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Gender and the Information Work Force: New Zealand Evidence and Issues[1]

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ABSTRACT *This paper documents the growth and gender composition of New Zealand's information work force over the period 1976–96. By 1996, about 55% of the female work force was employed in information occupations, compared to 40% of the male work force. The share of high-skilled information workers increased substantially over time, and faster for females than males. This suggests faster upskilling of the female information work force. The paper also briefly comments on some related, but much narrower, 'knowledge worker' concepts, and on some of the problems encountered if one wants to relate the work force measures to endogenous growth theory. The concluding comments provide a wish list of further research.*

Keywords: information workers, gender, the knowledge economy, New Zealand.

Introduction

The concepts of the 'knowledge economy' and 'knowledge society' have recently come to the forefront of policy debate in New Zealand (henceforth NZ).[2] However, it tends to be forgotten that there is a long history of the analysis of changes towards an information or knowledge-based economy which predates much of the recent hype about the knowledge economy and related (but mostly narrower) concepts, like the 'new', the 'weightless', the 'digital', the 'Internet'-economy, etc.[3]

The standard evidence used to document the size and growth of the information economy is the proportion of 'information workers' in the labour force.[4] Some of the seminal earlier studies for the US that analysed the fundamental shift in the labour force away from manual work towards information/knowledge work are Machlup, and Porat and Rubin.[5] Many OECD studies were also devoted to these changes. US data on information workers have recently been updated by Martin.[6] Earlier NZ studies include that by Conway and Dordick.[7]

This study focuses on the measurement of NZ's information work force by gender, thereby extending an earlier paper that did not analyse gender-specific changes and issues.[8] The earlier paper reported that NZ's information work force

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had increased greatly in size over the period 1976–1996. The major economic reforms implemented since 1984 seem to have led to a dramatic restructuring of the country's information work force. From considerably lagging behind the US in terms of the relative size of its information work force, NZ now seems to have caught up with the US in that respect. This somewhat surprising finding raises questions about the meaning of the term 'knowledge economy', especially given the patchy productivity growth performance of the NZ economy, its seemingly weak National Innovation System, etc. It would be simplistic to assume that there is only one kind of knowledge economy, i.e. that of the high productivity, high wage, high-tech variety. However, such questions are beyond the scope of this paper.[9]

After discussing the changes in NZ's information work force, comments are provided on some related, but much narrower, 'knowledge worker' concepts, i.e. the workers of the 'digital' economy and R&D personnel, and on some of the problems encountered if one wants to relate the work force measures to endogenous growth theory. The concluding comments suggest a number of directions for further research into gender-specific information work force issues. The selection of information occupations and other data issues were discussed in the earlier paper.[10] Information occupations have been selected from four-digit census occupation data.

Information Work Force Changes

Like its companion paper, this study broadly follows the OECD's inventory of information occupations, which was also used by Conway.[11] 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.[12] However, subjective choices and compromises are always involved in the delineation of the information work force. The approach taken was to modify, where appropriate, the list of information occupations identified by Conway in order to increase comparability of the estimates over the 1976–96 period.

Growth of the Information Work Force

Before reporting the gender-specific estimates, it is useful to provide aggregate data on the growth of information occupations in NZ (see Table 1). The estimates are more conservative, i.e. lower, than those of others for some of the earlier years.[13] Also, percentages for 1991 are likely to be overstated, due to the high level of unemployment that year, which seems to have affected information workers less than other workers. It should be noted that in contrast to Conway, the unemployed are excluded from our data, i.e. the focus is on people gainfully employed.

The data in Table 1 indicate the persistent growth of NZ's information work force. Its relative size now seems very similar to that of the US.[14] In contrast to the US, the NZ information work force grew faster during the 1986–96 decade compared to 1976–86. In the past, some analysts have argued that information work force growth in NZ had come to a halt. For example, Parrot and Forer report that the information work force shrank in relative terms during the late 1970s, due to the recession at that time.[15] In contrast, the restructuring and recession of the late 1980s/early 1990s seem to have had the opposite effect, i.e. raising the growth rate of the information work force.

