



Towards a Knowledge Economy? Changes in New Zealand's Information Work Force 1976–1996

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ABSTRACT *The New Zealand economy has undergone tremendous change since 1984, being transformed from one of the most regulated OECD economies to one of the most deregulated. Recently, the concept of a 'knowledge economy' has received attention in New Zealand, and policies are now aimed at creating such an economy. This study contributes to the debate by exploring the changes in the country's information work force in recent decades, and by attempting to relate them to some of the major features of the economy which have to be addressed in the search for an appropriate knowledge economy model.*

Keywords: information work force, knowledge economy and policies, economic growth, transaction sector, income distribution, innovation systems.

Introduction

In many OECD countries there has been a distinct change in the nature of economic reforms in recent decades. In contrast to the past, reforms today usually mean a shift towards less government intervention, freeing up product and labour markets. The probably most dramatic changes have occurred in New Zealand. Beginning in 1984, New Zealand's economy has been transformed from one of the most regulated in the OECD to one of the most open and market-based. Recently, the concept of the 'knowledge economy' has been given increased attention in New Zealand and reforms are now aimed at creating such an economy. The argument often put forward is that New Zealand has to shift from pastoral-based exports to knowledge-based exports. However, there is as yet little in-depth research of the existing knowledge economy in New Zealand.

The aim of this study is, firstly, to contribute to the debate by updating the measurement and analysis of the New Zealand information work force. How has its relative size and composition changed over time? It is found that there has been rapid growth of the information work force during the reform period, which seems to have been accompanied by upskilling. In terms of relative size, New Zealand's information work force seems to have caught up with that of the United States (US). The data also indicate that so far the trend toward part-time employment is less strong for information workers compared to non-information workers.

Secondly, the aim is to stimulate further discussion by highlighting four interrelated and controversial areas of research which have to be taken into account when evaluating the work force changes, and which have to be addressed in the search for an appropriate knowledge economy model. They are the economy's poor growth perform-

ance, the expansion of the 'transaction sector', changes in the distribution of income, and a seemingly weak 'National Innovation System'. Their implications for economic policy may be profound, requiring another redirection.

The paper begins with a brief review of some earlier information work force and knowledge-economy studies. This is followed by the presentation and discussion of five-yearly estimates of the New Zealand information work force (full-time, part-time and by major occupation group). Next, it is attempted to put the changes in the information work force into wider perspective. The final section reflects on some of the major shortcomings of this study and on the challenges facing public policy in a knowledge-based economy. Data issues are discussed in the Appendix.¹

Some Earlier Studies

The terms information/knowledge economy and information/knowledge workers have been around for a long time. In a pioneering study, Machlup² documented the shift in the US work force away from manual work towards 'knowledge' work. Porat and Rubin,³ using a somewhat different methodology, confirmed the continuation of this trend and introduced the concept of the information sector, with a concomitant shift to the term 'information workers'.⁴ *Information workers are defined as those working in occupations whose primary purpose is an output of produced, processed or distributed information, or its infrastructure support*, i.e. occupations primarily engaged in installing, operating and repairing information machines and technologies.⁵ The total of these workers make up the information work force. The steady growth of the share of information workers in OECD countries is well documented.⁶

However, Schement carefully re-evaluated Porat and Rubin's definition of the information work force and found that it grew significantly in the 1920s, rather than in the 1950s as they had suggested, owing to the expansion of US corporate bureaucracies.⁷ In hindsight, it seems preferable to distinguish between different types of information economies, e.g. the 'bureaucratic information economy', characterised by large clerical employment, and the 'knowledge-intensive information economy' (the 'knowledge economy'), characterised by a large and rising proportion of high-skilled information workers and a declining share of clerical workers.

Martin⁸ updated the measurement of the US information work force to the mid and late 1990s and found that information employment as a percentage of total employment had continued to grow since 1970, albeit at a slower rate than in the past. Also, the number of high-skilled information workers (those who handle information in non-routine ways) has been growing faster than the number of low-skilled information workers (those who handle information in routine ways). Such a shift can be seen as an indicator that an economy has become more knowledge-intensive.

Before we address the question of whether similar trends can also be observed in New Zealand, we briefly review some earlier New Zealand studies. Conway⁹ provided detailed estimates of the country's information work force for 1971 and 1976, and aggregate estimates for earlier years. However, he did not go beyond measurement. Parrot and Forer¹⁰ built on Conway's study and updated the information work force estimate to 1981. In addition, they looked at spatial aspects of the information work force and provided some discussion.

There are also studies that do not exclusively or explicitly focus on information employment, but on the wider information/knowledge economy. For example, Karunaratne and Cameron¹¹ measured and analysed New Zealand's fledgling information economy. They commented that New Zealand policy-makers seemed not to have

realised its critical importance,¹² and called for a paradigm shift in economic policy and firm strategies to embrace the world information economy and to create new competitive advantages, especially in differentiated knowledge-intensive goods.

Two further studies, in particular, stand out. One is *The Knowledge Economy* by Frederick and McIlroy.¹³ The other is what can be regarded as its predecessor, i.e. Dordick's *Information Technology & Economic Growth in NZ*.¹⁴ Frederick and McIlroy summarise much of the current state of the New Zealand knowledge economy and the challenges facing it. Comparing its features with those of its main competitors in the 'knowledge economy race', they note that in many respects, New Zealand seems 'a "junior" version of the US, heading in the right direction, but lagging behind in critical areas'.¹⁵ They note that the export sector has failed to develop a high-tech segment similar to that of Australia, Ireland, and Finland and argue that the country must increase its number of technical graduates, electronics production, and high-technology exports.¹⁶

Surprisingly, Frederick and McIlroy make no reference to Dordick, who foreshadowed most, if not all, of the issues raised by them. More importantly, Dordick also emphasised that 'innovation by means of information technology can lead to economic growth but only if it digs deeply into all sectors of the economy and not merely into the so-called "high tech" sectors',¹⁷ and that 'an important feature of information technology is its ability to modernise and rejuvenate traditional industries'.¹⁸ To state the obvious, development of a knowledge economy is not just a question of developing new knowledge-intensive goods and service industries, though that is very important, but also of making traditional industries more knowledge-intensive.

New Zealand's Information Work Force 1976 to 1996

Although the OECD's definition of the information work force given in the previous section and used in this paper is well established, measurement of the information work force is not a straightforward task. Occupation classifications change over time, new information occupations are being created, and the data might not be detailed enough to distinguish some information workers from non-information workers. There are always subjective choices and compromises involved in such an exercise (see the Appendix).

