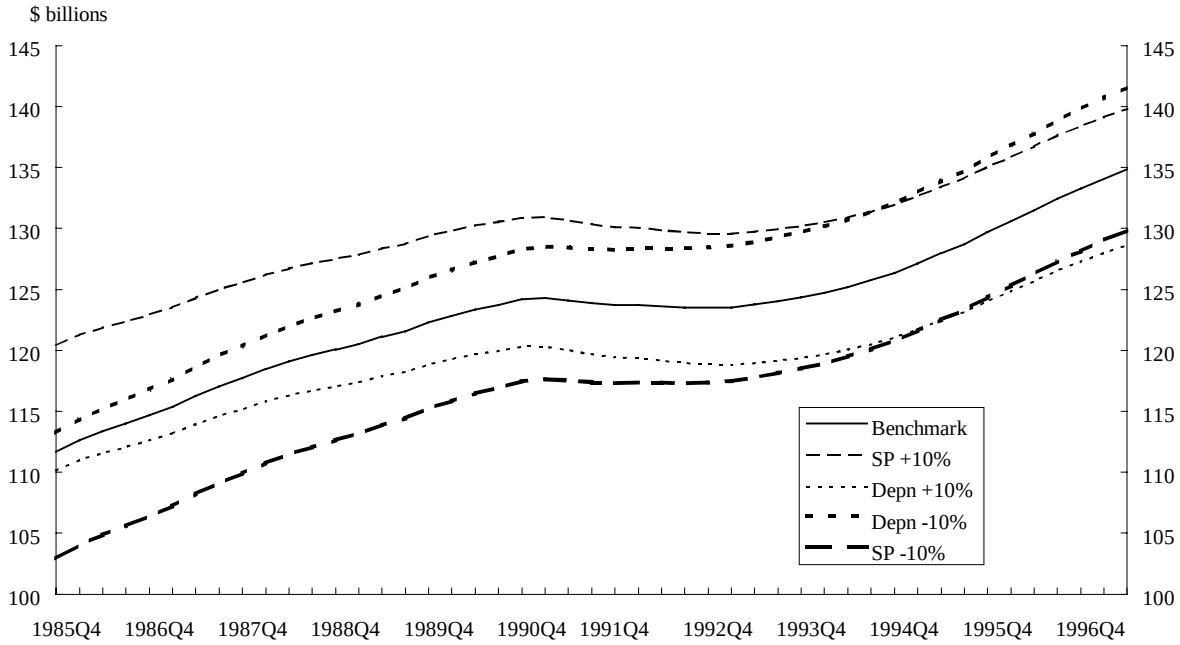
1985Q4	111630.5	1988Q4	120036.5	1991Q4	123680.3	1994Q4	126454.5
1986Q1	112635.5	1989Q1	120482.5	1992Q1	123690.1	1995Q1	127230.4
1986Q2	113301.7	1989Q2	121079.2	1992Q2	123547.4	1995Q2	128048.6
1986Q3	113948.5	1989Q3	121530.1	1992Q3	123462.9	1995Q3	128772.6
1986Q4	114615.1	1989Q4	122301.2	1992Q4	123434.1	1995Q4	129691
1987Q1	115338.5	1990Q1	122802	1993Q1	123487.4	1996Q1	130532
1987Q2	116224.2	1990Q2	123316.9	1993Q2	123693.4	1996Q2	131401.5
1987Q3	117011.5	1990Q3	123705.9	1993Q3	124001.7	1996Q3	132319.1
1987Q4	117680.1	1990Q4	124156.9	1993Q4	124322.2	1996Q4	133029.8
1988Q1	118437.5	1991Q1	124244.5	1994Q1	124703.4	1997Q1	133799.6
1988Q2	119054.6	1991Q2	124058.3	1994Q2	125233.6	1997Q2	134558.9
1988Q3	119567.9	1991Q3	123828.2	1994Q3	125826.6		

US data:

Estimates of US potential output and trend employment are from Collins (1998). US capital stock data is from the US central data bank of Standard & Poors D.R.I. This data is available on request.

Appendix A2:

New Zealand capital stock measures under various assumptions about starting point (SP) values and depreciation rates (depn):



Growth in Equilibrium TFP in New Zealand under various assumptions about the formation of the capital stock: