Skill and Australia's Productivity Surge

Staff Research Paper

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The views expressed in this paper are those of the staff involved and do not necessarily reflect those of the Productivity Commission. Appropriate citation is indicated overleaf.

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Preface

This paper was developed and written by Paula Barnes and Sharon Kennard under the general direction of Dean Parham. Tracey Horsfall provided administrative and production support.

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Abbreviations

ABS	Australian Bureau of Statistics
ABSCQ	Australian Bureau of Statistics Classification of Qualifications
ASCO	Australian Standard Classification of Occupations
BLS	Bureau of Labor Statistics
EPAC	Economic Planning Advisory Commission
ICT	Information and communications technology
IDS	Income Distribution Survey
LFS	Labour Force Survey
MFP	Multifactor productivity
MRTS	Marginal rate of technical substitution
OECD	Organisation for Economic Co-operation and Development
RBA	Reserve Bank of Australia
SIHC	Survey of Income and Housing Costs

OVERVIEW

Key points

- The demand for skilled workers in Australia increased faster than the demand for unskilled workers over the 1980s and 1990s.
  - Measured in terms of broad educational attainment levels, the supply of skilled workers relative to unskilled workers increased in line with changes in relative demand at the aggregate economy level.
  - Therefore there have been no major relative wage or relative unemployment pressures.
- Factors other than increased skill have mainly contributed to Australia's productivity surge from the mid-1990s.
  - The strongest growth in skill (measured in terms of educational attainment plus work experience) came in the late 1980s and early 1990s.
  - Growth in skill contributed 0.2 of a percentage point to the 0.7 per cent a year growth in multifactor productivity between 1988-89 and 1993-94.
  - But growth in skill contributed only around 0.05 of a percentage point to the 1.7 per cent a year growth in multifactor productivity from 1993-94 to 1997-98.
- International comparisons also fail to support a link between growth in skills and Australia's 1990s productivity surge. Compared to other countries, Australia's growth in skills was low but growth in productivity was high. Again, factors other than growth in skills appear to provide the main explanation for the magnitude of productivity growth (including international differences) in the 1990s.
- Nevertheless, education and skills clearly remain important for long-run growth and for meeting the changing pattern of demand. And, even in the context of the productivity surge, Australia's relatively high *level* of education may have contributed to the relatively rapid rate of uptake of information and communications technologies in the 1990s, which in turn made some contribution to the productivity acceleration.

Overview

More attention has been placed on developing skills for the workplace in recent years. The interest stems from three propositions:

- Australia needs to become a higher-skill, more knowledge-intensive producer in response to global pressures if it is to raise or even maintain its living standards.
- Technological change, particularly information and communications technologies, increases the relative demand for skill.
- The shift toward services in economic activity changes the demand for certain types of skills, with a focus on conceptual and interpersonal skills.

This paper examines the changing demand for skills and finds that, at the aggregate economy level, the supply of skilled relative to unskilled workers has increased in line with increasing relative demand. It also examines the effect of increased skill on conventionally-measured productivity growth and finds that, during the 1990s productivity surge, the contribution of skill to productivity growth has been overshadowed by the contributions of other factors.

Changing patterns of demand for and supply of skills

Skill is a multidimensional concept, which makes measurement difficult. A number of different proxies for skill have had to be relied upon in this paper. As there are some differences in trends between these measures, attention needs to be paid to the specific measure used in each case.

Changes in employment provide an indication of the demand for labour. The supply of labour can be measured by labour force numbers, which include unemployed persons. *Demand* for skilled workers has increased fairly continuously for at least two decades. Demand for skilled workers relative to unskilled workers, measured in terms of level of educational attainment (workers with post-school qualifications relative to those without), increased faster in the 1980s than the 1990s. Skilled employment rose from 38 per cent of total employment in 1980 to around 58 per cent in 2000. In the 1980s, skilled employment grew by 4.7 per cent a year, compared with growth of 0.5 per cent a year in unskilled employment. In the 1990s, skilled employment grew by 3 per cent a year, while unskilled employment contracted by 0.8 per cent a year.

In broad terms, the *supply* of skilled workers relative to unskilled workers has increased at similar rates. Therefore there have been no significant pressures for relative wage or relative unemployment changes.

A similar balance is found when the different productivities of different skill groups are taken into account. In both the 1980s and 1990s, changes in relative demand for and relative supply of skilled workers were similar. In the framework used, skill is proxied by the level of educational attainment and the different efficiencies, or marginal products, of different skill groups are explicitly incorporated in terms of relative wages.

These changes in demand and supply are presented in table 1, which shows the shift in relative demand, the shift in relative supply and the extent of the imbalance between these shifts. The responses to the imbalance, in terms of relative wage and relative unemployment movements, are also shown. The increase in relative demand slightly exceeded the increase in relative supply in the 1980s leading to a small increase in relative wages. The opposite was the case in the 1990s. There was virtually no change in relative unemployment in either period.

Overall, at the aggregate economy level, no major shifts in relative skill shortages or surpluses were found in either the 1980s or 1990s. Consequently, there were no major relative wage or unemployment pressures. This result also broadly held for a narrower definition of skill and an alternative measure of labour units — differences in results were small, particularly when data limitations are considered.

Table 1 **Changes in the demand for and supply of skilled workers relative to unskilled workers[a], 1980s[b] and 1990s**

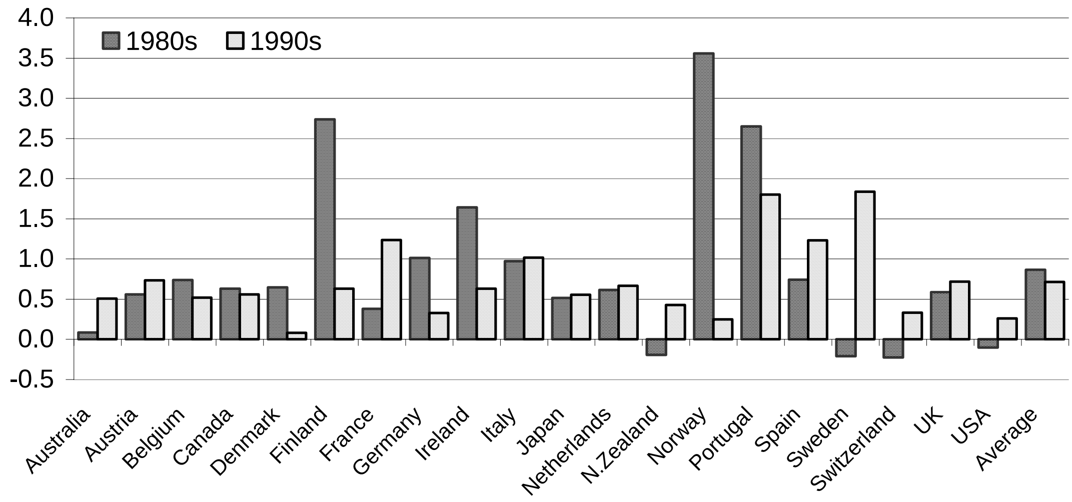
Per cent per year

	1980s	*1990s*
Shift in relative demand	3.8	3.5
less		
Shift in relative supply	3.4	3.7
equals:		
Shift in relative excess demand/supply	0.4	-0.2
also equals sum of:		
Relative wage movement[c]	0.4	-0.3
Relative unemployment movement[d]	-0.1	0.1

a Components may not add to total due to rounding. **b** 1981-82 to 1989-90, a shorter period than discussed above and not directly comparable. **c** A negative movement in *relative* wages does not necessarily mean a decline in the *absolute* wages of skilled workers. **d** A negative (positive) movement represents an increase (decrease) in relative unemployment rates.

Figure 1 **Growth in average years of education of the population aged 15 years and over, 1980s and 1990s**

Per cent per year



From an international perspective, the available evidence suggests that the *growth* in skill supply has been stronger in other OECD countries than in Australia over the past two decades (figure 1). Australia started from a relatively high base in 1980, but its growth in average years of education during the 1980s and 1990s was below the average of major OECD countries. As a result, Australia dropped from fifth to sixth in the overall rankings of average education levels between 1980 and 2000. The measure of skill used here is average years of education for the population — a different measure of skill to that discussed above and one that is measured for the population and not just those employed. The results for Australia are therefore not directly comparable with those presented above but they are useful for examining the relativities between countries.

Skill and the productivity surge

Increased skills can influence productivity growth in two ways. Firstly, skills can directly raise workers' output per hour worked. Secondly, there is a substantial body of opinion that skills in the workforce increase the rate of innovation through fostering the absorption and further development of technologies. The focus of this study, however, has not been to explore the latter linkages, but to determine how much of Australia's measured productivity growth could be directly attributable to growth in workforce skills.

In standard productivity analysis, for example as used by the Australian Bureau of Statistics (ABS) in its current estimates, labour input is measured as the total number of hours worked. Whilst this is the commonly used approach, conceptually it mismeasures labour input as it fails to account for embodied human capital or skill. A measure of labour input that also takes account of inputs of skill is sometimes referred to as a labour services measure. The flow of labour services comprises an hours worked (or 'quantity') component and a skill (or 'quality') component.

By extension, the standard quantity-based approach generates mismeasurements in productivity growth. The effects of increases in skill on output growth are captured in the productivity 'residual' rather than being attributed to growth in labour inputs.

The ABS has constructed an *experimental* labour services series. This series is constructed by differentiating the workforce on the basis of gender, educational attainment and workforce experience and aggregating the hours worked in each group using a set of weights that reflect the relative wages of the different groups. The assumption is that relative wages reflect different marginal products, which in turn reflect different skill levels. To the extent that people with higher levels of educational attainment and experience are paid more for an hour of work, wage premiums capture the influence of skill in forming the labour input measure.

The change in skill composition contributed 0.3 of a percentage point to labour services growth of 1.6 per cent a year between 1982-83 and 1997-98 (with growth in hours worked accounting for the difference of 1.3 percentage points). This skill composition change was mainly due to higher average levels of experience of the workforce, with less change in the average level of educational attainment.

Most of the increase in skill according to this measure was in the late 1980s and early 1990s (figure 2). Between 1986-87 and 1990-91, a shift toward skill contributed 1.1 percentage points to labour services growth of 3.0 per cent a year.

Using a labour services measure, rather than an hours worked measure, allows a skill component to be 'factored out' of the conventionally-measured labour productivity estimates. The contribution of skill composition change to growth in conventionally-measured labour productivity (and also to growth in multifactor productivity (MFP) and output) is the growth in skill composition multiplied by labour's share of total costs. Over the entire period, 1982-83 to 1997-98, the contribution of skill change was 0.2 of a percentage point to labour productivity growth of 2.3 per cent a year. Between 1986-87 and 1990-91, the change in skill composition accounted for around 0.7 percentage points of average annual labour productivity growth of 1.8 per cent. This period of strong growth in the skill component roughly corresponds to a period of strong growth in employment, suggesting that the relatively weak growth in labour productivity in the 1980s was not due to the engagement of workers with lower marginal products, as is sometimes asserted.