The Overall Trend

Table 1 presents our estimates of the total full-time and part-time information work force. There has been strong growth in the absolute and relative size of the full-time information work force, continuing an earlier trend.¹⁹ It should be noted that our estimates are more conservative (i.e. lower) than those of others, and that it *does* seem to make a large difference whether a simpler short-cut approach is used which just classifies some of the existing major occupation groups as totally 'informational', or whether the more detailed approach of this study is employed.²⁰ Furthermore, the percentage reported for 1991 is probably misleading because of high unemployment that year. There was a sizeable contraction in the total full-time work force between 1986 and 1991, mainly due to restructuring²¹ and the recession of the late 1980s/early 1990s.²²

The reader should also note that 'information technology occupations', i.e. the workers of the 'digital economy',²³ make up a tiny fraction of the total information work force. March reports that in 1996 about 4% of New Zealand's working population was employed in IT occupations and/or working for an IT industry company.²⁴

Table 1. New Zealand’s information work force

Year	Full-time workers			Part-time workers		
	Total	Information workers	% of total	Total	Information workers	% of total
1976	1,245,996	430,917	34.6	—	—	—
1981	1,272,087	444,894	35.0	—	—	—
1986	1,278,204	490,098	38.3	221,217	72,809	32.9
1991	1,151,199	513,798	44.6	249,204	95,292	38.2
1996	1,252,764	572,946	45.7	378,045	121,884	32.2

Source: Own calculations from the various New Zealand Censuses of Population and Dwellings: Department of Statistics, *New Zealand Census of Population and Dwellings 1976*, Volume 4, Labour Force, Wellington, 1980, Table 9. Department of Statistics, *New Zealand Census of Population and Dwellings 1981*, Volume 4, Labour Force, Wellington, 1983, Table 15. Department of Statistics, *New Zealand Census of Population and Dwellings, 1986*, Labour Force—Part 1, Series C, Report 4, Wellington, 1988, Table 8. Statistics New Zealand, Census 96 [computer file]: with Supermap 3 and for GIS and mapping, Wellington, 1997a. Statistics New Zealand, Census 1991, four-digit occupation data, supplied on request, 1999. Also see Appendix.

It is instructive to compare our estimates with those for the United States. Martin reports the following percentages for the size of the US information work force (percentage of all employed): 40.2% in 1970, 44.1% in 1980, 45.7% in 1990, and 45.8% in 1995.²⁵ In contrast to the United States, growth of New Zealand’s information work force has been stronger during the more recent decade. The New Zealand full-time information work force grew by 16.9% (13.7%) during 1986–1996 (1976–1986), while the total full-time work force shrunk by 2% during 1986–1996 (and increased by 2.6% during 1976–1986). While our definition of the information work force does not precisely match that of Martin, we are confident in stating that the comparison indicates that after having had a much smaller information work force as a percentage of the total work force than the United States in the past, *the relative size of New Zealand’s information work force now seems very similar to that of the United States*. It remains to be seen whether growth of the New Zealand information work force will level off from now on to parallel what happened in the United States since the early 1980s.

Looking at the part-time information work force data, it seems that the percentage of information workers has changed little over the 1986–1996 period. The 1991 percentage can again be regarded as peculiar. The high unemployment in 1991 seems to have affected non-information part-time employment to a much greater extent than information part-time employment, resulting in an especially high information worker percentage for that year. However, part-time employment has risen strongly in recent years relative to full-time employment. The ratio of the total part-time/full-time work force has risen from 0.17 in 1986, to 0.22 in 1991, and to 0.30 in 1996. It should be noted that the ratio of part-time/full-time information workers has risen by *less* (from 0.15 in 1986, to 0.19 in 1991, to 0.21 in 1996), i.e. *the trend towards part-time employment seems less strong for information workers, at least so far*.

Changes by Major Categories of Information Workers

Next we look at the breakdown of the information work force by major occupation groups, and changes in the size of these groups over time. There is some conflicting evidence on this issue for the United States. Kling,²⁶ analysing US occupation data for the period 1900–1980, focused on the split between high-skilled (‘good’) versus low-

Table 2. Composition of the full-time information work force by major occupation group

	1976	1981	1986	1991	1996
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
A. Professional etc.	121,555 (28.2) (9.7)	124,659 (28.0) (9.8)	135,663 (27.7) (10.6)	152,109 (29.6) (13.2)	178,086 (31.1) (14.2)
B. Admin and managerial	40,802 (9.5) (3.3)	45,690 (10.3) (3.6)	70,260 (14.3) (5.5)	106,212 (20.7) (9.2)	119,952 (20.9) (9.5)
C. Clerical	194,684 (45.2) (15.6)	199,161 (44.7) (15.7)	203,454 (41.5) (15.9)	144,879 (28.2) (12.6)	150,063 (26.2) (12.0)
D. Sales	51,891 (12.0) (4.2)	51,894 (11.7) (4.1)	56,373 (11.5) (4.4)	88,779 (17.3) (7.7)	102,747 (17.9) (8.2)
E. Production	21,985 (5.1) (1.8)	23,490 (5.3) (1.8)	24,348 (5.0) (1.9)	21,819 (4.2) (1.9)	22,098 (3.9) (1.8)
Total	430,917 (100) (34.6)	444,894 (100) (35.0)	490,098 (100) (38.3)	513,798 (100) (44.6)	572,946 (100) (45.7)

Note: The italic numbers in parentheses indicate percentage of the information work force, while the bold numbers indicate percentage of the total work force. Source as Table 1.

skilled ('bad') information occupations. He found that clerical (i.e. bad) jobs were the dominant occupation group of the information work force, and that all major sub-categories of the information work force had grown to a similar extent. Kling therefore questioned earlier findings that non-routine information occupations had grown relatively more than routine information occupations, and argued that the information work force may be more segmented than previously thought. In 1980, more than half of all US information workers were still employed in low-skilled information jobs. Kling's results seem to be at least partly supported for later years by Dunlop and Sheehan, who present a detailed occupational analysis of Australia (1987–1995) and the United States (1985–1995).²⁷ They found no clear evidence of upskilling in aggregate for either country, i.e. the growth rate of high-skilled employment in aggregate was not above that for low-skilled employment.

However, Kling's data do not go beyond 1980 and they have been collected according to the task-based occupation classification, not the skill-based classification introduced in the late 1980s,²⁸ and Dunlop and Sheehan do not distinguish between information and non-information occupations. It might be that high-skilled information employment has grown faster than high-skilled non-information employment, especially since the early 1980s. This question was addressed by Martin who found that the proportion of high-skilled information workers had indeed grown steadily, reaching almost 50% in 1995.²⁹

The New Zealand data in Table 2 show a similar pattern to that found by Martin for the United States. We regard all information workers in major occupation groups A (professional etc.) and B (administrative and managerial) as high-skilled. These groups are recognised as having the highest socio-economic status in society.³⁰ They also have increased steadily over time from 37.7% of the total information work force in 1976 to 52% in 1996. *This indicates upskilling of the information work force. By 1996, almost 24% of the total New Zealand full-time work force was employed in high-skilled information occupations.*

Table 2 also shows large shifts in the shares of occupation groups B, C and D between 1986 and 1991. There was a large absolute and relative increase in the number

Table 3. Composition of the part-time information work force by major occupation group