Table 1. The relative size of New Zealand's full-time information work force

Year	% Information workers
1956	*25.7*
1961	*28.9*
1966	*30.3*
1971	*33.7*
1976	*35.9*/34.6
1981	35.0
1986	38.3
1991	44.6
1996	45.7

Sources: The percentages for 1956–1976 shown in italics are taken from Conway, *op. cit.* The other percentages are the author's own estimates calculated from the various New Zealand Census of Population and Dwellings reports (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, *1986 New Zealand Census of Population and Dwellings, 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, 1997; Statistics New Zealand, Census 1991 4-digit occupation data, supplied on request, 1999).

The Overall Trend by Gender

Many analysts of information employment, for example Porat and Rubin, Conway, Kling, Castells and Martin, do not report data by gender, thereby missing important changes within the information work force.[16] This paper highlights some of these issues for the case of NZ.

The data in Table 2 indicate that, in absolute terms, there are fewer full-time female information workers compared to full-time male information workers. However, females are much more concentrated in information occupations compared to males. Since the mid-1980s, the majority of females in the work force have been employed in information occupations, whereas even in 1996, the percentage for males was only around 40%.

Because a change in the definition of part-time employment occurred between 1981 and 1986, part-time employment data are only reported for the years 1986, 1991 and 1996.[17] As can be seen from Table 3, part-time employment is dominated by females, both in relative as well as in absolute terms. However, for all years and for both genders, the percentage of information employment is smaller than that in the full-time work force (compare Tables 2 and 3), and has changed little over the decade 1986–96. The last column of Table 3 suggests that the higher unemployment in 1991 affected non-information part-time employment of females to a much greater extent than their information part-time employment, resulting in the large percentage of female information workers in that year (i.e. 43.1%).

Table 2. New Zealand's full-time information work force by gender

Year		Total	Information workers	% Info. workers
1976	**Male**	850,706	248,716	29.2
	Female	395,290	182,201	46.1
1981	**Male**	842,127	246,957	29.3
	Female	429,960	197,937	46.0
1986	**Male**	841,338	271,353	32.3
	Female	436,866	218,745	50.1
1991	**Male**	734,283	282,900	38.5
	Female	416,919	230,895	55.4
1996	**Male**	778,317	310,596	39.9
	Female	474,450	262,350	55.3

Sources: See Table 1.

Table 3. New Zealand's part-time information work force by gender

Year		Total	Information workers	% Info. workers
1986	**Male**	48,996	10,692	21.8
	Female	172,218	62,117	36.1
1991	**Male**	60,789	14,166	23.3
	Female	188,415	81,126	43.1
1996	**Male**	111,696	25,104	22.5
	Female	266,352	96,780	36.3

Sources: See Table 1.

Changes in Major Categories of Information Workers by Gender

The gender breakdown of the full-time information work force by major occupation groups is reported next (Tables 4 and 5). All information workers in major groups A and B are regarded as high-skilled. The data show that these workers make up a relatively larger proportion of the male, compared to the female, information work force, though the high-skilled proportion has risen for both males and females over time (from 47.4% of the full-time male information work force in 1976 to 61.5% in 1996, and from 24.4% of the full-time female information work force in 1976 to 41% in 1996). This indicates upskilling of the NZ information work force. Clerical occupations, accounting for 70% of female information jobs in 1976, are still the largest occupation group for females, but its relative size seems to be shrinking rapidly, down to 42% in 1996.