Figure 2 **Labour input indexes, 1982-83 to 1997-98**
Index 1982-83 = 100

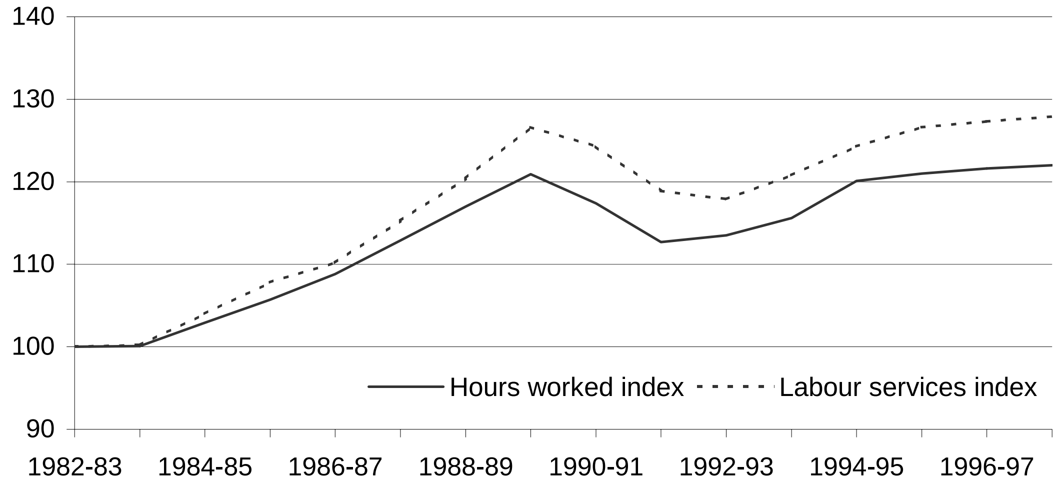
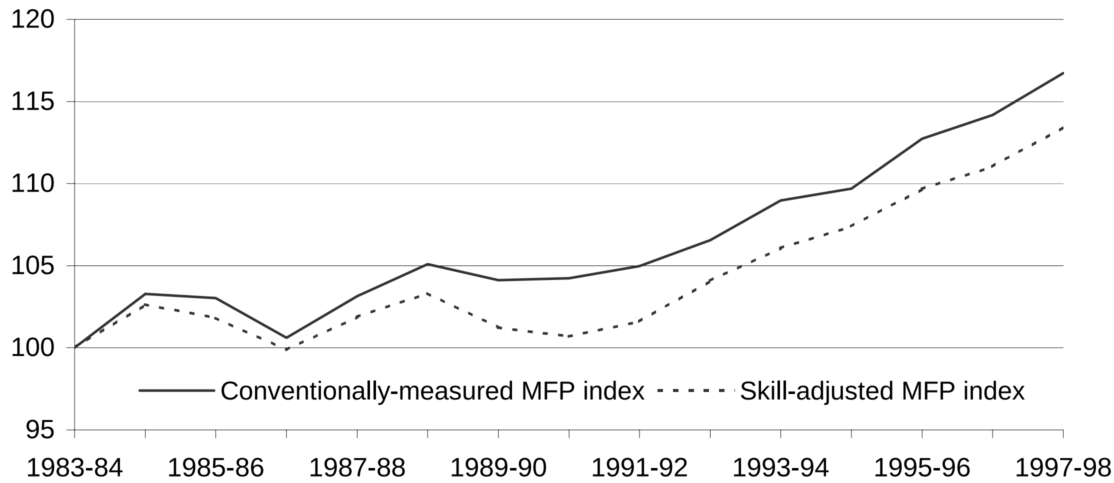


Figure 3 **MFP indexes, 1983-84 to 1997-98**
Index 1983-84 = 100



Box 1 **Trends in work experience and the ageing of the labour force**

The ABS labour services index (Reilly and Milne 2000) incorporates two measures of skill — educational attainment and potential workforce experience. Since actual experience data are unavailable for Australia, potential experience is calculated from age and years spent in education (and number of children for women). Whether it is actual or potential, work experience can be expected to grow with an ageing population.

ABS estimates of potential experience show positive growth in the 1980s and 1990s (see chapter 2). The proportion of the workforce with 20 to 29 years and 30 to 39 years potential experience has grown significantly since 1982-83, with a corresponding decline in the two lower experience groups. This growth is primarily due to the ageing of the labour force, with strong growth in the proportion of the labour force in the 35-44 years and 45-54 years age cohorts.

Growth in potential experience has driven the changes in the skill composition of the workforce between 1982-83 and 1997-98. With little growth in average years of education of those employed in the market sector during this period, it has been the movement of workers to higher potential experience groups, with associated higher marginal products and therefore higher wages, that has been the major influence on skill composition change.

The relationship between wages and experience was empirically tested by Reilly and Milne (2000). They found that experience has a statistically significant positive influence on wages, but there are diminishing returns to experience. At the margin, the return from an additional year of work experience is less than the return on the previous year of work experience. Workers' base decisions about investment in human capital or skills on the costs and benefits. And as workers age and near retirement they may reduce their investment in skills because the marginal benefits of such investment may be overtaken by the marginal costs. However, this is not to say that productivity declines in absolute terms with age — OECD (1998a) concluded that there is no evidence to suggest that the productive potential of older workers is substantially impaired by ageing per se.

Given the linkages between experience and age, an ageing population has implications for the future skill growth of the labour force. The age composition of the population has changed with falling fertility rates, increased life expectancy and the ageing of the 'baby boomer' cohort. Dowrick (2002) links falling Australian fertility rates to the accumulation of human capital, particularly for women. As women have attained higher levels of education, and their potential earnings have risen, they have chosen to increase their participation in the labour force and to have fewer children. When the large and experienced 'baby boomer' cohort retires it will be replaced by smaller, and obviously less experienced, younger cohorts. However, Dowrick points out that the younger cohorts are, on average, much better educated than those they are replacing. And he estimates that the average education level of the workforce will continue to rise for the next three decades as historical increases in school enrolments work their way through the adult population. Therefore the retirement of the 'baby boomer' cohort will not necessarily imply a fall in the average skill level of the workforce.

Table 2 **Growth in labour input and contribution of skill composition change[a], 1984-85 to 1997-98**

Per cent per year

	1984-85 to 1997-98	*1984-85 to 1988-89*	*1988-89 to 1993-94*	*1993-94 to 1997-98* **b**	*Acceleration*
	(a)	*(b)*	*(c)*	*(d)*	*(d) – (c)*
Labour services	1.6	3.7	0.1	1.4	1.3
equals:					
Labour quantity (hours worked)	1.3	3.3	-0.2	1.4	1.6
plus					
Skill composition change[c]	0.3	0.5	0.3	0.1	-0.2
Conventional MFP growth	0.9	0.4	0.7	1.7	1.0
Skill-adjusted MFP growth	0.8	0.2	0.5	1.7	1.2
Contribution of skill composition change to conventional MFP growth	0.2	0.3	0.2	0.0	-0.2

a Components may not add to total due to rounding. **b** 1997-98 is not a peak but later skill data are not available. **c** The period of most increase in skill identified earlier, 1986-87 to 1990-91, crosses two MFP peak-to-peak periods.

The skill component can also be 'factored out' of the conventionally-measured multifactor productivity estimates (figure 3). The ABS publishes MFP growth rates estimated over productivity cycles, the start and end points of which correspond to a productivity peak. Skill composition change during these MFP peak-to-peak periods (which are different to the periods examined above) is shown in table 2. Between 1984-85 and 1988-89, the change in skill composition contributed 0.3 of a percentage point to average annual (conventionally-measured) MFP growth of 0.4 per cent. Between 1988-89 and 1993-94, this decreased to a 0.2 of a percentage point contribution to average annual MFP growth of 0.7 per cent. During the period of the productivity surge from 1993-94, there was a further decline in the skill contribution to less than 0.05 of a percentage point to average annual MFP growth of 1.7 per cent (from 1993-94 to 1997-98). Thus, skill composition change decelerated and actually detracted from, rather than contributed to, the measured MFP surge in the 1990s.

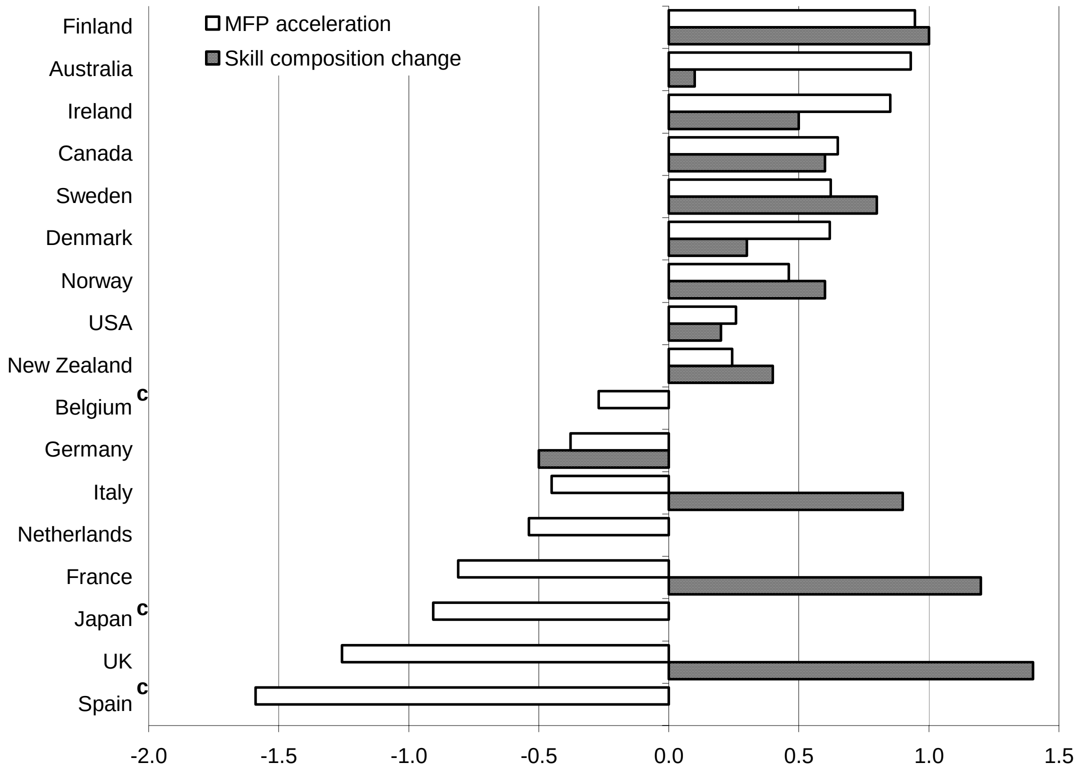
Whilst indirect effects could still be important (as noted below), there appears to be no significant *direct* and immediate impact of the increase in the skill of the workforce on productivity during the post 1993-94 surge.