	1986 No. (%)	1991 No. (%)	1996 No. (%)
A. Professional etc.	20,616 (28.3) (9.3)	34,122 (35.8) (13.7)	39,345 (32.3) (10.4)
B. Admin and managerial	5,499 (7.6) (2.5)	6,882 (7.2) (2.8)	10,971 (9.0) (2.9)
C. Clerical	41,805 (57.4) (18.9)	45,138 (47.4) (18.1)	56,757 (46.6) (15.0)
D. Sales	3,566 (4.9) (1.6)	7,563 (7.9) (3.0)	12,312 (10.1) (3.2)
E. Production	1,323 (1.8) (0.6)	1,587 (1.7) (0.6)	2,499 (2.0) (0.7)
Total	72,809 (100) (32.9)	95,292 (100) (38.2)	121,884 (100) (32.2)

Note: The italic numbers in parentheses indicate percentage of the part-time information work force, while the bold numbers indicate percentage of the total part-time work force. Source as Table 1.

of administrative and managerial workers, but also in the low-skilled category sales workers, and a remarkable decline in the number of clerical workers. By 1996 the share of clerical workers had fallen to only 26.2% of the information work force, whereas administrative and managerial occupations had increased to 20.9%, and sales occupations had increased to 17.9%.³¹

It seems plausible to explain many of the changes among major occupation group shares between 1986 and 1991 by the economic reforms and the severe recession of the late 1980s/early 1990s, which decimated the manufacturing sector. Nearly 26% of the manufacturing work force was lost during the 1980s.³² Moreover, deregulation of the financial sector and other policy changes led to a rise in information-intensive administrative and managerial positions. However, some of the changes may have been due to the re-classification of occupations (see the Appendix). A detailed analysis of the occupation changes by industry should provide further insights, but it is beyond the scope of the present study.

Changes among major occupation groups are less pronounced for the part-time information work force (see Table 3). The proportion of the high-skilled occupation groups A and B in the total part-time information work force has increased over the period 1986–1996 from 35.9% to 41.3%. The proportion of clerical workers has fallen, but by much less than in the full-time information work force. While the proportion of occupation group A information workers is similar to that in the full-time information work force, this is not the case for occupation group B. Part-time employment is comparatively uncommon amongst administrative and managerial workers.

Towards an Assessment

How should one interpret the growth of New Zealand’s information work force? Is it that the economic reforms have accelerated the emergence of a knowledge economy, which secures a bright future for the country? Or do we have to be more cautious, as suggested,

for example, by the findings of Frederick and McIlroy:³³ Providing a balanced assessment of the success or otherwise of New Zealand's reforms is difficult. Proponents and opponents usually pick selective evidence that supports their views. Also, it is not clear how long it should take until the reforms pay off. It is therefore not surprising that the outcomes of the reforms are being hotly debated. Evans *et al.*³⁴ and Silverstone *et al.*³⁵ provide a generally positive, if cautious, assessment of the reforms. At the other end of the spectrum are Dalziel,³⁶ Gregory³⁷ and Philpott³⁸ who, judging by the evidence to date, regard the reforms as a failure.

While it is not possible to provide any conclusive answers, the following discussion highlights some of the features and paradoxes associated with the 'New Zealand Experiment'. It focuses on what we regard as some of the major indicators of the outcomes of the reforms relevant to the changes in the work force, i.e. New Zealand's poor economic growth performance, particularly its unimpressive productivity growth, structural change towards a larger 'transaction sector', changes in the income distribution, and weaknesses in New Zealand's National Innovation System and the wider institutional framework. The aim is to stimulate further discussion and research by bringing together a number of diverse literatures.

New Zealand's Poor Growth Performance

The aim of the comprehensive economic reforms since 1984 has been to improve the country's unimpressive growth performance. From being one of the richest economies in the world, New Zealand has been steadily sliding down the OECD league table. Smith and Grimes³⁹ noted that during the 1950–1984 period, New Zealand's per capita income growth was 1.47% below the OECD average (excluding Japan), and they attributed a large proportion of this dismal performance to slow growth in total factor productivity (TFP).

However, since 1984, New Zealand's growth performance has not shown the expected improvement. According to Philpott,⁴⁰ GNP per capita has only grown at the abysmal rate of 0.2% p.a. over the 1984–1999 period, a third of the 0.6% p.a. growth rate over the 1969–1984 period. To put the disappointing performance into perspective, Gregory observed that:⁴¹ 'Thirteen years after the reform process began New Zealand has lost one and a quarter years of GDP per person relative to Australia and the loss continues to grow ... Real wages in 1997 are lower than in 1974 and 1975 ...'. He finds it difficult to believe that economic growth could have been worse if there had been no economic reforms at all!

Again, much of the weak performance is likely to be attributable to a lack of productivity growth. Färe *et al.*⁴² found a quite uneven sectoral impact of TFP growth during the period 1973–1994. They report that export-oriented primary sectors had the greatest TFP increases, along with some services (e.g. telecommunications, electricity, water, gas). The manufacturing sector recorded only modest increases, while there was a fall in average TFP growth in the financial and business services sectors. This is similar to the findings of Chapple⁴³ and Philpott.⁴⁴ The shift away from the primary sector towards manufacturing and especially services is probably a major reason for the observed poor overall TFP performance.

Diewert and Lawrence come to somewhat different conclusions.⁴⁵ Their findings suggest generally poor performance during the 1970s, followed by relatively strong productivity growth during 1980–1985 and a subsequent 'plateauing' of productivity through until 1993. They also find that after 1993 there was a productivity surge and argue that this is likely to have been aided by the effects of the labour market reforms

of the early 1990s, among other things. However, they also point out the many measurement problems associated with TFP studies.

There are many issues about the impact of the reforms on productivity growth that await further research. For example, despite Diewert and Lawrence's comments, the role of labour market deregulation is not clear. By cheapening some labour inputs, it might well have led to substitution of labour for capital, reducing productivity growth. Also, labour market deregulation may have destroyed 'social cohesiveness' at the workplace, further reducing productivity growth.⁴⁶ The relative importance of these factors is, in the end, an empirical question which is so far unanswered.

It should also be noted that discussion about the success or failure of the economic reforms has largely been divorced from discussion about science and technology, R&D and innovation issues, despite the fact that reforms to the country's research, science and technology (RST) system have been as dramatic as those in other areas (see below). These issues were either not touched upon at all, or mentioned only very briefly, by Evans *et al.*, Silverstone *et al.*, Dalziel, Gregory, and Philpott. It seems economic commentators, be they proponents or opponents of the reforms, have had little to say about the knowledge economy.