To summarize, while full-time information occupations make up a larger proportion of total full-time employment for females compared to males, males are still more concentrated in high-skilled information jobs. However, this difference has been shrinking over time, indicating relatively faster upskilling of the female

Table 4. Composition of New Zealand's full-time male information work force by major occupation group

	1976 No. (%)	1981 No. (%)	1986 No. (%)	1991 No. (%)	1996 No. (%)
A. Professional etc.	80,003 *(32.2)* ***(9.4)***	80,229 *(32.5)* ***(9.5)***	87,510 *(32.2)* ***(10.4)***	94,500 *(33.4)* ***(12.9)***	105,513 *(34.0)* ***(13.6)***
B. Administrative and managerial	37,941 (15.2) **(4.4)**	42,003 (17.0) **(5.0)**	59,889 (22.1) **(7.1)**	79,092 (28.0) **(10.8)**	84,978 (27.3) **(10.9)**
C. Clerical	67,092 (27.0) **(7.9)**	63,324 (25.7) **(7.5)**	62,076 (22.9) **(7.4)**	34,500 (12.2) **(4.7)**	39,951 (12.9) **(5.1)**
D. Sales	46,094 (18.5) **(5.4)**	42,828 (17.3) **(5.1)**	43,605 (16.1) **(5.2)**	57,459 (20.3) **(7.8)**	63,249 (20.4) **(8.1)**
E. Production	17,586 (7.1) **(2.1)**	18,573 (7.5) **(2.2)**	18,273 (6.7) **(2.2)**	17,349 (6.1) **(2.3)**	16,905 (5.4) **(2.2)**
Total information work force	248,716 (100) **(29.2)**	246,957 (100) **(29.3)**	271,353 (100) **(32.3)**	282,900 (100) **(38.5)**	310,596 (100) **(39.9)**

Note: The numbers in brackets indicate (i) percentage of the information work force, (ii) percentage of the total work force (in bold).
Sources: See Table 1.

Table 5. Composition of New Zealand's full-time female information work force by major occupation group

	1976 No. (%)	1981 No. (%)	1986 No. (%)	1991 No. (%)	1996 No. (%)
A. Professional etc.	41,552 (22.8) **(10.5)**	44,430 (22.4) **(10.3)**	48,153 (22.0) **(11.0)**	57,606 (25.0) **(13.8)**	72,573 (27.7) **(15.3)**
B. Administrative and managerial	2861 (1.6) **(0.7)**	3687 (1.9) **(0.9)**	10,371 (4.8) **(2.4)**	27,120 (11.7) **(6.5)**	34,974 (13.3) **(7.4)**
C. Clerical	127,592 (70.0) **(32.3)**	135,837 (68.6) **(31.6)**	141,378 (64.6) **(32.4)**	110,379 (47.8) **(26.5)**	110,112 (42.0) **(23.2)**
D. Sales	5797 (3.2) **(1.5)**	9066 (4.6) **(2.1)**	12,768 (5.8) **(2.9)**	31,320 (13.6) **(7.5)**	39,498 (15.0) **(8.3)**
E. Production	4399 (2.4) **(1.1)**	4917 (2.5) **(1.1)**	6075 (2.8) **(1.4)**	4470 (1.9) **(1.1)**	5193 (2.0) **(1.1)**
Total information work force	182,201 (100) **(46.1)**	197,937 (100) **(46.0)**	218,745 (100) **(50.1)**	230,895 (100) **(55.4)**	262,350 (100) **(55.3)**

Note: The numbers in brackets indicate (i) percentage of the information work force, (ii) percentage of the total work force (in bold).
Sources: See Table 1.

information work force. The more rapid growth of female earnings compared to male earnings between 1984 and 1997, which led to a reduction in the gender earnings gap,[18] is consistent with this finding.

