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THE CHANGING PATTERN OF SKILL DEMAND IN THE AUSTRALIA ECONOMY*

by

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Abstract

Over the last two decades there has been a pronounced shedding of low skill workers and increased demand for skilled workers observed in many countries. This has been attributed to a number of different causes with the most commonly cited reason being skill-biased technological change. In this paper the attributes of different occupations are used to obtain measures of three distinct skill dimensions- motor skills, interactive skills and cognitive skills- plus education. The paper presents an analysis of skill change for each of these skill dimensions for Australia for the period 1991-2001. The results indicate that there were very significant changes in skills mix during the decade coinciding with the the rapid increase in Information and Communication Technologies (ICTs) investment and, significantly, with the increasing share of ICT in the capital stock.

Introduction

Over the last two decades there has been a pronounced shedding of low skill workers and increased demand for skilled workers observed in many countries (Gautié 2002). This has been attributed to a number of different causes, with the most commonly cited reason being skill-biased technological change. In this paper the attributes of different occupations are used to obtain measures of three distinct skill dimensions - motor skills, interactive skills and cognitive skills - plus education. Motor skills are essentially the ability to do physical tasks. Cognitive skills relate to the possession and ability to create knowledge. Interactive skills refer to the ability to relate between managers and employees, employees and employees, and employees and customers. The paper presents an analysis of skill change for each of these skill dimensions for Australia for the period 1991-2001. The analysis examines the pattern of industry skill demand by analysing skill changes separately for full-time and part-time workers and for the sub-periods 1991-1996 and 1996-2001.

Skill Biased Technical Change

Trade hypothesis and the structure of trade

Among the explanations as to what has caused the skill composition of the Australian and other advanced economies to change over time is the changing pattern of trade between countries. The argument put forward is that increasing trade with developing countries has led to shifts away from labour intensive manufacturing industries in industrialised countries. This has the effect of lowering the relative demand for unskilled labour. A study by Pappas (1998) using shift-share analysis showed that the contribution of trade to changes in mean industry skill scores for Australia between 1976 and 1991 were very small, due in part to the fact that the share of employment in the trade sector is relatively small. Other studies, such as Wolff (1995) reach the same conclusion for the US. This paper will, therefore, concentrate on only the technical change aspects of skill structure.

The role of new technologies and how they have impacted on skill requirements have been studied in a number of different contexts both in Australia and elsewhere. A broad consensus has emerged that there is a high degree of complementarity between skill and technology (see Kelly and Lewis, 2003; Berman, Bound, and Machin, 1997; Bound and Johnson, 1992; Maglen and Shah, 1999; Goldin and Katz, 1998; Pappas, 1998; and Wolff, 1995). The principal argument is that recent technological change, notably the intensification of information and communications technologies (ICT) in the economy, has complemented skilled and highly skilled labour in production.

ICTs can change the composition of skills in the economy in two ways. First, the direct substitution of easily automated labour intensive type jobs by computer-based technologies will alter the composition of skills. It can also eventuate from the organisational complementarity that exists between computer based technologies and managerial and professional jobs (Autor, Katz, and Krueger, 1997; and Caroli, 1999). A study by Autor *et al.* (2000) found this to be the case for a major US bank where image processing technology was installed in the mid 1990s, with data entry jobs being directly affected. These jobs were typically filled by low skilled high school graduates. Jobs involving more discretion and interdependence were also streamlined. Nonetheless, subsequently there was more emphasis placed on the employment of college graduates relative to less educated labour. A Canadian study shows there has been a process of upskilling in workplaces where computer-based technologies have been introduced and that newly created jobs resulting from the introduction of these technologies tended to be high-skilled jobs. Most of the jobs made redundant were in the low-skilled categories (Gera and Masse, 1996).

ICTs enable organisational forms to vary to traditional, existing forms; they favour 'lateral communication and coordination'. Related to this is increased autonomy - this changed mode of supervision also requires different skills. People skills, or interactive skills, are critical to this process. They are an integral part of the new form of ICT enabled production and outputs and they are also critical to the process of change itself.

To summarise, skill biased technological change suggests that the demand for labour will vary by skill type as ICTs extend their reach in the economy (capital widening) and successive generations of ICTs improve their capability (capital deepening). Repetitive and easily routinised tasks are more likely to be substituted than 'complex and idiosyncratic' ones. Work that is cognitively demanding and requiring judgment or creativity, on the other hand, will be more difficult to automate and computerise (Bresnahan, Brynjolfsson and Hitt, 1999; and Autor, Levy and Murnane, 2000 & 2003) and hence less likely to be substituted.