Expansion of the Transaction Sector

One way to reconcile the poor growth performance of the New Zealand economy with the growth of the information work force, and particularly the rise in the number of managerial and administrative workers, is to argue that the reforms have resulted in an exaggerated growth of the transaction sector which has hindered productivity growth. The seminal study of transaction cost measurement at the economy-wide level is Wallis and North.⁴⁷ They define transaction costs as all the measurable costs associated with co-ordinating and controlling economic activity and market exchange. These costs make up the 'transaction sector'. In terms of empirical measurement, their model is similar to Porat and Rubin's information economy model.⁴⁸

Hazledine⁴⁹ argued that because New Zealand used to have a high level of social capital,⁵⁰ it used to function with a low level of transaction costs. Because the reforms since 1984 have destroyed much of the social capital, transaction costs, including managerial and administrative jobs, have exploded. According to Hazledine this has led to a massive decline in managerial productivity. However, there are empirical and theoretical considerations which suggest that Hazledine has overstated his case. Firstly, he includes all unemployed in the transaction sector work force, arguing that a pool of unemployed is necessary in a decentralised economy. But business cycle effects surely also have to be taken into account. Secondly, he does not comment on the change in occupation classification between the 1986 and 1991 census, i.e. the possibility that some of the increase in administrative and managerial workers is due to the re-classification of jobs. Thirdly, Hazledine focuses mainly on one part of the transaction sector work force, at the exclusion of others, e.g. the decline in clerical jobs.

There is confusion in the international literature, and also implicitly in Hazledine's book, about how to model the impact of the transaction sector on productivity growth. Several studies have concluded that transaction sector growth has indeed reduced productivity growth.⁵¹ Often, all 'transaction industries' are simply subtracted from GNP to obtain an adjusted measure. However, Wallis and North explicitly argued against doing this, as most transaction sector services are intermediate, not final, services.⁵² In another paper they suggested a new historical perspective on the relationship between technical and institutional change: institutions are not chosen to minimise transaction

costs, but overall costs (transaction plus transformation costs).⁵³ This opens the possibility for a more complex view of the possible sources of productivity growth.

In short, the level of resources used in the transaction sector does not necessarily allow one to draw conclusions about the efficiency of the sector. Transaction services cannot be seen as independent from material production in the sense that they can be subtracted from GNP without affecting 'real' output. In an age where economic activities are becoming increasingly less 'material' and more 'intellectual', one would have to distinguish carefully what part of a 'transaction service' really is a transformation or transaction activity. This, to the best of my knowledge, has not yet been done. Therefore, interpreting a large transaction sector *per se* as detrimental is too simplistic.

Having said that, it is now often argued that high transaction costs are the drivers of electronic commerce. In future competitive advantage will increasingly depend on reducing transaction costs through e-commerce and IT.⁵⁴ Seen from a longer-term perspective it might be that the 'high transaction cost economy' is just transitory, to be replaced by a knowledge economy which significantly economises on such costs. Further research concerning the measurement, analysis and likely development of transaction costs and their impact on the labour market is clearly indicated.

The Changing Income Distribution

The analysis of New Zealand's income distribution is a very contentious issue because it is directly related to the question of whether the reforms have delivered benefits to the general public, or just to a small section of the population. It is also hampered by data problems, probably more so than in most other OECD countries. However, the existing studies point out some of the peculiarities of the New Zealand situation, and help us to speculate about the relationship between income distribution and the growth of the information work force.

Dixon's study differs from others in that it focuses on weekly and hourly earnings instead of annual earnings.⁵⁵ Employing a number of measures, she found evidence of growing inequality between 1984 and 1997. This is similar to findings by Podder and Chatterjee for annual household gross income.⁵⁶ According to Dixon the level as well as growth of earnings inequality in New Zealand has been less than in the United States and the United Kingdom, though somewhat higher than in Australia.⁵⁷

One feature that differs from the United States and many other countries is that educational earnings differentials do not seem to have increased in New Zealand.⁵⁸ Although there was a rise in the skill premium during the 1980s,⁵⁹ it came to a halt, or even declined for some groups, during the 1990s. For example, it has been reported that the estimated income differential for a bachelor's degree peaked in 1991, and declined thereafter.⁶⁰

Another important issue is the likely impact of labour market deregulation in 1991. Dixon found that most of the increase in earnings inequality occurred during the 1986–1990 period, not after 1990, and Maloney⁶¹ could not confirm that the Employment Contracts Act (ECA) had reduced hourly earnings. These findings do not provide support for the argument that labour market deregulation and the dramatic fall in union density worsened the earnings distribution.⁶²

Since the late 1980s there have also been major tax and welfare benefit reforms in New Zealand. Top income tax rates have been cut, benefits reduced and their eligibility criteria tightened. There is evidence that this has increased the aggregate labour force participation rate by about 1.5%,⁶³ but also contributed to the overall increase in inequality.⁶⁴ Last but not least, differences between pre/post 1990 results can possibly be

explained by labour demand and supply changes, and the stage of the business cycle. Podder and Chatterjee⁶⁵ found that business cycle-induced changes in the distribution of employment across the working-age population had a much greater impact on income inequality than changes in the earnings distribution among the employed.

To sum up, there is consensus that the earnings distribution has become more unequal over time. The largest increase in earnings inequality coincided with the large increase in high-skilled information occupations during the second half of the 1980s. This supports the view that the changes observed in the composition of the information work force between 1986 and 1991 may be a reflection of actual work force changes, rather than of occupation classification changes.

It is also useful to list factors that may have *reduced* the dispersion of earnings since 1984 in order to appreciate the peculiarities of the New Zealand situation. Dixon mentions shifts in the composition of employment as possible factors:⁶⁶ (a) a strong decline (from 27.4% in 1984 to 19.5% in 1997) in the employment share of younger people (15–24 year olds) who have relatively low earnings; (b) a rise in the share of female employment, from 42.4% in 1984 to 48% in 1997 (female earnings are less dispersed than males).

Another factor counteracting earnings inequality may have been changes in the skill composition of international trade. A major aim of the economic reforms has been to open up the economy so as to integrate it with the global economy. The exchange rate was floated, trade barriers and subsidies have been reduced or completely eliminated, international capital movements into and out of New Zealand have grown substantially. A recent study by Deardoff and Lattimore, which estimates the factor content of New Zealand's trade for 1986 and 1996, suggests that the reforms increased the 'gains from trade' for workers with low qualifications and reduced them for higher qualified workers.⁶⁷ These results do not support the view that trade has led to a worsening in the distribution of income in New Zealand over recent decades. Instead, it is likely to have *improved* the wages of less-skilled workers.

These findings raise some interesting questions in regard to the stated aim of New Zealand policy-makers to develop a knowledge economy that has competitive advantages in skill-intensive sectors. If currently the tradable sector is not intensive in the use of labour with degrees or advanced tertiary training, how can new competitive advantages in knowledge-intensive sectors be created more or less from scratch? And how can it be done without worsening the relative position of the still large proportion of the labour force that is relatively unskilled? On balance, development of a knowledge-based economy might further widen the dispersion of earnings. Will this require a renewed emphasis on the welfare state during a possibly long transition period?