The international perspective also fails to support a link between growth in skill and Australia's productivity surge during the 1990s. As noted above, Australia's growth in skills, as measured in average years of education, has not been high relative to other OECD countries. Furthermore, skill composition change (measured solely in terms of educational attainment) was low in Australia compared with other major OECD countries (figure 4). Yet Australia's productivity acceleration was generally much higher than in other countries in the 1990s. And, more generally, there does not appear to be a strong correlation across countries between acceleration in productivity growth and movements in skill composition towards skilled workers (figure 4).

Examining the most recent productivity cycle for the United States, 1992 to 2000, skill composition change (measured in terms of educational attainment and work experience) contributed 0.2 of a percentage point to annual (unadjusted) MFP growth of 1.3 per cent. By comparison, skill composition change contributed around 0.05 of a percentage point to annual (unadjusted) MFP growth of 1.7 per cent between 1993-94 and 1997-98 in Australia.

Figure 4 **Change in MFP growth between the 1980s and the 1990s[a] and skill composition change[b] between 1985 and 1998**

Percentage points and per cent per year



[a] Change in MFP growth is the change in average annual MFP growth rate between the 1980s (1980 to 1990) and the 1990s (1990 to 1999). [b] Educational attainment measure. Does not include work experience and is therefore not directly comparable with the measure in table 2. [c] Data for skill composition change are not available.

Whilst these perspectives suggest that other factors have been more important over this period than change in skills, the importance of education and skills more generally, especially over the longer term, is not to be dismissed. Firstly, Dowrick (2002), in his review of the literature on how workforce skills influence economic growth, suggested that a conservative estimate of the increase in Australia's *long-run* economic growth rate, from an additional year of education in the adult population, is 0.3 of a percentage point.

Secondly, even in the 1990s period examined, the average *level* of education may have been important. A number of countries that have had relatively high average levels of education have also experienced relatively strong diffusion of information and communications technology (ICT) — for example, Australia, Canada, the United States and the nordic countries. This group of countries has also had an acceleration in MFP growth. This raises the possibility that the rate of absorption or uptake of ICTs could be related, in part, to average education levels. And to the extent that ICTs are a factor in acceleration in MFP growth, levels of education may have contributed indirectly to productivity acceleration. However, the contribution of ICT uptake to productivity acceleration, whilst significant, is still relatively small. Parham (2002) suggested that the ICT-related gains in Australia have been perhaps 0.1 or 0.2 of a percentage point of annual MFP growth.

Overall, these results suggest that increased skill of the workforce has not had a major effect on Australia's 1990s productivity surge. During the period of this productivity surge, there was a deceleration in the skill contribution to conventionally-measured MFP growth. And while there could be an indirect effect on innovation from the growth in employed skills, there is some evidence that the indirect effects over the 1990s, while important, have nevertheless been relatively modest.

1 The context for this study

Focus on the skill of the Australian labour force has increased in recent years, particularly in discussions of ‘the new economy’, the knowledge-based economy and productivity growth.

The skill of the labour force can be important in this context for two reasons.

- Increased human capital is a source of productivity growth.
- The changing nature of work has increased the demand for skills and increased the need for individuals to have appropriate skills in order to access employment opportunities.

Human capital is a source of new knowledge and also embodies knowledge which can be transferred to others through the process of learning. The accumulation of human capital can lead to productivity improvements, while skill shortages can mean productivity potential is unrealised.

The changing nature of work has included the introduction of new technologies. New production technologies, for example, can have an “upskilling” effect — decreasing the demand for low-skilled workers and increasing the demand for high-skilled workers. But “deskilling” may also occur, for example, where information technology performs information gathering and analytical tasks previously associated with skilled middle-management jobs.

1.1 Objectives and scope of the paper

The aim of this paper is to tackle two quite specific aspects of the relationship between skill and productivity.

1. To examine, at an aggregate level, changes in the supply of and demand for skilled labour relative to unskilled labour in Australia during the 1980s and 1990s. For example:
   (a) Have changes in demand for skilled relative to unskilled labour exceeded changes in relative supply?
   (b) To the extent that they have, what has been the response of relative unemployment rates and wages?

2. To examine the influence of changes in the skill of the workforce on measured productivity growth.

Chapter 2 examines trends in the skill profile of employment, based on different definitions of skill. Chapter 3 takes a closer examination of changes in skill composition on both the demand and supply sides. In principle, this can point to skill shortages or surpluses and relative wage and unemployment pressures that are masked in the examination of the skill profile of employment. The chapter develops a framework which takes account of the different productivities of different skill groups; and decomposes any imbalance in the growth in demand for and supply of skill into a relative wage effect and a relative unemployment effect. Chapter 4 assesses the effect that the increased skill profile has had on Australia's productivity performance.

2 Changing skill profile of employment

The skill profile of the Australian workforce has changed considerably over the last twenty years. Factors behind this change, together with the extent of the change, are briefly outlined in this chapter.

2.1 Factors affecting the skill profile of employment

The average skill level of the Australian workforce has increased over time. A number of demand and supply side factors have contributed to changes in the skill profile of those in employment.

Demand-side factors

The demand for higher skill levels is driven by firms' need for employees to perform more demanding tasks. The wages and salaries that must be paid to attract skilled employees puts a curb on the demand for skill.

A range of factors affects the demand for skilled workers, including the following.

- Shifts in the composition of production.
  - Growth in the demand for services has been a major factor changing the composition of production. Rapid growth in the service sector has led to growth in white collar employment, both high and low skill, with many of these new jobs placing a greater emphasis on interpersonal skills rather than the physical or motor skills required for many low-skilled blue collar production jobs. McLachlan, Clark and Monday (2002) found that the service sector has been the major source of demand growth for high-skilled workers since the mid-1980s.
- Expansion of international trade.
  - The effect of international trade on the demand for low-skilled workers is the subject of debate (see OECD 1996 for example). It is claimed that an increase in international trade will result in a relative decrease in demand for low-skilled labour if imports are concentrated in sectors that employ a larger

proportion of low-skilled workers and exports are concentrated in sectors that employ predominantly high-skilled workers.

- However, de Laine, Laplagne and Stone (2000) found little support for the trade explanation in Australia over the period 1978 to 1998. They identified increases in the share of skilled workers across all industries, rather than a few (trade-exposed) industries. They stated that this is consistent with changes due to technology more than increase in international trade.

- Technological change.
  - The implications of technological change for the skill profile of the workforce depend on the type of technological change and the area of application. Some technological change can be upskilling, while other types can be deskilling. In principle, the net effect is unclear.
  - However, in some circumstances, the links are clearer. OECD (1998b) notes that it is generally agreed that the introduction of new technologies into production processes decreases the demand for low-skilled workers and increases that for high-skilled workers. But, as new technologies perform a greater variety of tasks, the skills required for certain occupations may be reduced. For example, information technology is reducing the skill requirements of middle-management jobs.
  - There is considerable debate internationally over how much of the decreased demand for low-skilled workers is due to technological change (OECD 1996). Evidence of skill-biased technological change has increased (see for example, Berman, Bound and Machin 1998 and Machin and Van Reenen 1998). As noted above, de Laine, Laplagne and Stone (2000) found a majority of Australian industries have a positive association between technological change and the increased demand for skilled workers.

Some commentators expect the trend toward increased demand for skilled labour to continue. OECD (2000a) suggests that there is a new wave of innovation, primarily based on information and communications technologies, coursing through OECD economies and that human capital is a key requirement for innovation and growth. The OECD notes the need for increasing average skill levels of the labour force to facilitate adoption and use of technologies, and a growing need for highly skilled individuals in particular industries. Initial levels of education are seen as no longer being sufficient in an economy in which demand changes continuously — lifelong learning is seen as increasingly important. The types of skills needed are also changing with greater conceptual rather physical content of output requiring increased demand for conceptual skills in the workforce (Greenspan 2000).

Supply-side factors

The Economic Planning Advisory Commission (EPAC 1996b) identifies three interrelated sources of skills: inherited personal characteristics; skills developed through formal education and training; and skills developed through work experience and informal training. People make decisions about investing in acquiring skills (or human capital) for a range of personal and financial reasons, including improved chances of employment, achieving higher earnings and gaining a more satisfying career. In this context, it is pertinent to note that the proportion of Australians remaining at school and undertaking post-school education and training has increased.

Human capital models of education explain growth in participation in education as a function of either reduced costs of investing in extra education or increased return to that education. EPAC (1996a) lists a number of reasons why the cost of investing in education in Australia has fallen over the 1980s and 1990s.

- Increased part-time employment among students has decreased the income loss associated with full-time education.
- Full-time employment opportunities for young people have decreased, reducing the opportunity costs of education.
- There has been an increase in the range and level of subsidies available to those from low income families who wish to continue their education.

Against these factors is the possibility that increased part-time employment opportunities may reduce the likelihood of extending education and a possible counteracting influence of the introduction of payment for university study through the Higher Education Contribution Scheme. It has also been argued that education participation is supply rather than demand determined, so that the level of government funding for higher education determines the amount of participation. (EPAC 1996a)

The evidence on changes in the return to education is not clear. EPAC (1996a) noted that quantitative studies of wage data have produced mixed results. This may in some cases be the result of inadequate data and not adjusting for cohort characteristics.

2.2 Measurement of skill

As skill is a multidimensional concept, direct measurement is difficult. In empirical work, proxies for skill are often used (see Spenner 1990 for a detailed discussion of alternative measures of skill).

Two commonly used proxies are educational attainment and occupation. Measures of educational attainment are considered reasonable proxies for 'human capital' (OECD 1994). Occupation can be highly correlated with formal education. For example, most high-skilled white collar occupations require tertiary qualifications and high-skilled blue collar occupations require trade qualifications. But for some occupations, such as some low-skilled blue collar occupations, formal education may be less important, with greater reliance placed on on-the-job training and experience.

Each of these proxies has limitations. The educational attainment measure does not:

- capture variations in the quality of schooling over time;
- necessarily correspond with the actual skill requirements of the job (the use of credentials as a screening mechanism for jobs can mean that the employee has skills in excess of those needed for the job); or
- capture on-the-job learning (on-the-job training and work experience). Indeed, post-educational skills may be even more important than educational attainment but few hard measures are available (OECD 2001a) — length of work experience is one proxy.

And some occupational classifications:

- group heterogeneous skills, particularly at high levels of aggregation; and
- do not reflect changes in the skill content of both high-skilled and low-skilled occupations.

A third measure of skill is based on skill levels for detailed occupation groupings. It estimates the average levels of specific skills (cognitive, interactive, motor) possessed by the workforce. This measure is used less frequently because of its hefty data requirements.