Evidence of technological deepening

There has been a rapid expansion of the coverage of computers and Internet access in the Australian workplace over the last decade, particularly over the latter part. For example, in November of 1999 there were 65.3 per cent of businesses employing 1-4 people with computers; by June 2001 this had risen to 77.2 per cent. For larger businesses, those with 5-19 employees, the increase was quite modest. For this category of businesses the percentage with computers went from 84.7 per cent to 88.5 per cent over the same period. Internet access grew from 41.5 per cent for businesses employing 1-4 employees to 61.7 per cent between November 1999 and June 2001, representing an annual growth rate of 32.3 per cent. For businesses employing 5-19 people Internet access increased from 56.0 per cent to 73.2 per cent, an annual growth rate of 22.6 per cent (ABS 2002). This suggests that hardware investment in ICTs had approached saturation for the larger firms, but that the application of this infrastructure continued to develop, as evidenced by the rapid increase in Internet usage. In June 1999 there were 29.6 per cent of small businesses (less than 20 employees) using the Internet for email, 25.4 per cent for research, and 8.3 per cent for making or receiving payments. By June 2001 this had increased to 43.8 per cent for email, 41.5 per cent for research and 18.1 per cent for making or receiving payments (ABS 2002). Table 1 shows business use of selected IT items for *all* businesses between 1994 and 2002.

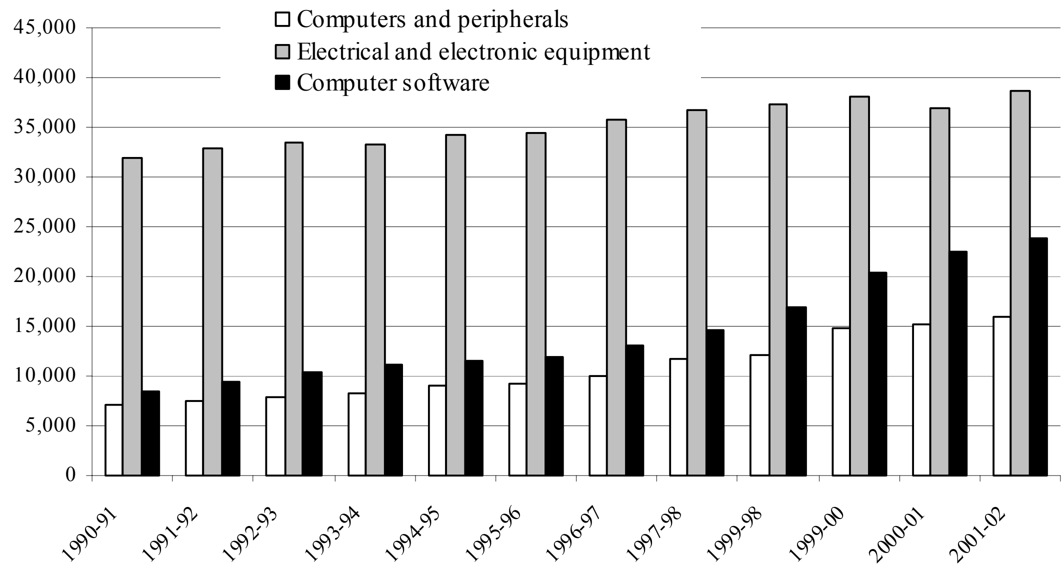
Table 1 Business Use of Selected Technologies in Australia, 1994-2002, per cent

	1994	*1998*	*2000*	*2001*	*2002*
Computers	49	63	76	84	84
Internet access	n/a	29	56	69	72
Web presence	n/a	6	16	22	24