The 'National Innovation System' and the Wider Institutional Framework

Another feature of New Zealand's economy is its low total R&D expenditure. The latest statistics (for 1997–1998) show that it has risen to 1.1% of GDP, whereas the OECD average is 2.1%.⁶⁸ The main reason is low business R&D expenditure (0.32% of GDP in 1997–1998, compared to the OECD average of about 1.5%). Government R&D funding continues to count for more than half of all R&D spending. Business sector R&D focuses on secondary industry and services; government R&D focuses mainly on primary production. It is also noteworthy that, while the proportion of high-tech R&D spending in the manufacturing sector increased significantly in recent years, now accounting for 22% of R&D expenditure in manufacturing, R&D expenditure as a

proportion of sales of manufactured products was only 0.37% in 1997–1998, compared to the 6.6% OECD average.⁶⁹

There is as yet no comprehensive study of New Zealand's National Innovation System (NIS). In recent years government agencies have made some efforts to measure and analyse specific elements, but not the NIS as a whole, and major gaps remain. Engelbrecht and Darroch provide a review of this literature and a snapshot of New Zealand's macro-level NIS in comparison to that of other OECD countries.⁷⁰ They conclude that New Zealand seems to have a weak NIS, ranking very low on most indicators, despite drastic reforms to its RST system since the late 1980s, and despite its openness to foreign direct investment (FDI).⁷¹

With the government's belated 'discovery' of the knowledge economy and society, reforms of the RST system are continuing. After an extensive foresight exercise, the public RST funding system is to change again, and the government is making some effort to encourage the development of a highly skilled science and technology work force, including a new 'New Economy Research Fund', a business incubator programme, some elite science scholarships, and some so far minor tinkering with the student loan scheme.⁷² New Zealand is to develop mostly the same high-tech industries as other OECD countries, i.e. IT, biotechnology, advanced materials. There is to be a change in culture, and scientists are to be empowered.

There is little critical reflection on what contribution the RST system can make to the development of new competitive advantages, and little or no discussion of the mix and complementarity of institutions necessary to achieve this.⁷³ The view that the science system has to be re-oriented to more directly affect technology and growth seems too simplistic.⁷⁴ It can be argued that the distinction between blue-sky and more immediately economically useful research is largely spurious, and that academic research should not be made the scapegoat for shortcomings in other parts of the NIS.⁷⁵ Daniels⁷⁶ reports the belief that international trade competitiveness in technology-intensive (TI) production is a source of national economic welfare gains has received little empirical attention in the literature. His findings suggest that the association is neither strong nor consistent.⁷⁷

What are the implications of the knowledge economy push for an economy that currently has competitive advantages mainly in natural resource-based production, not only for the RST system, but also for FDI policies, education policies, labour market institutions and industrial relations, the education and training system? Are the current institutional arrangements likely to be conducive to such a push? What are the possibly contradictory effects, how can they be overcome? There is an urgent need for studies of New Zealand's NIS and the wider institutional framework. Simplistic notions of success in the knowledge economy are dangerous. A sophisticated policy response is needed for a sophisticated knowledge economy. It remains to be seen whether the centre-left Labour/Alliance government elected in late 1999 will address these issues.

Concluding Comments: What Policies for the Knowledge Economy?

This study has documented the shift towards a high-skilled information work force in New Zealand during a period of tumultuous economic and social change. In some respects the work force data are encouraging, but their interpretation remains controversial, and there are many gaps in our knowledge that await further research. The occupation approach adopted in this study should be extended to enable further analysis of the knowledge economy. For example, one could investigate occupation groups by industry to highlight changes in industry structure in terms of information worker

intensity. We also need measures of human capital that go beyond simply 'counting heads'.

A major ingredient of success in a knowledge economy is a well-trained, flexible and innovative work force. There is an ongoing need for research on the determinants of participation in post-compulsory education, and continued monitoring of the funding mechanisms of education.⁷⁸ Despite the fact that by 1996 the relative size of New Zealand's information work force was similar to that of the United States, there is a need to develop and sustain a highly skilled science and technology work force.

A major area of research usually associated with the growth of the information work force that has not been addressed in this study is skill-biased technological change and the impact of Information Technology (IT). The main reason is lack of New Zealand data. However, the topic clearly requires further research. Without it, we cannot determine to what extent the work force changes have been due to technological change and/or the reforms. Suffice to say that the international evidence concerning the role of IT is far from clear-cut. Focusing on the United States, there seems to be a positive correlation between the use of computers on the one hand and wages,⁷⁹ skilled labour, and skill-upgrading on the other hand.⁸⁰ However, it is not clear what the causal relationships are. Others have argued that there is little complementarity between highly skilled workers and the use of computers,⁸¹ and that IT has not led to technical change (as commonly understood by economists to mean a shift in the production function), but to input substitution.⁸²

Also, advocates of the knowledge economy often invoke 'new growth theory', which endogenises the role of knowledge in economic growth, in support of their arguments. However, little acknowledgement is usually given to the fact that the micro-economic policy implications of new growth theory are far from settled.⁸³ This is partly due to the fact that key concepts associated with the term knowledge economy are so difficult to measure.⁸⁴

Resolution of these issues may have profound implications for economic policy. However, until they are resolved it is difficult to know what economic policies a government should pursue to foster development of the knowledge economy. A return to old-fashioned Keynesian policies, as for example advocated by Philpott,⁸⁵ is unlikely to be successful, and neither is a continuation of the 'hands-off' policies relying on 'level-playing fields' that have characterised New Zealand government policies from the mid 1980s until very recently.

Stiglitz has pointed out some of the challenges facing public policy in a knowledge economy.⁸⁶ The peculiar characteristics of knowledge have to be taken into account, especially the existence of extensive externalities. He emphasises the need for government policy to identify projects that result in externality-generating innovations. Also, there are real dangers to competition in a knowledge economy, and a tendency to under-appreciate the importance of basic research. Competition laws and intellectual property regimes need to be re-examined.⁸⁷ He continues:

The fact that knowledge is, in central ways, a public good and that there are important externalities means that exclusive or excessive reliance on the market may not result in economic efficiency. For those of us who believe in the power of market forces, the challenge is to find the best 'partnership' between the private and public sector—an assignment of roles and responsibilities not dictated by the paradigms of the past that are unsuited to the knowledge economy of the future ... simple slogans ('picking winners') will not get us very far. We are all in uncharted territories, ...⁸⁸

Stiglitz also emphasises the organisational dimensions of the knowledge economy.

Knowledge sharing depends on trust, i.e. social capital. In the New Zealand context it is legitimate to ask whether the industrial relations framework is likely to be appropriate for the development of a high productivity knowledge-based economy. Have the labour market and public sector reforms resulted in corporate cultures that, to borrow from Stiglitz,⁸⁹ encourage 'vicious circle[s] of knowledge restriction instead of ... virtuous circle[s] of knowledge sharing'? Will the recent abolition of the ECA and adoption of a new industrial relations framework be able to meet the challenges of the knowledge economy?

In the age of the largely unknown knowledge economy new policy approaches are required and the whole institutional matrix of a country has to be assessed. There are many possible futures. Too often, discussion seems to be based on technological or economic determinism. This raises the spectre of a new TINA (There Is No Alternative) syndrome, which would greatly hinder and impoverish the policy debate.