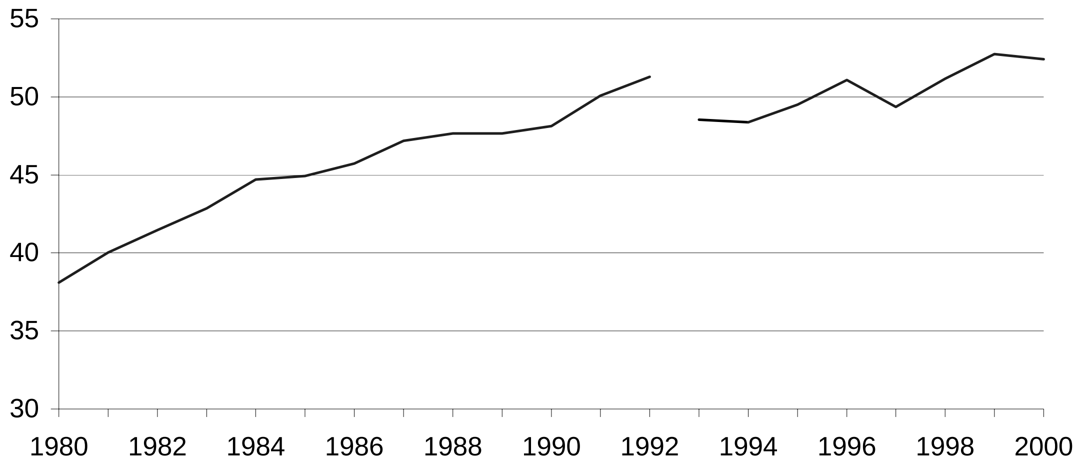
2.3 Trends in the skill profile of employment

According to conventional measures, the average skill level of the employed workforce has increased over time in Australia. Figure 2.1 shows skill measured in terms of educational attainment, with skilled defined as 'with post-school qualifications', that is with a completed qualification (tertiary or vocational) beyond the highest level of secondary school. There is an upward trend in the skilled employment share over the period 1980 to 2000, with some indications that there was a higher rate of increase in the 1980s than the 1990s.[1]

This trend was the result of increases in the employment of workers with degrees and those with other qualifications, such as vocational qualifications (figure 2.2). While employment of workers with degrees increased more in the 1990s than the 1980s, the opposite was the case for workers with other qualifications, the largest proportion of workers with post-school qualifications.[2] In the 1980s, there was a shift toward employment of those completing secondary school, with a further increase in the 1990s. The share of the workforce that did not complete secondary school fell significantly.

Figure 2.1 **Share of total employed[a] with post-school qualifications, 1980 to 2000[b]**

Per cent



a Excluding employed persons still at school. **b** Break in data series in 1992 (see appendix A for details).

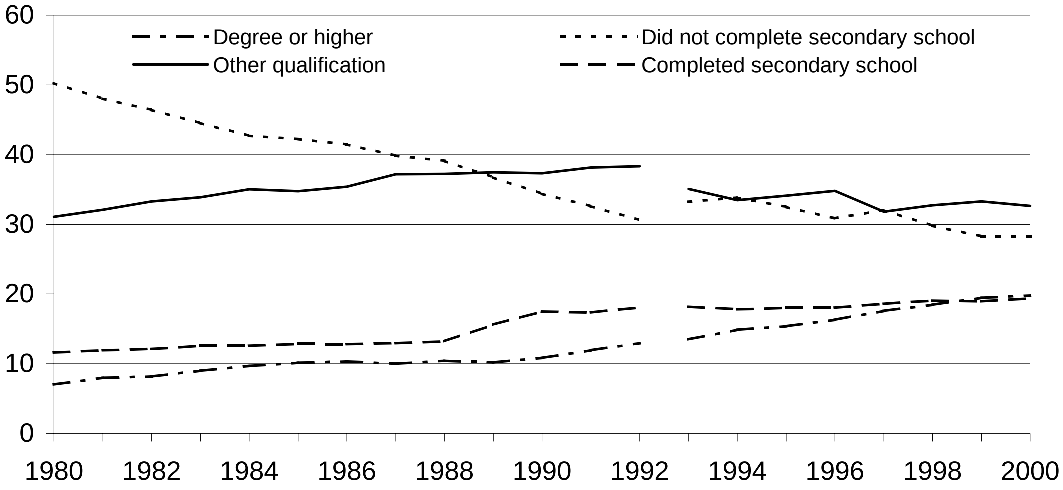
Data sources: Based on ABS (*Labour Force Status and Educational Attainment, Australia*, Cat. no. 6235.0; *Transition from Education to Work, Australia*, Cat. no. 6227.0).

1 The break in series makes comparisons between 1990 and 2000 problematic. A broad guide to the effect of the break in series is provided by the ABS (see appendix A). Broad adjustment of the latter years of the series increases the share of skilled workers to 58 per cent in 2000. This narrows the difference in the growth rate in the skilled share of employment between the 1980s and 1990s.

2 The share of the workforce with other qualifications fell slightly in the 1990s. While this group represents a larger proportion of the total 'with post-school qualifications' category than degree qualifications, growth in the degree group was sufficiently high to offset the decline in the other qualifications group. The overall result was an increase in the total 'with post-school qualifications' category.

Figure 2.2 **Share of total employed[a] by educational attainment level, 1980 to 2000[b]**

Per cent



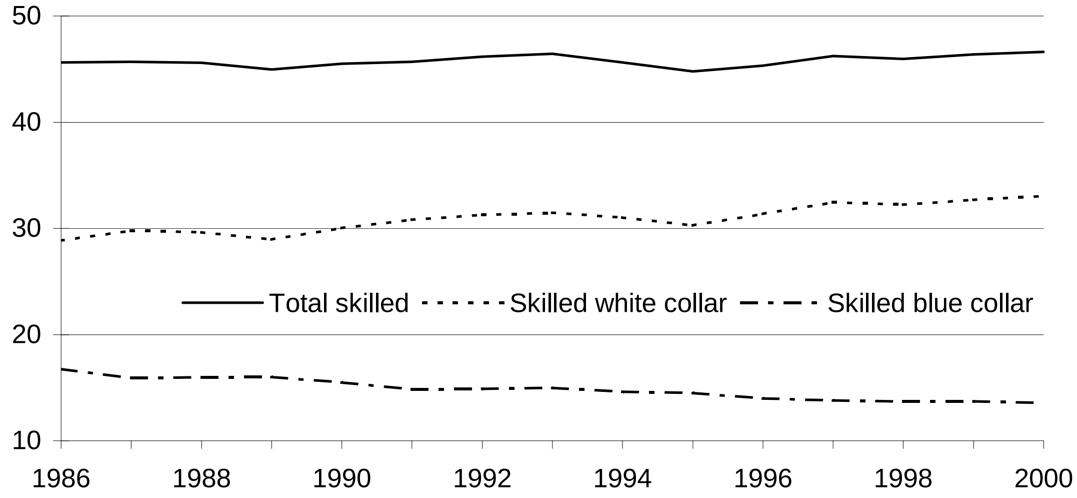
a Excluding employed persons still at school. **b** Break in data series in 1992 (see appendix A for details).

Data sources: Based on ABS (*Labour Force Status and Educational Attainment, Australia*, Cat. no. 6235.0; *Transition from Education to Work, Australia*, Cat. no. 6227.0).

On an occupation-based classification, skilled white collar workers have increased slightly as a share of total employment, but skilled blue collar workers have decreased since 1986[3] (figure 2.3). When added together, the total skilled employment share has risen marginally. A fall in the late 1980s has been offset by a rise in the 1990s. The occupation-based skill classification shows a less pronounced trend (although over a shorter period) than that given by the educational attainment classification of skill. This may reflect a general increase in the skill content of all occupation groups.

3 A major change in occupational classification means that comparable data before 1986 are not readily available.

Figure 2.3 **Share of total employed in skilled[a] occupations, 1986 to 2000[b]**
Per cent



[a] Skilled white collar is the sum of Managers and administrators, Professionals and Para-professionals occupation groups. Skilled blue collar is Tradespersons. [b] Data from 1996 onwards have been converted from Australian Standard Classification of Occupations (ASCO) second edition to ASCO first edition using a broad concordance from ABS (1998).

Data source: Based on ABS (*Labour Force, Australia*, Cat. no. 6203.0).

As noted above, good measures of post-school learning are difficult to obtain. Reilly and Milne (2000) constructed a potential work experience series for Australia, noting that they had found no data on actual work experience. Their potential experience measure is based on age and years of education years (and number of children in the case of females[4]).

The estimated series, presented in figure 2.4, shows an increasing trend in average length of work experience since the early 1980s. This average increased at a faster rate in the 1990s than in the 1980s for males and total persons (in fact for males there was a fall in the 1980s). The opposite was true for females. An increase in the average age of the labour force has been the main factor behind the increase in potential work experience. This potential work experience measure is a component of the analysis in chapter 4 of the effect of skilled employment on productivity performance.

---

4 The number of children is based on unit record data from ABS surveys which record the number of *dependant* children for each female worker. It was assumed that for up to three children one year was spent out of the workforce for each child, but for four or more children the total time out of the workforce was five years. The exclusion of children who are no longer dependants means that the potential experience of some females may be overestimated. The series will reflect declines in fertility rates but will not reflect any changes over time in the amount of time spent out of the workforce per child.

Figure 2.4 **Average potential experience of the workforce[a], 1982-83 to 1997-98[b]**

Years

a Based on wage and salary earners in the market sector of the economy (that is the sector of the economy for which outputs can be measured independently of inputs). **b** Based on data for 1982-83, 1986-87, 1990-91, 1994-95, 1995-96, 1996-97 and 1997-98, with intervening years interpolated.

Data source: Unpublished ABS data based on Reilly and Milne (2000).

Data related to specific skills are also difficult to obtain. Pappas (1998) estimated that between 1976 and 1995 there was a trend increase in the average cognitive and interactive skill level of employed persons in Australia, with an acceleration in trend after the mid-1980s. The trend in motor skills was one of decline, reflecting a decrease in employment of occupations such as tradespersons. These measures are derived by combining estimates of occupation shares of employment with estimates of labour skills required for each occupation. The trends in mean skill levels are therefore subject to cyclical changes in employment shares.

Overall, this range of measures indicates an increasing average skill level of the workforce over the past two decades. However, the choice of skill measure affects whether the period of greatest growth was the 1980s or the 1990s. Table 2.1 summaries the growth rates for the measures examined above. The educational attainment measure shows a faster increase in the 1980s than the 1990s, while the occupation measure shows little change between the mid-1980s and 2000. The potential work experience measure grew faster in the 1990s than the 1980s for employed persons in total, but for females the fastest growth was in the 1980s. In chapter 4, a skill measure constructed by Reilly and Milne (2000), which aggregates measures of education and experience for the workforce of the market sector of the economy, is examined. This aggregate measure shows the period of most growth in skill was the late 1980s and early 1990s.