Most of the changes among major occupation group shares between 1986 and 1991 can be explained by the economic reforms, the severe recession of the late 1980s/early 1990s, as well as deregulation of the financial sector and other policy changes. However, some of the changes may also reflect the re-classification of managerial and clerical occupations.[19]

Changes among major occupation groups are less pronounced for the part-time information work force, though the evidence regarding upskilling differs markedly from that for full-time workers. Similar to full-time employment, the high-skilled groups A and B make up the majority of part-time male information employment, in contrast to female part-time employment (see Tables 6 and 7). However, there seems to have been relative deskilling of male part-time employment. The combined share of occupation groups A and B has fallen from 63% in 1986 to 54.5% in 1996. In contrast, the share of high-skilled part-time occupations for females has increased from 31.2% in 1986 to 37.8% in 1996, although the majority of female part-time information jobs are still in the clerical group, and the extent of upskilling seems much less than for full-time female information workers.

The Information Work Force and New Growth Theory

NZ's information work force has grown steadily over time, approaching half of the total work force, and its composition has changed greatly. This phenomenon should not be confused with changes in other, much narrower and sometimes overlapping, sub-categories of the information work force.

Table 6. Composition of New Zealand's part-time male information work force by major occupation group

	1986 **No. (%)**	**1991** **No. (%)**	**1996** **No. (%)**
A. Professional etc.	4125 (38.6) **(8.4)**	6177 (43.6) **(10.2)**	9735 (38.8) **(8.7)**
B. Administrative and managerial	2613 (24.4) **(5.3)**	2166 (15.3) **(3.6)**	3948 (15.7) **(3.5)**
C. Clerical	2373 (22.2) **(4.9)**	2763 (19.5) **(4.5)**	6042 (24.1) **(5.4)**
D. Sales	1179 (11.0) **(2.4)**	2361 (16.7) **(3.9)**	4203 (16.7) **(3.8)**
E. Production	402 (3.8) **(0.8)**	699 (4.9) **(1.1)**	1176 (4.7) **(1.1)**
Total	10,692 (100) **(21.8)**	14,166 (100) **(23.3)**	25,104 (100) **(22.5)**

Note: The numbers in brackets indicate (i) the percentage of the part-time information work force, (ii) the percentage of the total part-time work force (in bold).
Sources: See Table 1.

Table 7. Composition of New Zealand's part-time female information work force by major occupation group

	1986 No. (%)	1991 No. (%)	1996 No. (%)
A. Professional etc.	16,491 (26.5) **(9.6)**	27,945 (34.5) **(14.8)**	29,610 (30.6) **(11.1)**
B. Administrative and managerial	2886 (4.7) **(1.7)**	4716 (5.8) **(2.5)**	7023 (7.2) **(2.6)**
C. Clerical	39,432 (63.5) **(22.9)**	42,375 (52.2) **(22.5)**	50,715 (52.4) **(19.0)**
D. Sales	2387 (3.8) **(1.4)**	5202 (6.4) **(2.8)**	8109 (8.4) **(3.1)**
E. Production	921 (1.5) **(0.5)**	888 (1.1) **(0.5)**	1323 (1.4) **(0.5)**
Total	62,117 (100) **(36.1)**	81,126 (100) **(43.1)**	96,780 (100) **(36.3)**

Note: The numbers in brackets indicate (i) the percentage of the part-time information work force, (ii) the percentage of the total part-time work force (in bold).
Sources: See Table 1.

One way of looking at the 'new economy' part of the knowledge-based economy is to focus on changes in information technology (IT) occupations, i.e. changes in the work force of the 'digital economy'.[20] So far such workers make up only a small fraction of the work force, though their number is expected to grow strongly in future. It has been reported for NZ that in both 1991 and 1996, about 4% of the working population was employed in IT occupations and/or working for an IT industry company.[21] In terms of occupations, only eight are identified even at the 5-digit level, ranging from unskilled to highly skilled and managerial. Female IT workers tend to be less skilled than males.[22]

Another way of looking at the knowledge-based economy is to focus on research and development (R&D) personnel. Internationally comparable data on R&D personnel in NZ are contained in the official R&D publications. These workers make up an even smaller group than do IT workers. For example, in 1997/98 there were 12,899 full-time equivalent R&D staff, comprising researchers (including engineers), technicians and support staff, up from 10,547 in 1995/6.[23] On the other hand, a detailed study of NZ's human resources in science and technology in 1996 reported larger figures: the total number of such human resources accounted for 14.7% of the population (535,374 people); employed scientists and engineers constituted 2.98% of the total labour force (48,546 people).[24] It is not explained how these statistics relate to those given in the official NZ R&D statistics.