Appendix: Occupation Data

There have been major changes between the 1968 International Standard Classification of Occupations (ISCO) and the 1988 ISCO. The latter groups occupations by skill level, and is therefore better suited for addressing questions concerning trends in higher-skilled versus lower-skilled information workers, whereas the 1968 classification is task based, i.e. it groups together occupations that perform similar types of work. In New Zealand the 1988 ISCO was first used in the 1991 census. There are difficulties in comparing some major occupation groups pre/post 1991. For example, more managerial classifications were introduced in 1991, and a certain number of clerical jobs are likely to have been re-classified as managerial, though the extent of this is difficult to determine (Statistics New Zealand, personal communication).

An earlier change in the classification of occupation data occurred between 1981 and 1986. For 1976 and 1981, the New Zealand work force comprises all persons 15 years of age and over who were normally employed for 20 hours or more each week.⁹⁰ From 1986 onwards, only people who worked 30 hours or more were counted as full-time.⁹¹ We do not correct our full-time occupation data for this, as part-time employment prior to 1986 was relatively low. If this has introduced a bias, it should result in a slight overstatement of the full-time information workforce for the earlier years. Our estimates of the part-time information work force are for 1986, 1991 and 1996 only, because of the change in the definition of part-time/full-time between 1981 and 1986. Moreover, the 1976 census data only identify persons in full-time employment.

In order to increase comparability of our estimates across census years the list of information occupations identified by Conway⁹² was modified. The combined effect of the changes made turned out to be relatively minor: The proportion of the information work force in the total classified work force in 1976 falls slightly from 35.9% to 34.6%. The major differences between Conway's and our classification are the exclusion of supervisors, and the inclusion of all sales representatives.⁹³

The information occupations have been selected from four-digit occupation data for each census. The total number of occupation groups identified in the census has been greatly reduced over time, from 1,155 in 1968 to 560 in 1996. For a detailed comparison of the New Zealand classifications see Statistics New Zealand.⁹⁴ The complete 1996 list of 112 information occupations identified from the New Zealand Standard Classification of Occupations 1995 is provided elsewhere.⁹⁵

Notes and References

1. There are three appendices. Only a shortened version of Appendix A is provided in this paper. Its longer version, as well as Appendices B and C, are available from H.-J. Engelbrecht, *Changes in the Information Work Force of a Strongly Reforming Economy: The Case of New Zealand 1976–1996*, Discussion Paper No. 00.07, Department of Applied and International Economics, Massey University, May 2000 <<http://econ.massey.ac.nz/discuss.html>>. Appendix B contains detailed data tables for the five years for which the full-time information work force has been derived from census data. Appendix C reports similar tables for the three years for which the part-time information work force has been calculated.
2. Fritz Machlup, *The Production and Distribution of Knowledge in the United States*, Princeton University Press, Princeton, NJ, 1962.
3. Marc U. Porat and Michael R. Rubin, *The Information Economy* (in 9 volumes), Government Printing Office, Washington, DC, 1977.
4. For a discussion of Machlup's and Porat and Rubin's approaches, and the subsequent literature related to the measurement of the information economy, see H.-J. Engelbrecht, 'A comparison and critical assessment of Porat and Rubin's *Information Economy* and Wallis and North's *Transaction Sector*', *Information Economics and Policy*, 9, 4, 1997, pp. 271–90.
5. OECD, *Information Activities, Electronics and Telecommunications Technologies: Impact on Employment, Growth and Trade*, Volume 1, OECD, Paris, 1981, pp. 22–23.
6. OECD, *Trends in the Information Economy*, ICCP Report No. 11, OECD, Paris, 1986.
7. J. R. Schement, 'Porat, Bell, and the information society reconsidered: The growth of information work in the early twentieth century', *Information Processing & Management*, 26, 4, 1990, pp. 449–65.
8. S. B. Martin, 'Information technology, employment, and the information sector: Trends in information employment 1970–1995', *Journal of the American Society for Information Science*, 49, 12, 1998, pp. 1053–1069; S. B. Martin, 'Employment in the information age', *INFO*, 1, 3, 1999, pp. 271–83.
9. Michael Conway, 'Information occupations: The new dominant in the New Zealand work force', in Communications Policy Research Group, Commission for the Future (eds), *Network New Zealand Working Papers*, Paper No. 2, May 1981.
10. N. Parrot and P. Forer, 'The information sector in New Zealand 1971–1981', *New Zealand Geographer*, 42, 1, 1986, pp. 25–30.
11. N. Karunaratne and A. Cameron, 'The New Zealand information economy and regional cooperation', in M. Jussawalla, D. Lamberton and N. Karunaratne (eds), *The Cost of Thinking: Information Economies of Ten Pacific Countries*, Ablex Publishing Corporation, Norwood, NJ, 1988, pp. 217–26.
12. In many respects this statement applied for more than another quarter century, i.e. until the recent, and belated, emphasis on the knowledge economy.
13. Howard Frederick and Don McIlroy, *The Knowledge Economy*, The New Zealand Internet Institute, Wellington, 1999 (available from <<http://www.knowledge.gen.nz>> and <<http://www.moc.govt.nz/itag/publish.htm>>).
14. Herbert S. Dordick, *Information Technology & Economic Growth in NZ*, Victoria University Press for the Institute of Policy Studies, Wellington, 1987.
15. Frederick and McIlroy, *op. cit.*, p. 15.
16. *Ibid.*, p. 30.
17. Dordick, *op. cit.*, p. 12.
18. *Ibid.*, p. 76.
19. Although Conway's (*op. cit.*, p. 13) estimates for earlier years are not fully comparable to ours, the change over the previous 20 years seems to have been similar. His estimates of the full-time information work force were: 25.7% in 1956; 28.9% in 1961; 30.3% in 1966; 33.7% in 1971; and 35.9% in 1976.
20. For example, using the simpler approach, Dordick (*op. cit.*, p. 17) reported that in 1983, 44.6% of the New Zealand work force was comprised of information workers. This compares to our estimates of 35.0% in 1981 and 38.3% in 1986. There is also a large discrepancy between our estimates and those supplied by New Zealand to the OECD (1986, *op. cit.*, Table 1, p. 8). The latter are substantially higher (39.4% in 1976, 39.8% in 1981).