Table 2.1 **Different measures of skill, 1980s and 1990s**

Measure	*1980*	*1980s growth*	*1990*	*1990s growth*
		Per year per cent		Per year per cent
Education				
Percentage of total employed with post-school qualifications[a]	38.1	2.4	48.1	1.8
Occupation				
Percentage of total employed in skilled occupations[b]	45.6	-0.1	45.5	0.2
Work experience				
Average years of potential work experience of employed in the market sector[c]	16.7	0.5	17.4	1.1

[a] Adjustment has been made for the break in series in the 1990s (see appendix A). [b] 1980s is 1986 to 1990. Data before 1986 are not readily available due to a break in series. [c] 1980s is 1982-83 to 1990-91 and 1990s is 1990-91 to 1997-98. The market sector accounted for 65 per cent of total employment in 1997-98.

Sources: Education measure is based on unpublished ABS data. Occupation measure is based on ABS (*Labour Force, Australia*, Cat. no. 6203.0). Work experience data are unpublished ABS data based on Reilly and Milne (2000).

International perspective

Other countries have also experienced an increase in the skill level of the population. The available evidence suggests that the growth has been stronger in other OECD countries than in Australia.

As noted above, there is a range of skill measures. Comparability of skill measures across countries is particularly problematic and has been the subject of extensive work by researchers. Barro and Lee (2001) provide a dataset of average years of education of the population that have been adjusted for comparability across countries.[5] This education measure is different to that used earlier in the chapter.[6] However, it is the cross-country relativities that are of interest here.

Figure 2.5 presents this measure for major OECD countries for 1980 and 2000. The average years of education in Australia was above the average of this group of countries (represented by the vertical line) in both periods.

Figure 2.6 shows that Australia experienced higher growth in average years of education in the 1990s (0.5 per cent a year) than the 1980s (0.1 per cent a year). For both periods, Australia's growth was lower than the average of the OECD countries

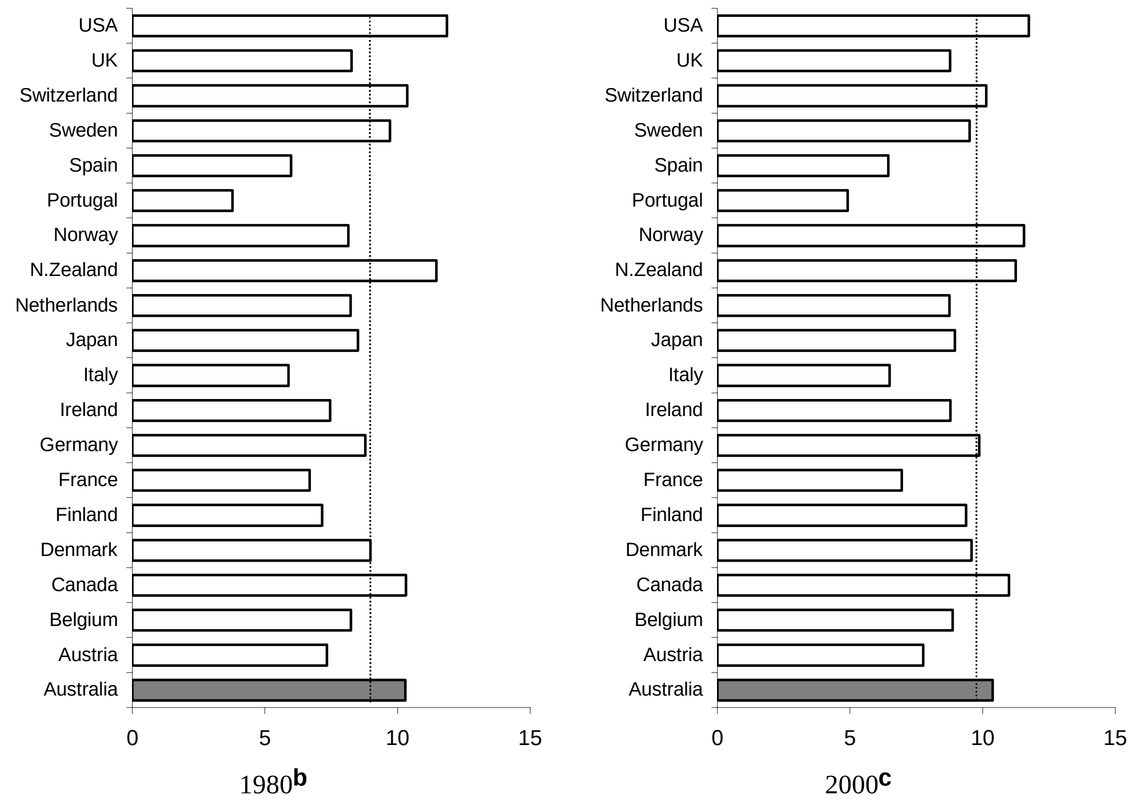
5 These adjustments include taking account of changes in school duration over time within countries.

6 Like other measures of skill, average years of education has its limitations. For example, distributional changes in educational attainment can be offsetting and not show up in the average.

shown. Across the sample of major OECD countries, some experienced significant growth in average years of education in the 1980s. However, in some cases, particularly Portugal, this growth was from a low initial average in 1980. Those countries that already had high average years of education by 1980, such as the United States and New Zealand, had limited scope for growth and experienced moderate or even negative growth.

Overall, it appears that Australia started from a relatively high base in 1980, but its growth in average years of education during the 1980s and 1990s was below the average of major OECD countries.

Figure 2.5 **International comparison, average years of education of the population aged 15 years and over, 1980 and 2000[a]**
Years

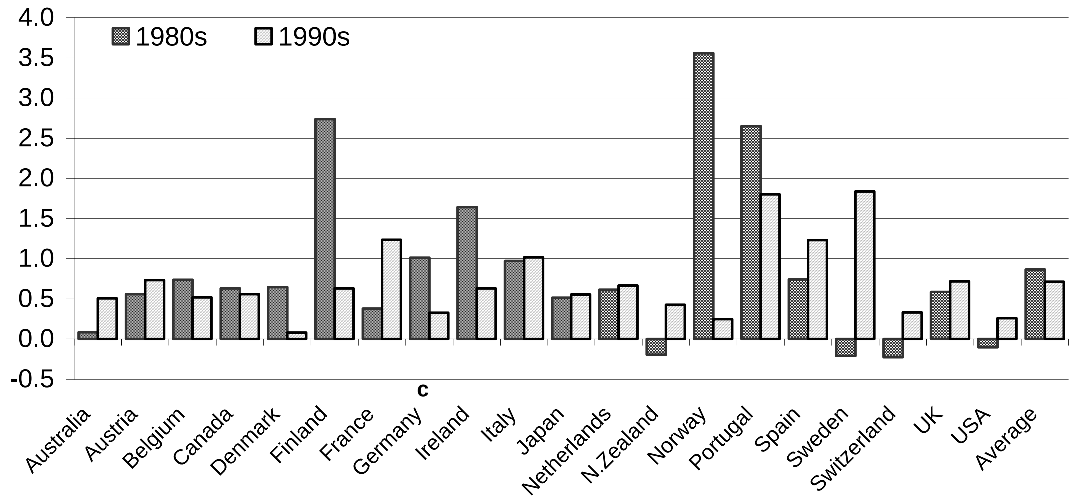


[a] Vertical line is the average of the group of countries. [b] Germany is West Germany. [c] Germany is unified Germany.

Data source: Barro and Lee (2001).

Figure 2.6 **International comparison, growth in average years of education of the population aged 15 years and over, 1980s[a] and 1990s[b]**

Per cent per year



a 1980s growth is average annual growth between 1980 and 1990. **b** 1990s growth is average annual growth between 1990 and 2000. **c** West Germany for the 1980s and unified Germany for the 1990s.

Data source: Barro and Lee (2001).

3 Balance between the supply of and demand for skilled labour

The trends over the last 20 years in the skill structure of the workforce examined in chapter 2 represent the outcome of significant changes in both the demand for and supply of skilled and unskilled labour. This chapter provides a more formal examination of changes in the balance between the demand for and supply of skilled workers relative to unskilled workers. Two approaches are taken. The first is to look at relative demand and supply purely in terms of numbers of workers. The second is to apply a framework, developed by Nickell and Layard (1998), that also takes account of the different marginal products or efficiency of different skill groups.

3.1 Trends in the demand for and supply of skilled labour in Australia

The actual skill composition of employment is dictated by the interaction of demand and supply, both of which are affected by the range of factors outlined in chapter 2. Any change in the demand for skilled labour relative to unskilled labour, which is not matched by change in relative supply, will translate into some combination of a relative wage movement and a relative unemployment movement. The wage setting mechanism for each skill group (that is, how wages respond to excess demand/supply in each of the labour markets) will determine the particular combination of relative wage and unemployment movements. For example, if there is complete relative wage rigidity, all the shift in relative excess demand will go into unemployment changes.[1]

In this chapter, skill is measured in terms of the level of educational attainment. The following figures examine changes in the skilled labour market, measured in terms of workers with post-school qualifications (details of this skill classification are provided in appendix A). As demonstrated in chapter 2, there is a variety of ways of defining skill and a more limited number of proxies for measuring it.

[1] In principle, divergence in changes in relative demand and supply could also lead to change in relative vacancy rates. However, over periods of comparatively high unemployment, changes in relative unemployment are more likely.

Figure 3.1 **Skilled employment as a share of total employment and skilled labour force as a share of total labour force[a], 1980 to 2000[b]**

Per cent

a Excluding persons in the labour force who are still at school. **b** Break in data series in 1992 (see appendix A for details).

Data sources: Based on ABS (*Labour Force Status and Educational Attainment, Australia*, Cat. no. 6235.0; *Transition from Education to Work, Australia*, Cat. no. 6227.0).

Figure 3.1 shows the upward trend in the demand for skilled labour as a share of total labour demand[2], together with the increase in the skilled labour supply as a share of total labour supply. The skilled labour force share has increased broadly in line with the increase in the skilled employment share. There has been a strong increase in the retention rate at secondary schools and in the number of students going on to complete tertiary education.