Source: ABS (2002a) Cat. No. 8129.0

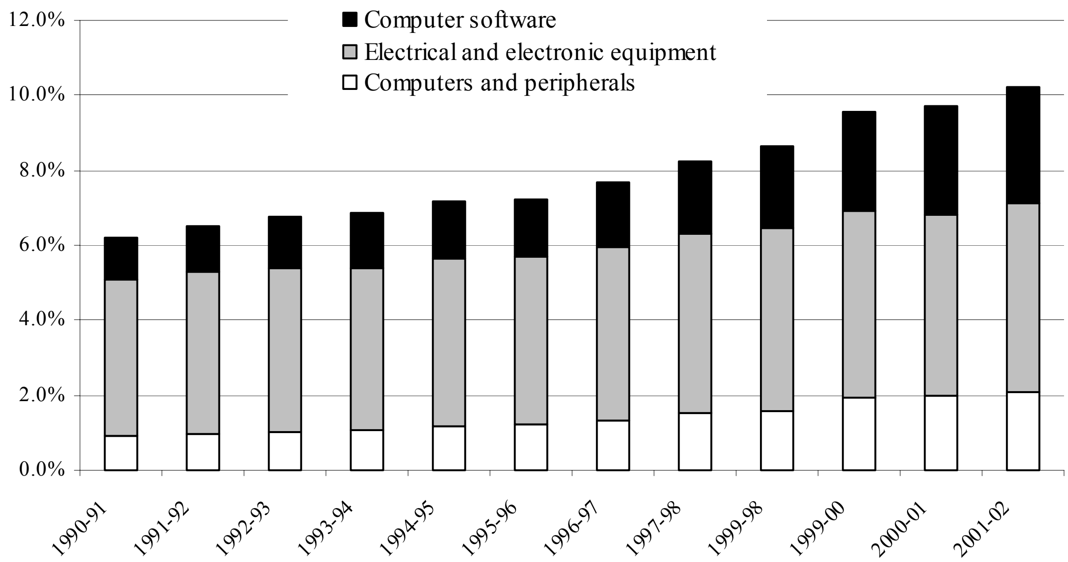
Further evidence of the increasing influence of ICTs can be found in the changing net stock of IT capital in the economy. In figure 1 the net stock of selected electrical, electronic and IT equipment for Australia over the past decade is shown. All items showed substantial increases, but it is computers, peripherals and computer software that have shown the greatest growth. It is also important to recognise that the items of interest in figure 1 are net of depreciation. These items are written off within four years, which makes the observed net increases all the more impressive. As a consequence of this, the increases in the net IT stock suggest much of it is relatively young and represents not only capital widening, but significant capital deepening. How this stock has been applied in the workplace and what the relationships are with labour and skill demand is of great interest.

Figure 1 Change in Net Information Technology Capital Stock, $m (constant prices 2000-2001 = 100)



Source: ABS Cat. No. 5204.0, table 98

Figure 2 Share of Selected Equipment in the Net Capital Stock, Australia, 1991-2002, per cent



Source: ABS Cat. No. 5204.0, table 98 & 86

In figure 2 the relative importance of ICTs in the net capital stock is shown. Between 1990-91 and 2001-2002 they virtually doubled their share in the capital stock. Computers and peripherals, and computer software increased their share in the total net capital stock, and hence production, over the past decade. Interestingly, the growth in hardware (computers and peripherals) seemed to slow after 1999-2000 (coinciding with the sharp slow down in the IT sector during this period), but computer software investment continued to increase quite sharply.

Table 2 shows the growth rates of selected IT capital stocks as a share of the total net capital stock for the period 1991 to 2002. It is clear that the net rate of investment for IT was rapid over this period and, further, that investment in IT far outstripped the overall increase in the net capital stock.[1]

[1] Since the growth rate of a ratio is simply the difference of the growth rates of the numerator and denominator, positive growth rates of the IT to capital ratio mean that the growth in net IT investment is running relatively faster than overall capital investment.

Table 2 Annual Growth Rate of Share of Net IT Capital Stock in Net Total Capital Stock by Industry between 1991 and 2002, Australia, per cent[2]

Industry	*Computers and peripherals*	*Electrical and electronic equipment*	*Computer software*
Agriculture, forestry and fishing	6.3	-2.8	8.5
Mining	5.3	-6.9	3.1
Manufacturing	6.0	-4.3	5.7
Electricity gas and water supply	15.2	-1.1	4.1
Construction	3.6	-3.6	7.3
Wholesale trade	7.2	-2.8	7.0
Retail trade	5.7	-2.7	4.8
Accommodation, cafes and restaurants	5.2	-1.2	3.9
Transport and storage	-0.4	-4.3	4.6
Communication services	9.7	9.8	1.2
Finance and insurance	2.0	-4.7	11.4
Property and business services	3.4	-3.3	5.0
Government administration and defence	0.9	-5.7	9.1
Education	6.3	0.3	7.0
Health and community services	6.3	-1.9	4.8
Cultural and recreational services	6.1	-1.6	0.5
Personal and other services	5.4	-2.7	5.1
All industries	4.4	-1.0	6.4