21. A. Bascand and R. Clements, 'The effects of restructuring on employment: 1985–89', *Reserve Bank Bulletin*, 52, 2, 1989, pp. 124–26.
22. Using data for the June quarter of each year, the unemployment rate was 2.8% in 1981, 4% in 1986, 10.1% in 1991, and 6.1% in 1996 (P. Dalziel and R. Lattimore, *The New Zealand Macroeconomy: A Briefing on the Reforms*, 3rd edn, Oxford University Press, Auckland, 1999, p. 131).
23. L. Margherio, D. Henry, S. Cooke, S. Montes and K. Hughes, *The Emerging Digital Economy*, Secretariat on Electronic Commerce, US Department of Commerce, Washington, DC, 1998. See <<http://www.ecommerce.gov>>.
24. Frank March, *Statistics on Information Technology in New Zealand*, IT Policy Group, Ministry of Commerce, Wellington, 1999, p. 14. This proportion was the same as in 1991. See March for the definition of IT occupations in the New Zealand context. In the United States, aggregate IT employment has similarly changed little, although employment in IT industries is forecast to grow twice as fast as that in other industries between 1996 and 2006 (Margherio *et al.*, *op. cit.*, pp. A1–9).
25. Martin (1998, *op. cit.*, Table 3, p. 1057). She used Porat and Rubin's (*op. cit.*) more restrictive definition of information workers, which is similar to what has been done in this study. When the wider definition is used information occupations accounted for more than 50% of the US workforce by the mid to late 1970s (see e.g., Porat and Rubin, *op. cit.*, Vol. 1, p. 119, and R. Kling, 'More information, better jobs?: Occupational stratification and labor-market segmentation in the United States' information labor force', *Information Society*, 7, 2, 1990, pp. 77–107).
26. Kling, *op. cit.*
27. Y. Dunlop and P. Sheehan, 'Technology, skills and the changing nature of work', in P. Sheehan and G. Tegart (eds), *Working for the Future: Technology and Employment in the Global Knowledge Economy*, Victoria University Press, Melbourne, 1998, pp. 201–52.
28. The potential importance of the classification change, in particular for the proportion of clerical workers, is discussed below for the New Zealand case. One may wonder whether Kling's conclusions would need to be modified if his occupation data were re-classified according to the now common skill-based approach.
29. Martin (1998, *op. cit.*, p. 1058) noted that changes were concentrated in a narrow range of information occupations. Growth was strongest in the most non-routine information handling occupations, while losses were heaviest in the most routine information handling occupations. The share of all other types of information occupations was fairly constant. Martin favoured technological unemployment as the theory to explain these changes.
30. Peter Davis, Keith McLeod, Miriam Ransom and Patrick Ongley, *The New Zealand Socioeconomic Index of Occupational Status (NZSEI)*, Research Report No. 2, Statistics New Zealand, Wellington, 1997.
31. The findings do not necessarily contradict Kling's (*op. cit.*) emphasis on the importance of clerical jobs. In 1981 the proportion of clerical workers in the total New Zealand information work force was higher than that reported by Kling for the United States in 1980 (44.7% compared to 39.5%).
32. Richard Willis, 'Ten years of change in New Zealand manufacturing employment', in P. S. Morrison (ed.), *Labour, Employment and Work in New Zealand 1994, Proceedings of the Sixth Conference*, 24–25 November 1994, Victoria University of Wellington, Wellington, 1995, pp. 344–55.
33. *Op. cit.*
34. L. Evans, A. Grimes and B. Wilkinson with D. Teece, 'Economic reform in New Zealand 1984–95: The pursuit of efficiency', *Journal of Economic Literature*, XXXIV, 4, 1996, pp. 1856–1902.
35. B. Silverstone, A. Bollard and R. Lattimore, *A Study of Economic Reform: The Case of New Zealand*, Elsevier Science, Amsterdam, 1996.
36. Paul Dalziel, 'New Zealand's Economic Reform Programme was a Failure', mimeo, Department of Economics, University of Canterbury, Christchurch, 1999. (also available from <<http://www.economic-myth-busters.org.nz>>).
37. Robert Gregory, 'Labour market outcomes in the UK, NZ, Australia and the US: Observations on the impact of labour market and economic reforms', *Discussion Paper No. 401*, Centre for Economic Policy Research, Australian National University, Canberra, 1999.
38. Brian Philpott, 'New Zealand structural policies: Outcomes for the last fifteen years and new directions for the next', *Paper 295*, Research Project on Economic Planning, School of Economics and Finance, Victoria University of Wellington, Wellington, 1999.

39. Richard Smith and Arthur Grimes, 'Sources of economic growth', *Reserve Bank Bulletin*, 53, 2, 1990, pp. 140–48.
40. Philpott, 1999, *op. cit.*
41. Gregory, *op. cit.*, pp. 10, 16. See also Dalziel (*op. cit.*), who provides a similar comparison. Gregory (*op. cit.*, p. 18) states that 'New Zealand presents us with the largest puzzle ... What could have been done better? The need to understand what happened in New Zealand is fundamental. After all the reforms there were consistent with the advice emanating from the World Bank, the IMF, the OECD and most economists'.
42. R. Färe, S. Grosskopf and D. Margaritis, 'Productivity growth', in B. Silverstone, A. Bollard and R. Lattimore, *A Study of Economic Reform: The Case of New Zealand*, Elsevier Science, Amsterdam, 1996, pp. 73–100.
43. Simon Chapple, 'Searching for the Heffalump? An exploration into sectoral productivity & growth in New Zealand', *Working Paper 94/10*, New Zealand Institute of Economic Research, Wellington, 1994.
44. Brian Philpott, 'New Zealand's aggregate and sectoral productivity growth 1960–95', *Paper 274*, Research Project on Economic Planning, School of Economics and Finance, Victoria University of Wellington, Wellington, 1995.
45. Erwin Diewert and Denis Lawrence, 'Measuring New Zealand's productivity', *New Zealand Treasury Working Paper 99–5*, Wellington, 1999, p. xx (available at <<http://www.treasury.govt.nz/workingpapers/99-5.htm>>).
46. See Tim Hazledine, *Taking New Zealand Seriously: The Economics of Decency*, Harper Collins New Zealand, Auckland, 1998, pp. 110–17.
47. J. Wallis and D. North, 'Measuring the transaction sector in the American economy, 1870–1970', in S. Engerman and R. Gallman (eds), *Long-Term Factors in American Economic Growth*, NBER Studies in Income and Wealth No. 51, University of Chicago Press, Chicago, 1986, pp. 95–148.
48. See Engelbrecht, *op. cit.*, 1997.
49. Hazledine, *op. cit.*, pp. 118–26.
50. Social capital is defined as the social structure which facilitates co-ordination and co-operation, i.e. trust and loyalty, the empathy and sympathy found in relationships between people.
51. See Engelbrecht (*op. cit.*, 1997) for further details.
52. J. Wallis and D. North, 'Should transaction costs be subtracted from gross national product?', *Journal of Economic History*, XLVII, 3, 1988, pp. 651–54.
53. D. North and J. Wallis, 'Integrating institutional change and technical change in economic history: A transaction cost approach', *Journal of Institutional and Theoretical Economics*, 150, 1994, pp. 609–24.
54. See, for example, L. Garcia, 'Networked commerce: Public policy issues in a deregulated communication environment', *Information Society*, 13, 1, 1997, pp. 17–31.
55. S. Dixon, 'Growth in the dispersion of earnings: 1984–97', *Labour Market Bulletin*, 1&2, 1998, pp. 71–107.
56. N. Podder and S. Chatterjee, 'Sharing the national cake in post reform New Zealand: Income inequality trends in terms of income sources', Discussion Paper, Social Policy Research Centre, Massey University, Palmerston North, 1998. Their findings for total income inequality are stronger than those reported in studies investigating the distribution of earnings (wages and salaries). They report that over the period 1984–1996, the bottom 80% of New Zealand income recipients suffered a reduction in their share of total incomes paid out, while the top 5% realised a 25% gain.
57. Dixon, *op. cit.*, p. 84.
58. *Ibid.*
59. S. A. Maani, *Investing in Minds: The Economics of Higher Education in New Zealand*, Institute of Policy Studies, Wellington, 1997.
60. R. Winkelmann, 'The economic benefits of schooling in New Zealand: Comment and update', *New Zealand Economic Papers*, 32, 2, 1998, pp. 187–95.
61. T. Maloney, 'Has New Zealand's *Employment Contracts Act* increased employment and reduced wages?', *Australian Economic Papers*, 36, 1997, pp. 243–64.