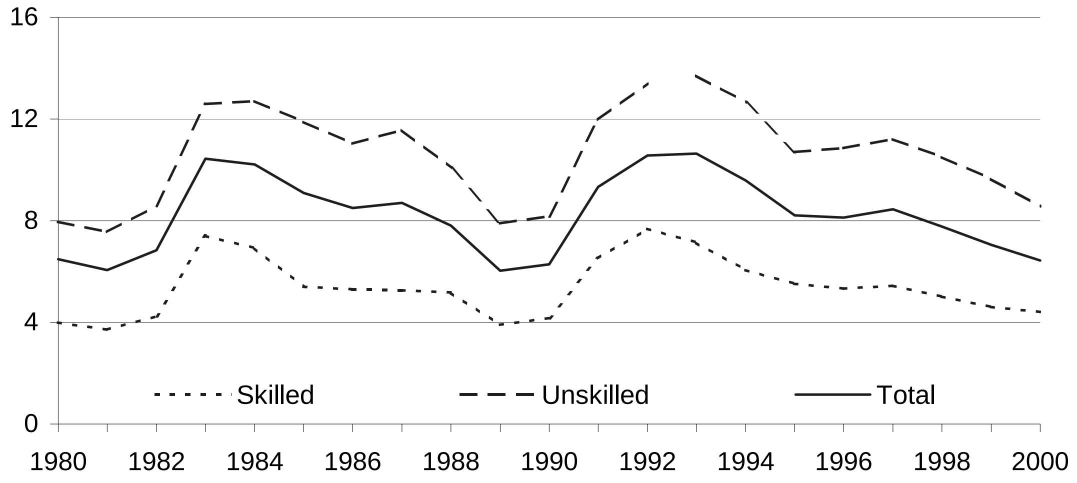
Figure 3.2 shows that the unskilled unemployment rate is higher than the skilled unemployment rate, with both fluctuating in a relatively stable way. Figure 3.3 further demonstrates that, despite the increased relative demand for skilled labour, the relative unemployment rate (of skilled to unskilled workers) has been reasonably stable.[3] As noted by Vickery (1999), shifts in unemployment of both skilled and unskilled labour appear to be for reasons unrelated to relative demand

2 Demand is proxied by employment. A more appropriate measure of labour demand would be the sum of employment and vacancies, but data on vacancies disaggregated by educational attainment are not readily available.

3 There are different views on whether relative unemployment rates have gone up for unskilled workers depending on the level of aggregation and proxy used for skill (see de Laine, Laplagne and Stone (2000)). For example, Pappas (1998) shows increases in unemployment rates for workers with motor skills compared with those with interactive skills.

shifts across skill groups, with changes in unemployment rates for different skill groups mainly determined in the short run by the state of the business cycle.

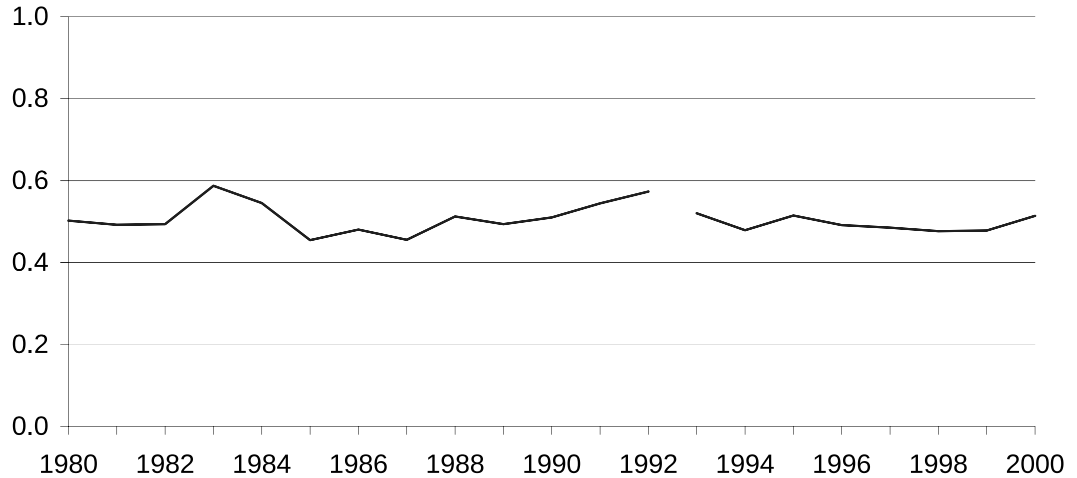
Figure 3.2 **Skilled, unskilled and total unemployment rates[a], 1980 to 2000[b]**
Per cent



a Excluding persons in the labour force who are still at school. **b** Break in data series in 1992 (see appendix A for details).

Data sources: Based on ABS (*Labour Force Status and Educational Attainment, Australia*, Cat. no. 6235.0; *Transition from Education to Work, Australia*, Cat. no. 6227.0).

Figure 3.3 **Ratio of the skilled unemployment rate to the unskilled unemployment rate[a], 1980 to 2000[b]**

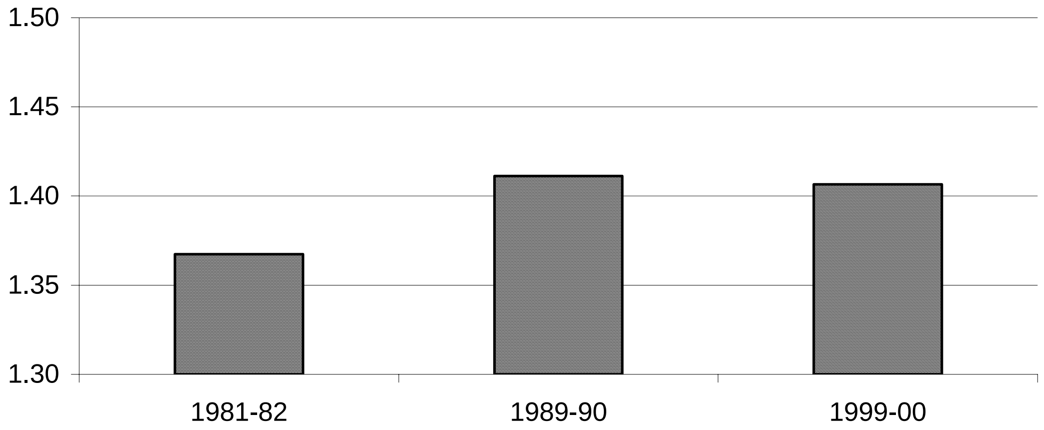


a Excluding persons in the labour force who are still at school. **b** Break in data series in 1992 (see appendix A for details).

Data sources: Based on ABS (*Labour Force Status and Educational Attainment, Australia*, Cat. no. 6235.0; *Transition from Education to Work, Australia*, Cat. no. 6227.0).

Figure 3.4 also supports this finding, showing fairly stable relative wages. Studies, such as Borland (1998) and Vickery (1999), which examined relative wage changes in terms of demand and supply shifts, found that wage differentials by skill (measured in terms of educational attainment and occupation) had not changed significantly over the 1980s and the early to mid-1990s.[4] Both found that while the increase in skilled employment in Australia is consistent with an increase in the demand for educated labour (rather than being supply driven), substantial increases in supply over the period since the 1970s helped contain any pressure for changes in wage relativities between skill groups. Vickery (1999) noted that, while earnings inequality in a broader sense did increase over this period, this was not due to an increase in returns to observable skill factors. Examining a later period, de Laine, Laplagne and Stone (2000) found that growth in wages of high-skilled[5] workers was only 4 percentage points higher than that for all other occupations between 1986 and 1998. More recent work by Borland, Gregory and Sheehan (2001), does show a larger increase in the earnings of workers in high-skilled occupations relative to workers in low-skilled occupations to 2000. But this does not appear to show up when skill is measured in terms of broad educational attainment levels.

Figure 3.4 **Skilled wages as a proportion of unskilled wages[a], 1981-82, 1989-90 and 1999-00[b]**



[a] Usual weekly wages for employed persons *with* post-school qualifications as a proportion of usual weekly wages for employed persons *without* post-school qualifications. Based on employed persons aged 15-64 with current earned income, excluding employed persons who are still at school. [b] No adjustment has been made for break in data series in 1992 (see appendix A for details).

Data source: Based on ABS (*Survey of Income and Housing Costs,* unpublished data).

[4] Again, at a different level of aggregation and using a different skill definition, Pappas (1998, p. 276) found that between 1986 and 1991 male average earnings for interactive skills rose more than average earnings for cognitive skills, which in turn rose more than average earnings for motor skills. However, between 1991 and 1995 these earnings differences narrowed slightly.

[5] High-skilled was defined as Managers and administrators, Professionals and Para-professionals (as defined in the ABS Australian Standard Classification of Occupations, first edition).

3.2 Taking account of the efficiency of skill groups

While the background in section 3.1 shows that the demand for and supply of skilled labour have been moving together, the purpose of the rest of this chapter is to examine this more formally and to take account of the efficiency of different skill groups.

Framework

Employers regard skill groups differently — workers in different skill groups have different marginal products and are not perfect substitutes. Nickell and Layard (1998) set out a framework that explicitly incorporates skilled and unskilled labour and measures relative demand in terms of demand in each skill category weighted by relative wages (to reflect relative marginal products).

This framework can be used to examine the extent to which changes in the demand for skilled workers relative to unskilled workers have been matched by changes in relative supply. It also identifies the relative wage and unemployment outcomes in response to these shifts. And by examining the skilled labour market relative to the unskilled labour market it is possible to abstract from changes that affect the skilled and unskilled labour markets in a similar way (for example, cyclical and general growth effects).

The basic model can be summarised as:

shift in relative demand for skilled workers	–	shift in relative supply of skilled workers	=	relative wage movement	+ relative unemployment movement	(1)

The details of the derivation of this framework are provided in appendix A. The left-hand side of equation (1) establishes whether, and the extent to which, there is a shift in relative excess demand for skilled labour. The right-hand side shows how the shift in relative excess demand can be divided between relative wage and relative unemployment effects. In rigid labour markets, relative unemployment effects will dominate. In flexible labour markets, relative wage effects will dominate.

The shift in relative demand is estimated as the ratio of the share of skilled labour in total labour costs to the share of unskilled labour in total labour costs. This is a function of skilled and unskilled employment and relative wages. Based on the assumption that workers are paid their marginal product, employment in each skill category is weighted by the wage for that skill group.

Nickell and Layard defined skill in terms of educational attainment and this is the definition used in this chapter.[6] Specifically, skilled is defined as 'with post-school qualifications' and unskilled is defined as 'without post-school qualifications'. This skill classification is at a broad level of aggregation and obviously will not allow the identification of skill shortages or surpluses in particular occupations or industries.

Results

Nickell and Layard examined a number of OECD countries over various periods from the mid-1970s to the early 1990s. They found that relative demand and supply in Australia, over the period 1978-79 to 1989-90, had shifted by similar amounts. The increase in relative supply was only slightly greater than the increase in relative demand. This was in contrast to a number of other OECD countries, such as the United Kingdom and the United States, where increases in relative demand outstripped increases in relative supply by significant amounts.

Applying the Nickell and Layard framework to the 1990s allows comparison with the 1980s. To improve comparability of data, and allow extension of the Nickell and Layard approach, the 1980s period has also been re-estimated using a slightly shorter period (1981-82 to 1989-90).[7] Results for the 1980s and 1990s are presented in table 3.1.

Table 3.1 is organised as follows. Columns 1 to 4 show the annual average change in each of the elements of equation (1). Column 5 provides the resulting net average annual percentage change in relative demand less relative supply (which is equal to the sum of the movements in relative wages and relative unemployment).