Changes in R&D personnel and in the digital work force capture much narrower occupation changes than does the broad measure of the information work force used in this study. Without recourse to economic theory it is not clear which work force variable should be preferred for analysing the knowledge-based economy. The choice depends on which questions are to be addressed using what model(s).[25]

However, the 'new' or 'endogenous' growth theories are currently of not much help in this matter. This is mainly due to two major problems. Firstly, there are many different types of endogenous growth models.[26] To name but two broad groups, there are 'ideas' models and 'human capital' models.[27] The former focus on knowledge or R&D embodied in the use of new capital and intermediate goods (i.e. non-labour inputs), whereas the latter focus on skills, which either solely accrue to the person investing in those skills or which can also raise the productivity of other workers. Also, depending on which human capital growth model is chosen, human capital can be approximated by a variable like R&D personnel, or it can cover a much wider group of occupations, or it can be unrelated to occupations as such.[28] Until we know which growth model, or which combination of models, applies in the case of NZ, we don't know which human capital variable(s) to focus on.

The second, and related, major problem is that the key concepts associated with the term knowledge-based economy are very difficult to measure. In short, we don't yet know what the relevant key variables are, or how to measure them appropriately. Given these circumstances, the development of public policies to foster the knowledge-based economy in NZ is particularly challenging.[29]

Concluding Comments: A Wish List of Further Research

The current study could be extended and refined in many ways, for example by focussing on the gender composition of the information work force by age groups and by ethnicity, and by analysing gender-specific aspects of unemployment, the geography of the information work force, and international migration. There is also a need for comparative international studies. For example, a study of employment in the Australian knowledge economy found less clear evidence of upskilling over the decade to 1995.[30] However, that study employed a different methodology, which did not distinguish between information and non-information workers as such.

Also, in order to refine the analysis of gender-specific differences in the participation in the information work force one should try to adjust for the inevitable inaccuracies involved in using occupation data. Kirkwood has pointed out that the occupational classification gives little indication of status within each occupation.[31] For example, females may be employed at a lower level within occupations than their male counterparts. In this context, the question arises by how much the finding of faster upskilling of the female information work force might be biased. Kirkwood also noted that full-time employed females seem to work fewer hours than males in all occupation groups (at the 1-digit level).[32] A refined measurement of the information work force by gender could be based on hours worked.

A logical next step in the analysis would be to look at changes in the information work force by industry. This would highlight changes in industry structure, for example the extent of employment changes by gender in 'high-tech' industries, and differences in information worker intensity between industries. A related approach going beyond the standard industry classification would be to estimate a revised version of Porat and Rubin's 'secondary' or 'in-house' information sector.[33]

This study, as well as the possible extensions mentioned so far, is based on selecting certain occupations as informational. It should be noted that there are

other ways of measuring work force changes towards an information or knowledge-based economy. One could try to analyse broad skill changes in the economy over time drawing on the detailed skill profile of each occupation. Using the US Dictionary of Occupational Titles (DOT),[34] researchers have been able to analyse the changing importance of different types of skills, for example cognitive, interactive and motor skills, by industry and for the whole economy.[35] Since late 1998, DOT has been superseded by O*NET (Occupational Information Network) which is more appropriate for today's information-based occupations.[36] The use of the latter as a research tool needs to be explored.