Source: ABS Cat. No. 5204.0, table 98 & 86

In table 3 the growth rates of the share of IT stock in the net capital stock are examined separately for the first and second half of the period spanning 1991 to 2002. The rate of growth appears to have accelerated from 1996 onward, which is consistent with the data shown in figure 2. However, table 3 confirms that the acceleration was greater for IT investment than for other types of capital equipment, particularly after 1996. Although not shown here, this pattern was typical of most industries.[3]

Table 3 Growth in Net IT Stock, Australia, per cent per year

All industries	*1991-1996*	*1996-2002*
Computers and peripherals	2.8	5.7
Electrical and electronic equipment	-0.8	-1.2
Computer software	4.2	8.2

Source: ABS Cat. No. 5204.0, table 98 & 86

Increasing capital intensity within industries potentially will influence skill requirements. The following table shows the changes observed in the capital-labour (K/L) ratio for Australia between 1991 and 2001 by industry at the ANZSIC[4] 1 digit level. The data in table 4 show that there was considerable growth in the K/L ratio over the period and also a lot of variation between industries. The issue is not that capital/labour ratios are static or declining, it is that the structure, nature and application of capital is changing – a good example of embodied technological change.

[2] The growth rates are calculated using constant prices for net stock, 2000-2001 = 100.0.
[3] Data available from the authors on request.
[4] Australian and New Zealand Standard Industrial Classification.

Table 4 Annual Growth Rate in Capital-Labour Ratio, Australia, 1991-2001, per cent

Industry	*1991-1996*	*1996-2001*	*1991-2001*
Agriculture, Forestry and Fishing	-0.8	1.4	0.3
Mining	5.3	9.9	7.6
Manufacturing	1.8	4.9	3.4
Electricity, Gas and Water Supply	9.5	2.8	6.2
Construction	-0.7	-1.0	-0.9
Wholesale Trade	1.3	5.9	3.6
Retail Trade	1.7	1.5	1.6
Accommodation, Cafes and Restaurants	1.1	3.3	2.2
Transport and Storage	2.0	2.2	2.1
Communication Services	2.9	5.7	4.3
Finance and Insurance	3.4	0.9	2.1
Property and Business Services	-2.3	0.6	-0.8
Government Administration and Defence	1.0	1.6	1.3
Education	1.1	2.0	1.6
Health and Community Services	2.4	2.1	2.3
Cultural and Recreational Services	3.3	6.8	5.1
Personal and Other Services	2.1	2.4	2.3
Total (Industry)	1.6	3.7	2.6

Source: ABS 2003 Cat No. 6291.0.55.001, Table 05 & Cat. No. 5204.0, table 86

Measurement of Skill and Skill Change

The issue of skill measurement will confront any analysis of skills at an aggregate level. Measures typically favoured by economists in studies of human capital rely on years or level of education as a measure of skill attainment. The obvious shortfalls are that these measures do not necessarily capture the actual skill requirements of jobs – the rapid growth in educational attainment may have as much to do with credentialism as skill attainment (Attewell, 1990). An alternative favoured by sociologists focuses on the skill attributes required of jobs, as defined in the US Department of Labour's Dictionary of Titles (DOT). Despite the limitations of using the DOT (see Attewell, 1990), it provides a convenient basis for the analysis of skills independent of productivity measures and knowledge of individuals or workplaces and so is used for the following analyses. A brief overview of how skill scores are assigned to an occupation and industry follows. The full details can be found in Kelly and Lewis (2003).

Mean skill scores (i.e. average skill per hour worked in the whole economy) for four skill dimensions for 1991, 1996 and 2001 were calculated. Census data for 1991, 1996 and 2001 were used to compile the skill indexes for each of the skill dimensions being considered. Measures of skill were constructed using data and information from Australian occupational task descriptions contained in the Australian Standard Classification of Occupations (ASCO), 2nd edition. These were then combined with occupation by industry employment matrices showing total hours worked for part-time and full-time workers and scales of skill complexity for four skill dimensions developed by the United States Department of Labour (USDOL).

The Dictionary of Occupational Titles (DOT), 4th edition (1991) used in the US provides a schema for rating skills at the finest level of occupational detail, as shown in table 5. In DOT jobs are classified as requiring workers to function to some degree in relation to data, people, and things. The scale for each skill dimension shown in table 5 is in descending order.