The results refer to *relative* movements in demand, supply, wages and unemployment. A negative movement in relative wages, for example, does not necessarily indicate any decline in wages in absolute terms. And zero movement in relative unemployment gives no indication of whether aggregate unemployment has grown or declined. A negative movement in the relative unemployment term indicates an increase in the unemployment rate of skilled workers relative to unskilled workers.[8]

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6 Direct measurement of skill is difficult and proxies, such as educational attainment, have their disadvantages (as discussed in chapter 2). However, one advantage of the use of educational attainment in this framework is that it is characteristic of the person rather than their employment. This allows easier classification of the unemployed than for some alternative measures.

7 Sufficient data were unavailable for the years before 1981-82.

8 Because this term is $(1-u_1)/(1-u_2)$, it will be negative (positive) if u_1 rises (falls) faster than u_2. See appendix A for further details. For all other changes (columns 1 to 3), a negative change indicates a relative decrease.

Table 3.1 **Changes in the demand for and supply of skilled workers relative to unskilled workers[a], 1980s[b] and 1990s[c]**

Per cent per year

	1	2	3	4	5
Period	*Change in relative demand*	*Change in relative supply*	*Relative wage[d] movement*	*Relative unemployment movement*	*Net change[e] (1-2 = 3+4)*
1981-82 to 1989-90	3.76	3.41	0.40	-0.05	0.35
1989-90 to 1999-00	3.52	3.73	-0.29	0.07	-0.22

a Assumes an elasticity of substitution between skilled and unskilled labour of 1. Results based on alternative assumptions are presented in appendix A. **b** The 1980s period in this table (1981-82 to 1989-90) is shorter than the 1980s period discussed in section 3.1 and results are therefore not directly comparable. **c** The data used for 1999-00 have been adjusted for the break in series shown in section 3.1 so results in this table are not directly comparable with results reported earlier. **d** A negative movement in *relative* wages does not necessarily mean a decline into the *absolute* wages of skilled workers, but can just be the result of a decline in the relative position of skilled workers **e** Components may not add to total due to rounding.

Source: Productivity Commission estimates based on unpublished ABS data from the Labour Force Survey and Survey of Income and Housing Costs.

Between 1981-82 and 1989-90, relative demand and relative supply shifted by similar amounts, but with the increase in relative demand slightly in excess of the increase in relative supply.[9] Consequently there was a small rise in relative wages. In the 1990s, movements in relative demand and relative supply were again similar, but this time the increase in relative supply was slightly in excess of the increase in relative demand. Relative wages fell slightly. The relative unemployment rate was virtually unchanged in both the 1980s and 1990s.

The data and assumptions used in this analysis were varied in a number of ways. These alternative results are detailed in appendix A. The main variations were to use hours worked as the measure of labour, rather than numbers of people, and to examine a narrower definition of skill.

Overall, the results using hours worked were fairly similar to those based on numbers of workers. A change in the relative hours worked would be necessary to change the results compared with those based on numbers of workers. When measured on an hourly basis, an increase in relative hours increases the change in relative supply and lowers the relative wage movement.[10] There was little change in relative hours worked during the 1990s but, in the 1980s, there was higher growth in hours for the skilled group than for the unskilled group. As a result, in the 1980s

9 This is a different net effect to the Nickell and Layard (1998) estimates for the period 1978-79 to 1989-90. But again, the result is very close to balance between changes in relative demand and relative supply.

10 Limitations related to the hours data used in this paper are discussed in appendix A.

the estimates based on hours worked showed an increase in relative supply slightly in excess of the increase in relative demand (the opposite to estimates based on the number of workers). However, taking account of the small size of the changes, data limitations and the possibility of measurement error, the appropriate interpretation of estimates based on both methods is probably that movements in relative demand and relative supply were close to being in balance.

The results based on a narrower definition of skill — high-skilled (those with degree qualifications or higher) relative to all other workers — were more divergent. The magnitude of changes in both the demand for and supply of high-skilled workers relative to all other workers was larger than for the broader skill split — growth for high-skilled workers was faster than growth for other skilled workers. However, in general, the difference was larger for relative demand than for relative supply. This meant that, compared with the broader skill split, the narrow skill split accentuated relative excess demand or muted relative excess supply. But again, given the small variations between results, the limitations of the data and the possibility of measurement error, the results do not differ dramatically when the skill definition is changed.

3.3 Summary

Overall, in both the 1980s and 1990s, changes in relative demand and relative supply kept pace with each other to a large extent. While the different definitions of skill and labour units affect whether relative demand growth is slightly greater than relative supply growth or the opposite, the differences are small, particularly when data limitations are considered. The differences between the results for the narrow and broad definitions of skill highlight that growth is fastest in the high-skilled end of the labour market.

The response to the small differences that do exist between growth in relative demand and relative supply was largely through the relative wage movement. Small relative wages shifts occurred in both the 1980s and 1990s. Using the numbers employed approach, relative wages rose slightly in the 1980s, but using the hours worked approach they fell. This reflects a rise in the relative hours worked in the 1980s. In the 1990s, when relative hours worked were fairly constant, relative wages fell or were stable under both methods. There was virtually no change in relative unemployment throughout the results.

These results are broadly consistent with findings of earlier studies of the 1980s and early 1990s, and show a continuation of the early 1990s trend to the end of the 1990s. For example, Vickery (1999) found that wage relativities between skill groups remained fairly constant over the 1980s and early 1990s and Borland (1998) found that changes in relative earnings in different education/experience groups had a slightly compressing effect on the distribution of earnings between the early 1980s and mid-1990s.[11] Vickery (1999) also found stable relative unemployment rates up to the early 1990s.

11 These studies examine skill at a similar level of aggregation as this paper. As noted earlier, studies, such as Pappas (1998), which examine skill at a more disaggregated level can show more movement in relative earnings and unemployment levels.

4 The influence of skill on productivity

This chapter explores the influence of the increase in skills in the Australian workforce on Australia's productivity performance. Drawing on experimental ABS estimates, it seeks to determine whether increased skills have accounted for much of Australia's 1990s productivity surge.

A growth accounting framework, as commonly used in official productivity estimates (for example, by the Bureau of Labor Statistics (BLS) in the United States and the Australian Bureau of Statistics (ABS)), is employed. The first step is to construct a measure of aggregate labour input that takes account of changes in the skill composition of the workforce. Experimental estimates constructed by the ABS are used for this purpose. The second step is to determine what difference this labour input measure makes to estimates of productivity growth, compared with the standard ABS practice of measuring labour input as the sum of hours worked by all individuals. This difference indicates the extent to which the increase in workforce skills accounts for measured productivity growth.

The growth accounting framework captures only a limited view of the importance of skills in promoting productivity growth. The chapter outlines the limitations.

4.1 Labour services: taking account of changes in skill composition

The ABS publishes annual productivity estimates for the market sector[1] of the economy as part of the National Accounts (ABS Cat. no. 5204.0). The labour input measure currently used by the ABS in forming its productivity estimates is simply the sum of total hours worked across the market sector — a labour *quantity* input measure. Each unit of labour input (hour worked) is treated as generating equal output. Labour is assumed to be homogeneous.

When a labour quantity input measure is used in estimation of productivity growth, the effect of a shift in skill composition toward the skilled on output growth is captured in higher productivity growth and not higher labour input growth.

[1] The market sector comprises those sectors for which outputs can be measured independently of inputs. For example, Agriculture, Manufacturing and Accommodation, cafes and restaurants.

Accounting for changes in composition of the workforce as 'embodied' increases in labour input would make productivity estimates more accurate and representative of actual 'disembodied' improvements in productivity. An outline of the growth accounting framework is provided in box 4.1.

The ABS has been experimenting with labour input measures that capture changes in the skill composition of labour input, and therefore measure the flow of labour services and not just the quantity of hours worked. Allowing for changes in the skill composition of employment would allow the influence of changes in skills to be factored out of traditional productivity measures. This is standard practice, for example, in BLS procedures for constructing US productivity estimates.

Box 4.1 **Framework for analysis of changes in skill composition**

Growth in labour services is equal to growth in labour quantity plus the change in the skill composition of labour. The contribution of skill composition to output growth and productivity growth is equal to the change in skill composition multiplied by the labour income share. These relationships can be demonstrated using the following Cobb-Douglas function

$$Y = AK^{\alpha}L^{1-\alpha}$$

where output (Y) is a function of capital (K), labour services (L) and multifactor productivity (A).

Taking the log of this function and converting to growth rates

$$y = a + \alpha k + (1-\alpha)l$$

where $l = l_{sc} + h$, that is, growth in labour services (l) is equal to growth in labour quantity (h) and growth in skill composition (l_{sc}).

It is assumed that the output elasticities are equal to the factor shares, s_k and s_l, therefore

$$y = a + s_k k + s_l l_{sc} + s_l h$$

Now expressing in terms of labour productivity growth

$$y - h = a + s_k k - s_k h - (1 - s_k)h + s_l h + s_l l_{sc}$$

Which simplifies to

$$y - h = a + s_k(k-h) + s_l l_{sc}$$

Therefore, labour productivity growth is equal to multifactor productivity growth, plus capital deepening ($s_k(k-h)$) plus the contribution of changes in skill composition ($s_l l_{sc}$).

Why adjust for changing skill composition?

In reality labour is not homogeneous. Some workers, whether it be on the basis of their experience or their education level, will generate more output for each hour worked than other workers. For example, an hour worked by an experienced professional with a high level of education, such as a doctor or engineer, will generate more output than an hour worked by a worker recently out of high school with no work experience. Workers with more experience or a higher level of education can be thought of as having higher marginal products — at the margin, an hour of their input will generally produce more output.

In this chapter, changes in the skill profile of the labour force are referred to as changes in skill composition. In other literature, this is often referred to as changing labour 'quality'. However, this term can have negative connotations. Gordon (2000, p. 215) stated:

> … it is positively offensive, not to mention politically incorrect, to describe the 1970s shift in the composition of the labour force towards a greater percentage of females as a shift to lower quality. The preferred word, "composition"… is neutral and describes the outcome of a particular weighting scheme.

Essence of the methodology

The ABS recently released experimental estimates of a labour services measure that accounts for changes in skill composition (ABS 2001).[2] The estimation method used by the ABS is similar to that already being used by the BLS in the United States. The ABS method distinguishes between labour force groups on the basis of skill. Groups are defined by educational attainment, work experience and gender. Work experience is used as a proxy for the on-the-job training and skill development that workers receive while employed. The gender distinction accounts for any differences in the productivities of males and females in different educational attainment and experience groups.[3]

While it is assumed that differences in the skill level between workers result in differences in marginal products, these differences are very difficult to observe directly. The ABS has assumed that these differences can be observed indirectly

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[2] The ABS has already incorporated the equivalent on the capital side, a new measure of capital services, into productivity estimates. Capital services is considered to be a conceptually superior method as it captures the flow of economic services from assets over time. This compares with the previous method, capital stock, which is a wealth measure.