A related approach is to use longitudinal career history data to define knowledge workers and to trace their movements over time and across sectors. Using British survey data, Tomlinson used this approach and was able to measure the more intangible aspects of knowledge workers, such as learning and tacit knowledge, and trace their flow through the economy as workers changed employment.[37]

Last but not least, gender-specific differences with respect to skill-biased technological change, the impact of IT, and associated changes, need to be explored. Currently, the outcome of the debate about the productivity impact of IT and the 'new economy' in the US and elsewhere is still somewhat inconclusive.[38] However, some economists, especially those working with firm level data, have pointed out that IT is economically beneficial mostly because it facilitates complementary innovations, in particular organizational changes and investments in complementary organizational capital.[39] The current lack of appropriate data makes econometric analysis of these issues especially difficult in the case of NZ.

To give just one example of possible gender differences with respect to technological change: Hawke provides evidence from Australia that computer skills possessed by females are rewarded at a higher rate than equivalent skills possessed by males.[40] Does this imply, as the author suggests, that increasing female computer literacy might be a way of further reducing the gender wage gap? What are the other gender-specific impacts of the use of IT and associated organizational changes?

Notes and References

1. An earlier version of this paper was presented at the Ninth Conference on Labour, Employment and Work, Victoria University of Wellington, New Zealand, November 2000. All web addresses cited below were last tested on 17 February 2001.
2. See, for example, Howard Frederick and Don McIlroy, *The Knowledge Economy*, The New Zealand Internet Institute, Wellington, 1999 (<http://www.knowledge.gen.nz>); Ministry of Research, Science & Technology, *Creating a Knowledge Society*, Wellington, 2000 (<http://www.morst.govt.nz/creating/>).
3. For an assessment of the 'new economy' argument in the New Zealand case, see I. Claus and C. Smith, 'What's the "new economy"'? And has it crossed the Pacific to New Zealand?', *Reserve Bank of New Zealand Bulletin*, 63, 1, 2000, pp. 16–29 (<http://www.rbnz.govt.nz/research/bulletin/index.html>). For references to the weightless economy, see Danny Quah's webpage (<http://econ.lse.ac.uk/~dquah/>). For a discussion of the digital and Internet economy, see e.g., Erik Brynjolfsson and Brian Kahin (eds), *Understanding the Digital Economy: Data, Tools, and Research*, MIT Press, Cambridge, MA, 2000; and European Communication Council, *E-conomics: Strategies for the Digital Marketplace*, Springer, Berlin, 2000.