Those tasks that involve more complex responsibility and judgment are assigned lower numbers for each category and the less complicated have higher numbers. For example, for the data skill dimension (see table 5) 'compiling' would be considered a more complex task than 'copying'. The same applies for the other dimensions. Each dimension is considered separately. The scale relates to an ordering of the complexity of tasks normally undertaken in an occupation, it does not signal anything about the intensity of use of those skills. At an industry level, this is determined by the hours of employment, or utilisation, of the skills embodied in an occupation. The occupation, in turns, tells us something about the tasks undertaken and how they relate to the scale of complexity shown in table 5.

Table 5 Scale of Complexity for Skill Categories

Data	*People*	*Things*
0 Synthesizing	0 Mentoring	0 Setting Up
1 Coordinating	1 Negotiating	1 Precision Working
2 Analyzing	2 Instructing	2 Operating-Controlling
3 Compiling	3 Supervising	3 Driving-Operating
4 Computing	4 Diverting	4 Manipulating
5 Copying	5 Persuading	5 Tending
6 Comparing	6 Speaking-Signaling	6 Feeding-Off bearing
	7 Serving	7 Handling
	8 Taking Instructions-Helping	

Source: USDOL (2000)

Previous studies, such as Wolff (1995), Kelly and Lewis (2003), Pappas (1998) and Autor, Levy and Murnane (2003) have used approaches similar to this to determine the skill scores of an industry. For consistency, the nomenclature used in those studies to relate to the various skill dimensions is employed here. Thus, the schema shown above is applied as follows.

Four types of skill are analysed: motor skills, education, interactive skills and cognitive skills.[5] The 'data' category in table 5 provides a measure of cognitive skills, the 'people' category aligns with interactive skills and the 'things' category provides a good indicator of motor skills. The education category used for this study comes from the education requirement listed for each occupation in the ASCO (2nd edition). The levels of education, based on the Australian Qualifications Framework (AQF), were grouped into six levels, with masters and doctoral degree the highest and AQF I & II[6] the lowest, the measure being made complete by the addition of a 'no qualification required' level. All other measures were inverted, that is, the least complex tasks were given the lowest score. The scale was converted to a common scale of 0 to 10. Finally, the scores were assigned to a given occupation for each skill dimension at the finest level of information on occupations, the ASCO (2nd edition) 6 digit level. The most complex task undertaken in an occupation for each skill dimension, as identified from the ASCO, provided the basis for applying the scores.

[5] A fifth measure of skill (i.e. "strength") based on a separate system of categorising the physical demands of work in the USDOL DOT is employed in the analysis by Wolff (1995). However, a similar measure cannot be derived from the task descriptors used in the ASCO.

[6] AQF I&II are the most basic of qualifications requiring a narrow range of elementary competencies, such as demonstrating "… basic practical skills such as the use of relevant hand tools" (AQF 2002). They may be acquired through accredited training courses and/or recognition of prior learning (AQF 2002).

Thus, the mean skill score for a given dimension in industry *k* is as follows:

$$S_k = \sum_{m,n=1}^{r,u} s_m O_{mn} \Big/ \sum_{m,n=1}^{r,u} O_{mn} \qquad (1)$$

with the mean skill for a given skill dimension for the economy defined as:

$$S = \sum_{k,m,n=1}^{q,r,u} s_m O_{kmn} \Big/ \sum_{k,m,n=1}^{q,r,u} O_{kmn} \qquad (2)$$

k = (1, ...q)

m = (1, ...r)

n = (1,.....u)

where:

S is the mean skill score;

s is the skill score of an occupation and is constant across time;

O is the number of hours worked.

subscripts denote:

k industry;

m occupation;

n part-time or full-time employment status.

Given that the skill score for a given skill dimension and occupation is held constant for each time period, it is changes to the occupational composition of employment that determines changes in the economy-wide mean skill level. This can be represented as:

$$\Delta S = s_m \sum_{k,m,n=1}^{q,r,u} \Delta\left(O_m \Big/ \sum_{k,m,n=1}^{q,r,u} O_{kmn} \right) \qquad (3)$$

with the subscripts as described above.

From (2) it is apparent that changes in mean skills in the economy can arise from changes in the share of an occupation in an industry and changes in industry shares of total hours employed in the economy.