62. Union density, i.e. the percentage of the total work force that belongs to unions, fell from 43.5% in 1985 to 19.9% in 1996 (Statistics New Zealand, *New Zealand Official Yearbook 1998*, GP Publications, Wellington, 1998, p. 323). Maloney's (*op. cit.*, 1997) results suggest that this was overwhelmingly due to the introduction of the ECA.
63. T. Maloney, 'The impact of recent welfare reforms on labour supply behaviour in New Zealand', *Working Paper No. 180*, Department of Economics, University of Auckland, 1998.
64. B. Easton, 'Income distribution', in B. Silverstone, A. Bollard and R. Lattimore, *A Study of Economic Reform: The Case of New Zealand*, Elsevier Science, Amsterdam, 1996, pp. 101–38.
65. *Op. cit.*
66. Dixon, *op. cit.*, p. 88.
67. A. Deardoff and R. Lattimore, 'Trade and factor market effects of New Zealand's reforms—revisited', *New Zealand Economic Papers*, 33, 2, 1999, pp. 81–86.
68. However, it increased on average 6.2% per year from 1990–1991 to 1997–1998, which is one of the highest growth rates in the OECD [Ministry of Research, Science & Technology, *New Zealand Research and Development Statistics 1997/98*, Publication No. 17, Wellington, 1999a (see <<http://www.morst.govt.nz>>)]. Consistent and internationally comparable R&D statistics for New Zealand are only available from 1989 to 1990 onwards (biannually since 1991–1992).
69. *Ibid.*, pp. 2, 14.
70. H.-J. Engelbrecht and J. Darroch, 'A comparative macro-level assessment of New Zealand's "National Innovation System"', *Prometheus*, 17, 3, 1999, pp. 283–98.
71. For a discussion of the reforms of the RST system see P. Winsley and L. Hammond, 'Policies for transforming the science and innovation system in New Zealand: 1988–1997', *Prometheus*, 15, 2, 1997, pp. 267–78; and P. Winsley, P. Couchman and D. Gilbertson, 'Future development of New Zealand's science and technology system', *Prometheus*, 16, 1, 1998, pp. 57–68. In contrast to Ireland, which is seen by some commentators as an example of what could be achieved in New Zealand, FDI has been mainly 'brown field', i.e. taking over and modernising existing enterprises, rather than green field, and less directed into sectors where New Zealand does not (yet) have a competitive advantage.
72. See, for example, Ministry of Research, Science & Technology, *Blueprint for Change: Government's Policies and Procedures for its Research, Science and Technology Investments*, Wellington, 1999; Ministry of Research, Science & Technology, *Bright Future: Making Ideas Work for New Zealand*, Wellington, 1999; Ministry of Research, Science & Technology, *Briefing for Incoming Minister*, Wellington, 1999 (all available from <<http://www.morst.govt.nz>>).
73. The latter broadens the NIS perspective and arguably goes beyond it. On this point, see J. Howells and J. Roberts, 'From innovation systems to knowledge systems', *Prometheus*, 18, 1, 2000, pp. 17–31.
74. P. Pavitt, 'The social shaping of the national science base', *Science Policy Research Unit Electronic Working Paper No. 5*, University of Sussex, 1997.
75. *Ibid.*, pp. 26–27.
76. P. Daniels, 'Economic gains from technology-intensive trade: An empirical assessment', *Cambridge Journal of Economics*, 23, 4, 1999, pp. 427–47.
77. Daniels (*ibid.*, p. 443) suggests several potential explanations for this: it is possible that TI trade does not have a positive impact on economic performance 'owing to foreign ownership of the domestic TI sector and international income flows, less favourable (than assumed) price, income and demand elasticities of TI sector output, adverse terms of trade and offsetting welfare impacts of TI trade success, limited skilled labour requirements or learning economies, or the relative isolation of the TI export sector and minimal inter-industry linkages and a low incidence of spillovers into other domestic production sectors'.
78. Maani, *op. cit.*
79. A. Krueger, 'How computers have changed the wage structure: Evidence from microdata, 1984–1989', *Quarterly Journal of Economics*, CVIII, 1, 1993, pp. 33–60.
80. D. Autor, L. Katz and A. Krueger, 'Computing inequality: Have computers changed the labor market?', *Quarterly Journal of Economics*, CXIII, 4, 1998, pp. 1169–1213.

81. T. Bresnahan, 'Computerisation and wage dispersion: An analytical reinterpretation', *Economic Journal*, 109, 1999, pp. F390–F415.
82. D. Jorgenson and K. Stiroh, 'Information technology and growth', *American Economic Review*, 89, 2, 1999, pp. 109–15.
83. See, for example, Peter Howitt (ed.), *The Implications of Knowledge-Based Growth for Micro-Economic Policies*, The University of Calgary Press, Calgary, 1996; P. Aghion and P. Howitt, *Endogenous Growth Theory*, MIT Press, Cambridge, MA, 1998.
84. For example, Howitt (*op. cit.*, p. 10) notes that 'we have no generally accepted empirical measures of such key theoretical concepts as the stock of technological knowledge, human capital, the resource cost of knowledge acquisition, the rate of innovation or the rate of obsolescence of old knowledge'. See also Aghion and Howitt (*op. cit.*, pp. 435–41).
85. Philpott, 1999, *op. cit.*
86. Joseph Stiglitz, *Public Policy for a Knowledge Economy*, speech delivered to the Department of Trade and Industry and Centre for Economic Policy Research, London, 27 January 1999 (<<http://www.worldbank.org/html/extdr/extme/jssp012799a.htm> >).
87. *Ibid.*, pp. 22–23.
88. *Ibid.*, p. 26.
89. *Ibid.*, p. 13.
90. Department of Statistics, 1980, 1983, *op. cit.*
91. Department of Statistics, 1988, *op. cit.*
92. Conway, 1981, *op. cit.*
93. See Engelbrecht (2000, *op. cit.*) for further details.
94. Statistics New Zealand, *New Zealand Standard Classification of Occupations 1995*, Wellington, 1995, pp. 9–14.
95. Engelbrecht, 2000, *op. cit.*, Appendix A.