4. See, e.g., W. Baumol, S. A. B. Blackman and E. Wolff, 'Is the United States becoming an information economy?', in J. W. Cortada (ed.), *Rise of the Knowledge Worker*, Butterworth-Heinemann, Boston, 1998, pp. 151–64.
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7. 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; Herbert S. Dordick, *Information Technology & Economic Growth in NZ*, Victoria University Press for the Institute of Policy Studies, Wellington, 1987.
8. See H.-J. Engelbrecht, 'Towards a knowledge economy? Changes in New Zealand's information work force 1976–1996', *Prometheus*, 18, 3, 2000a, pp. 265–82.
9. *Ibid.* That paper discusses some of the features and paradoxes associated with NZ's 'economic experiment' and raises questions about policies for a knowledge economy. For a discussion of the diversity of occupational structures of 'informational' societies see, e.g., Manuel Castells, *The Rise of the Network Society*, Blackwell Publishers, Oxford, 1996 (especially chapter 4). Hodgson has discussed the possibility of different knowledge economy utopia (see Geoffrey Hodgson, *Economics & Utopia: Why the Learning Economy is not the End of History*, Routledge, London, 1999).
10. Engelbrecht, 2000a, *op. cit.* A list of the 112 occupations selected as information occupations for 1996 is available from the discussion paper version of the paper (H.-J. Engelbrecht, Discussion Paper No. 00.07, Department of Applied and International Economics, Massey University, 2000b, available at <http://econ.massey.ac.nz/discuss.html>).
11. OECD, *Information Activities, Electronics and Telecommunications Technologies: Impact on Employment, Growth and Trade*, Vol. 1, Paris, 1981; Conway, *op. cit.*
12. OECD, *op. cit.*, pp. 22–23.
13. See Engelbrecht, 2000a, *op. cit.*
14. See Martin, 1998, *op. cit.*
15. N. Parrot and P. Forer, 'The information sector in New Zealand 1971–1981', *New Zealand Geographer*, 42, 1, 1986, pp. 25–30.
16. Porat and Rubin, *op. cit.*; Conway, *op. cit.*; R. Kling, 'More information, better jobs?: Occupational stratification and labor-market segmentation in the United States' information labor force', *Information Society*, 7, 2, March 1990, pp. 77–107; Castells, *op. cit.*; Baumol *et al.*, *op. cit.*; Martin, 1998, 1999, *op. cit.*
17. Previously, part-time employment was defined as comprising all persons 15 years of age and over who were normally employed for less than 20 hours a week. This was changed to less than 30 hours a week from the 1986 Census onwards (Department of Statistics, *1986 New Zealand Census of Population and Dwellings, Labour Force – Part 1, Series C, Report 4*, Wellington, 1988).
18. See S. Dixon, 'Growth in the dispersion of earnings: 1984–97', *Labour Market Bulletin*, 1&2, 1998, pp. 71–107.
19. See the discussion in Engelbrecht, 2000a, *op. cit.*
20. See, e.g., US Department of Commerce, *Digital Economy 2000*, Washington, DC, 2000 (<http://www.esa.doc.gov/>).
21. Ministry of Economic Development, *Statistics on Information Technology in New Zealand 2000*, Information Technology Policy Group, Wellington, 2000, p. 11.
22. *Ibid.*, pp. 15–17.
23. Ministry of Research, Science & Technology, *New Zealand Research and Development Statistics 1997/98*, Publication No. 17, Wellington, 1999, p. 8/9 (<http://www.morst.govt.nz>).

24. Ministry of Research, Science & Technology, *Human Resources in Science and Technology in New Zealand*, Wellington, 1998 (<http://www.morst.govt.nz/publications/hr/index.htm>).
25. It should be noted that the broad measure of the information work force adopted in this study can be used in further economic analysis, especially when available at the industry level. See the survey in H.-J. Engelbrecht, 'The international economy, knowledge flows, and information activities', in D. Lamberton (ed.), *The New Research Frontiers of Communication Policy*, North-Holland, Amsterdam, 1997a, pp. 19–42.
26. See Philippe Aghion and Peter Howitt, *Endogenous Growth Theory*, MIT Press, Cambridge, MA, 1998.
27. P. J. Klenow, 'Ideas versus rival human capital: industry evidence on growth models', *Journal of Monetary Economics*, 42, 1998, pp. 3–23.
28. For example, a common way of measuring human capital in cross-country growth studies is to use average years of schooling or a similar education measure as proxy. Suffice to say that the empirical modeling of human capital in economic growth is controversial (see, e.g., J. Temple, Growth effects of education and social capital in the OECD countries, Economics Department Working Papers No. 263, OECD, Paris, 2000; <http://www.oecd.org/eco/wp/onlinewp.htm#2000>).
29. See the comments in Engelbrecht, 2000a, *op. cit.*, especially pp. 276–77.
30. Y. Dunlop and P. Sheehan, 'Technology, skills and the changing nature of work', in Peter Sheehan and Greg Tegart (eds), *Working for the Future: Technology and Employment in the Global Knowledge Economy*, Victoria University Press, Melbourne, 1998, pp. 201–52.
31. H. Kirkwood, 'Exploring the gap: an exploration of the difference in income received from wages and salaries by women and men in full-time employment', in Philip S. Morrison (ed.), *Labour, Employment and Work in New Zealand 1998, Proceedings of the Eighth Conference*, Institute of Geography, Victoria University of Wellington, Wellington, 1999, pp. 85–95.
32. *Ibid.*
33. See the discussion in 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, 1997b, pp. 271–90.
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