To simplify exposition we denote the occupational share of industry k as:

$$b_{km} = O_m \Big/ \sum_{m=1}^{r} O_m \qquad (4)$$

and an industry's share of total hours employed in the economy as:

$$h_k = \sum_{m=1}^{r} O_m \Big/ \sum_{k=1}^{q} O_k \qquad (5)$$

Thus, the change in mean skill for the economy as a whole for skill dimension j is:

$$S_{jt} - S_{jt-1} = \sum \left((b_{km} h_k)_t - (b_{km} h_k)_{t-1} \right) \qquad (6)$$

An exact decomposition is provided by:

$$\Delta S = \sum \Delta b_{km} \overline{h}_k + \sum \overline{b}_{km} \Delta h_k \qquad (7)$$

with change expressions identified by the delta symbol and the bar over expressions indicating the inter-temporal mean.

The first term on the left of equation (7) provides the within-industry effect, the second expression the between-industry effect. Both of these are further decomposed to show the contribution of the part-time and full-time workforce to changes in mean skill.

The way changing industry shares of total employment affect economy-wide mean skill scores can be explained as follows. If an industry with a relatively high proportion of skilled workers increases its share of overall employment, then there will be an increase in the economy-wide average skill level. This is the inter-industry effect and can be split into the contributions from part-time and full-time employment by applying the respective weights for part and full-time hours employed.

Intra-industry changes to occupation composition work the same way. When an occupation that is relatively highly skilled increases its share of employment within a given industry, that industry experiences an increase in its mean skill level. This can be further decomposed into the contributions from part-time and full-time employment. This enables an examination of whether the large shift towards part-time employment over the last decade has resulted in deskilling. If the occupational composition of part-time employment is different to that of full-time employment, then a change in emphasis within an industry toward one or the other will influence the economy-wide mean skill score. The sum of such changes across the economy shows the within-industry effect on the change in the economy-wide average skill level.

Results

Table 6 shows the percentage change for each of these dimensions between 1991 and 2001. The mean skill levels for full-time workers for interactive, cognitive and education skills increased by about 9.9, 9.2 and 6.4 per cent respectively between 1991 and 2001. Motor skills per hour employed for full-time workers declined by 10.8 per cent. The decline in motor skills for part-time workers was 8.1 per cent. Mean education skills for part-time workers also showed a small decline. This does not necessarily mean that the part-time workforce became less educated over the period in question, but rather, that the educational level required (as represented by the hours employed) was less intensive. The increases for part-time workers in interactive and cognitive skills were quite modest. Overall the increase in mean skills was highest for interactive and cognitive skills and relatively modest for education skills (or educational attainment). Motor skills dropped significantly. It is clear that the changes in total mean skills mask the differing outcomes between the part-time and full-time workforce.

Table 6 Change in Average Skill Levels, Australia, 1991-2001, per cent

	Motor	*Interactive*	*Cognitive*	*Education*
All	-12.4	6.9	5.7	2.6
Part-time	-8.1	3.3	1.7	-0.8
Full-time	-10.8	9.9	9.2	6.4

Table 7 Decomposition of Economy-Wide Change in Average Skill Levels, Australia, 1991-2001

1991-2001	*Motor*	*Interactive*	*Cognitive*	*Education*
total change	-0.317	0.248	0.162	0.088
total within industry	-0.192	0.148	0.118	0.058
p-t mean skill	-0.003	0.035	0.025	0.014
f-t mean skill	-0.160	0.170	0.135	0.105
p-t share of industry employment	0.093	0.159	0.124	0.127
f-t share of industry employment	-0.122	-0.216	-0.167	-0.187
total between industry	-0.125	0.101	0.045	0.030
industry share of total employment - pt	0.098	0.264	0.192	0.208
industry share of total employment - ft	-0.223	-0.164	-0.147	-0.178

It can be seen from table 7 that motor skills declined substantially over the decade from 1991 to 2001. This is a continuation of a trend observed using similar methodology for both the US and Australia (see Kelly and Lewis, 2003; Pappas, 1998; and Wolff, 1995). Interactive, cognitive skills and education skills increased, although the change for education was relatively small. The within-industry effect for all skill dimensions was dominant (see table 8).

The data in table 7 also decomposes the total skill change between 2001 and 1991 into contributions from part-time and full-time workers. From table 7 it can also be seen that the mean skill of both part-time and full-time employment within industries for the motor skill dimension decreased, although the part-time decrease was fairly minor. The net effect of the changing status of employment (i.e. the changing shares of hours worked by part-time and full-time workers) reinforced the decline in the mean skill of both the part-time and full-time workforce. Thus the switch to part-time employment was deskilling – the -0.122 in mean skills given up from the drop in full-time employment within industries was greater than the 0.093 contribution to skills from the increased use of the part-time workforce.

Other skill dimensions showed increases in the mean skill level of both part-time and full-time employment. The common thread for all skill dimensions was that the contribution from the change in mean part-time skill levels was relatively small; the full-time workforce was the main contributor to mean skill levels. The status effect, the impact of changing part-time and full-time shares of employment within industries, pulled the skill level down. One way of viewing the changes taking place is that the growth in full-time work has been relatively skilled in nature, but less important in terms of its contribution to total employment. Growth in part-time employment has been substantial, but continues to be in occupations that are relatively lower skilled than full-time jobs. This has tended to moderate the overall increase in the non-manual skill dimensions between 2001 and 1991. In the case of motor skills it had a reinforcing effect.

In all cases the within-industry effects were larger than the between-industry effects. The within-industry effect is usually interpreted as resulting from technological change, changes in the capital intensity within an industry and changes in the relative price of labour skills (Pappas, 1998). Disentangling capital intensity effects over time from technological change is not a straightforward matter, since much of the technological development we observe is embodied in new capital.

The other effect on change in mean skill levels comes from the changing composition of industry shares of total employment in the economy. The between-industry effect captures the impact of changing product demands; trade and other structural change (see Pappas, 1998). Around 0.1 of the increase in interactive skills was due to the between-industry effect, while for motor skills the effect was to reduce the mean skill level for the economy by 0.125, reinforcing the within-industry effect. Table 8 shows the relative contributions of within- and between-industry effects for each of the skill dimensions for the period 2001 and 1991.

Table 8 Contribution to Change, per cent

1991-2001	*Motor*	*Interactive*	*Cognitive*	*Education*
Total within industry	60.6	59.5	72.5	66.3
Total between industry	39.4	40.5	27.5	33.7
Total	100.0	100.0	100.0	100.0

In summary, the within-industry effects were the main contributor to change for all skill dimensions over the 2001-1991 period. These were, in relative terms, most pronounced for cognitive skills. The conclusion to draw from these results is that technological change has been the dominant influence. It has allowed for, or driven, a restructuring of occupations within industries. Although greater emphasis on part-time employment has been deskilling (suggesting technology-skill substitution), this has been outweighed by the changing occupational contribution within full-time employment and to a lesser extent, part-time employment (suggesting that technology exhibits skill complementarity).

The full-time workforce (other than for motor skills) has become more skilled, but is less important in production. The increased share of part-time employment has not been as highly skilled as the full-time employment it displaced. The balance of the two effects has still seen increases in mean industry skill levels for the economy for the non-manual skills, particularly for interactive skills. This is consistent with the nature of technological change that has taken place. This has been in the form of information systems and transactional processing technologies. It has been shown elsewhere (see for example, Caroli, 1999; and Autor *et al.,* 2000) that these enable better management technologies to be implemented, allowing tighter scheduling of labour, flatter management structures and smaller workforces for a given output.

Changes in mean skills have also been decomposed for the relevant sub-periods. Coinciding with the census periods for Australia, the decomposition is for 1996 to 2001 and 1991 to 1996. The weights applied are for the whole period, that is, 1991-2001. Only the change variables shown in equation (7) vary for the sub-periods.

Table 9 Decomposition of Economy-Wide Change in Mean Skill Levels, Australia, 1996-2001

1996-2001	*Motor*	*Interactive*	*Cognitive*	*Education*
total change	-0.150	0.122	0.094	0.043
total within industry	-0.112	0.110	0.092	0.048
mean skill for p-t	-0.012	0.038	0.030	0.023
mean skill for f-t	-0.088	0.093	0.078	0.048
p-t share of industry employment	0.042	0.069	0.054	0.059
f-t share of industry employment	-0.055	-0.090	-0.071	-0.081
total between industry	-0.037	0.012	0.002	-0.005
industry share of total employment - pt	0.049	0.101	0.076	0.083
industry share of total employment - ft	-0.086	-0.089	-0.073	-0.087

Table 10 Decomposition of Economy-Wide Change in Mean Skill Levels, Australia, 1991-1996

1991-1996	*motor*	*interactive*	*cognitive*	*education*
total change	-0.167	0.126	0.068	0.044
total within industry	-0.080	0.038	0.026	0.010
mean skill for p-t	0.009	-0.003	-0.005	-0.009
mean skill for f-t	-0.072	0.076	0.057	0.057
p-t share of industry employment	0.050	0.090	0.070	0.068
f-t share of industry employment	-0.066	-0.125	-0.096	-0.106
total between industry	-0.088	0.089	0.042	0.034
industry share of total employment - pt	0.049	0.163	0.116	0.125
industry share of total employment - ft	-0.137	-0.075	-0.074	-0.091

The data in tables 9 and 10 are interpreted in the same way as before. Table 11 summarises these changes into the percentage contribution from each effect for each sub period and skill respectively. It can be seen that the change that occurred between 1996 and 2001 was predominantly from within-industry changes in occupational composition. Although less pronounced, the opposite was the case for the period 1996 to 1991 (see table 10).

Table 11 Contribution to Mean Skill Change, Australia, 1991 – 2001, per cent

	Total Change		*Total within Industry*		*Total between Industry*	
	1991-1996	1996-2001	1991-1996	1996-2001	1991-1996	1996-2001
motor	53	47	42	58	70	30
interactive	51	49	26	74	88	12
cognitive	42	58	22	78	95	5
education	51	49	17	83	116	-16

With the exception of cognitive skills the contributions to total change for each of the sub-periods was about the same. For cognitive skills 58 per cent of the change in mean skill levels occurred in the latter half of the decade. The individual effects are strikingly different for the sub-periods. The within-industry effects for the later period account for 74, 78 and 83 per cent of the total within-industry effect for interactive, cognitive and education skill changes respectively that occurred between 1991 and 2001. Most of the occupational adjustment that has occurred has coincided with the rapid increase in ICT capital expenditure (see figures 1 and 2) observed from 1996-7 onwards and has been due to within-industry changes (see table 9).

The between industry changes that took place and the impact that these had on changes in mean skill levels are nearly entirely attributable to the post-recession period, 1991-1996. In total the effects played a much smaller part in the change observed over the decade. One possible explanation is that the effects of the recession were not evenly spread across industries, or that the normal pattern of recovery sees some industries grow more quickly than others.

Conclusion

Significant de-skilling of the part-time workforce occurred in the first half of the 1990s, although the effect of this on the overall skill level of the workforce was more than compensated for by the increasing skill level of the full-time workforce. Most of the impact on skill demand from the changing industry structure of the economy occurred prior to 1996, with the change after this time having very little impact. The latter half of the decade was characterised by the changing structure of occupations within industies. There was further intensification of higher skill occupations among the full-time workforce, while the part-time workforce experienced only modest (positive) change to their mean skill level. These changes coincided with the the rapid increase in Information and Communication Technologies (ICTs) investment and, significantly, with the increasing share of ICT in the capital stock.

The increasing importance of ICT in the capital stock is clearly having an impact on the type of skills demanded in the economy. This is most likely occurring due to direct demand for ICT related skills and indirectly through the enabling characteristics of ICTs. Importantly, it is not only the increasing emphasis of computers in the workplace and industry, but the rapid increase in the uptake of software applications by industry. This can be seen in the share of computer software in the total capital stock increasing by nearly 7 per cent per annum over the decade to 2001. Of some interest is that the growth rate of net computer software capital virtually doubled after 1996, from 4.2 to 8.2 per cent per annum. Around three quarters of within-industry changes for non-manual skills over the decade to 2001 occurred after 1996. It appears that ITCs have allowed a substantial re-ordering of occupations within industries, that is, they are enabling a reorganisation of workplaces that places greater emphasis on skills, particularly interactive and cognitive skills. The extent to which these skills are able to be diffused through formal training and education needs to be explored.

The implications for policy are clear – traditional ‘blue-collar’ skills will stagnate or continue to decline, this will test the ability of the labour market to adjust and absorb the existing supply of these skills. The inability of many individuals to adjust to the current and expected skill demands of industry will continue to see a large component of unemployment in Australia being structural in nature. When capital becomes technologically obsolete, the social consequences will be relatively benign. When the skills of workers become obsolete, the social consequences are much more serious, with unemployment, financial hardship and marginalisation the likely outcome. The vocational education and training (VET) sector should be taking a lead role on this issue, as equipping displaced workers with relevant skills will be critical to successful re-adjustment.

In the longer term, the balance between the VET and university education sectors in Australia may need revisiting. Within vocational education training the move away from traditional skilled manual trades and low skill employment needs to be acknowledged and greater emphasis placed on skills to meet the needs of the service sector. The university sector will continue to be the primary source of skills as the knowledge intensity of production in the economy increases.

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