[3] Differences in male and female experience levels due to females taking time out to have children and the higher proportion of females in part-time work are the main reasons why the ABS decided to have separate male and female wage regressions.

through differences in wage rates. This is based on the assumption that, in competitive markets, firms will pay workers according to their marginal product. And so, wage rate differences reflect productivity differences.

The relative wages of the different labour groups are used as weights to aggregate the hours worked by each group to form an aggregate labour services measure. With the assumption that wages reflect marginal products, the labour services measure reflects the different productivities of the hours worked by the different groups. The greater the education level and experience a classification of worker has, the greater will be the corresponding wage level and the greater will be the weighting in the labour services input index. A shift in composition toward skill will shift the aggregate labour services measure further above the aggregate hours worked measure.

Whilst the ABS methodology is largely similar to the framework used by the BLS, one major difference is the estimation of the work experience measure. The BLS is able to use data on actual work experience, but these data are not available in Australia. Instead potential experience is calculated, based on age, years of education and the number of children in the case of female workers.[4] This measure regards education years and work experience years as mutually exclusive and therefore will not capture work experience gained whilst studying, such as from part-time employment. Further details of the ABS methodology can be found in appendix B and are fully detailed in an ABS staff paper (Reilly and Milne 2000).

ABS estimates

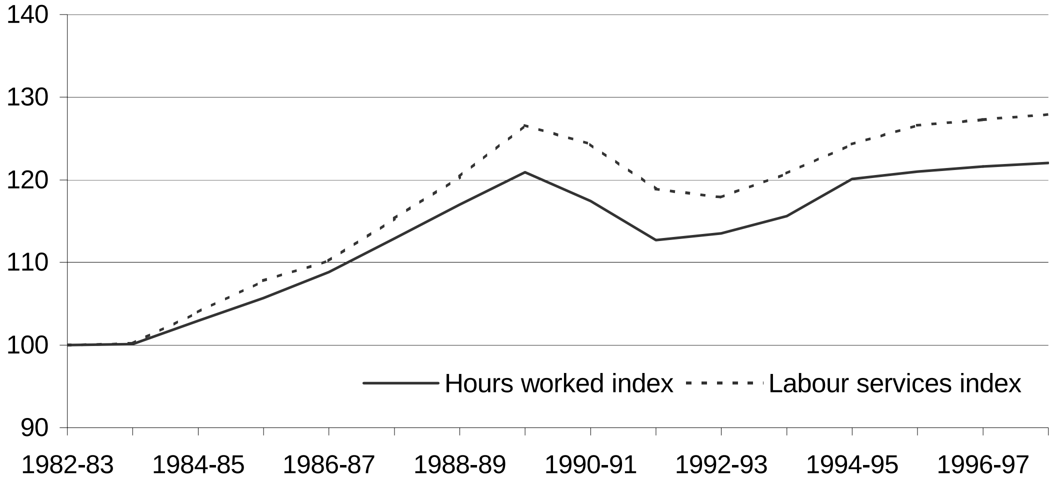
Figure 4.1 shows ABS estimates of a labour services input index for the period 1982-83 to 1997-98.[5] Over this period, hours worked grew by 1.3 per cent a year, while the adjusted labour input index grew by 1.6 per cent a year. This result indicates an increase in skill composition of 0.3 per cent a year over the entire period. However, the majority of that compositional shift occurred in the late 1980s and early 1990s.

4 Potential experience = Age – 5 – Education Years − (Number of children). The relationship between age and experience is not linear as the wage regression involves diminishing returns to experience. This issue is discussed in more detail in box 1.

5 The experimental labour input series uses data from the Income Distribution Survey (IDS) for the years 1982-83, 1986-87 and 1990-91. As this survey was conducted only at four year intervals, the data points between these years have been interpolated. The method of interpolation used by Reilly and Milne is detailed in appendix C. The Survey of Income and Housing costs replaced the IDS in 1994-95. This is an annual survey. Data for years 1994-95 to 1997-98 are taken from this survey.

Figure 4.1 **Labour input indexes, 1982-83 to 1997-98**

Index 1982-83 = 100



Data source: Unpublished ABS data based on Reilly and Milne (2000).

Growth attributable to the change in skill composition was strongest in the late 1980s and the start of the 1990s and weakest in the mid-1990s. Table 4.1 identifies trends in four sub-periods, as examined in Reilly and Milne (2000).[6] The period of strongest shift in skill composition towards the skilled was 1986-87 to 1990-91, with growth of 1.1 per cent a year. Conversely, in the following period, skill composition growth was negative at –0.6 per cent a year.

Table 4.1 **Growth in hours worked and labour services, 1982-83 to 1997-98**

Per cent per year

	Growth in hours worked index	*Growth in labour services index*	*Skill composition change*
1982-83 to 1986-87	2.1	2.4	0.3
1986-87 to 1990-91	1.9	3.0	1.1
1990-91 to 1994-95	0.6	0.0	-0.6
1994-95 to 1997-98	0.5	0.9	0.4
1982-83 to 1997-98	1.3	1.6	0.3

Source: Unpublished ABS data based on Reilly and Milne (2000).

As noted by Reilly and Milne (2000), there are interesting links to be made between changes in skill composition and the business cycle. During an economic downturn the composition of labour would be expected to shift toward the skilled as firms lay

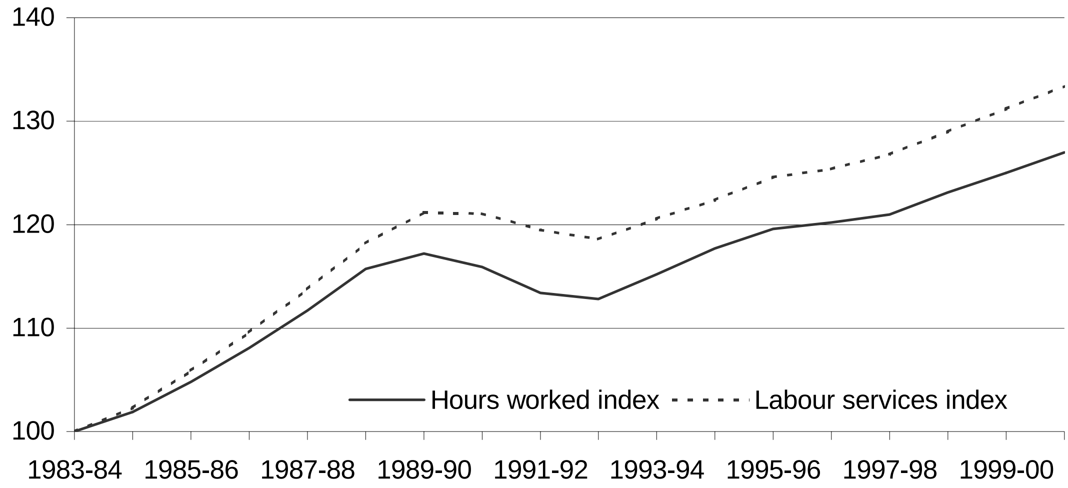
[6] These periods are based on the IDS survey years up to 1994-95.

off unskilled workers, whereas during an expansion the reverse would be true. When an economy is coming out of a recession and as labour demand expands generally, firms will recall less productive workers.

The Australian experience in the 1980s and 1990s illustrates the cyclical effect. There was growth in skill composition at the beginning of the economic downturn of the early 1990s. And, during the period of strong economic recovery and growth in the mid-1990s, there was negative growth in skill composition as strong employment growth led to the pick up of lower-skilled workers.

In 2001, the ABS published a smoothed labour services input series for 1983-84 to 2000-01 (figure 4.2). The additional years (1998-99 to 2000-01) were simply extrapolated from a revised version of the series developed by Reilly and Milne. The rest of the analysis in this chapter concentrates on the period up to 1997-98 only based on the revised Reilly and Milne data.

Figure 4.2 **Smoothed labour input indexes[a], 1983-84 to 2000-01**
Index 1983-84 = 100



a Data smoothed using a three year moving average. Data for the labour services index for years 1998-99 to 2000-01 have been extrapolated.

Source: ABS (2001).

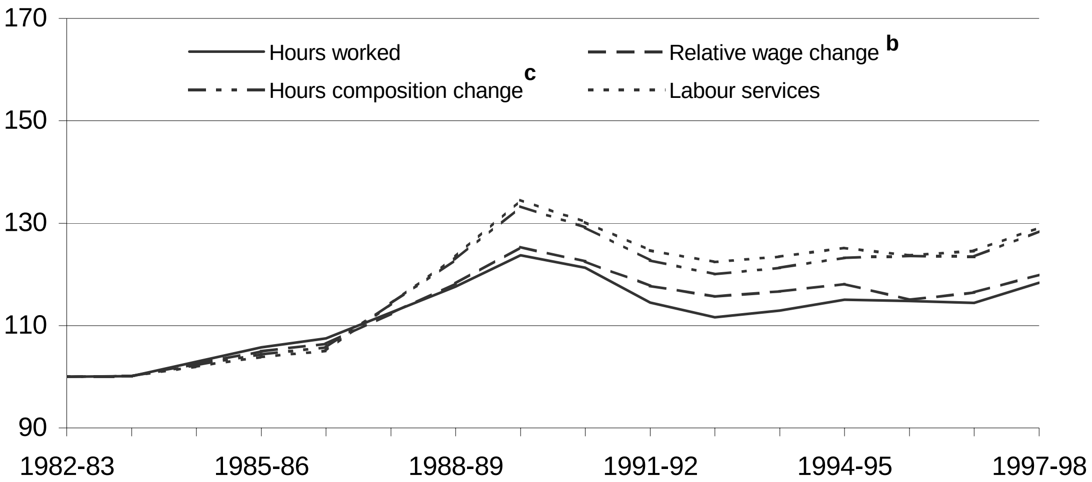
The influence of the components of skill change

Change in skill composition can be the result of two different influences. Firstly, it can be the result of a change in the relative hours worked by skill groups. For example, relative growth in hours worked in high-skill groups, with their associated higher wages, will cause growth in skill composition. Secondly, skill composition change could be the result of a change in relative wages. For example, if the return to skill increases the weighting on higher-skilled hours increases. The analysis in chapter 3 indicates that over a similar period there was little movement of relative wages between skill groups, and therefore changes in relative wages are not expected to have had a major influence on skill composition change.

The quantity and wage effects can be separated. The results of these calculations are shown in figures 4.3 and 4.4. Two indexes have been estimated. The first is an index of labour services where only the composition of hours is allowed to change (relative wages held constant). The second is an index of labour services where only the relative wages are allowed to change (composition of hours held constant). Indexes have been calculated for males and females separately, rather than for persons.[7] For both males and females, growth in the index of hours composition has been strong compared with growth in the index of relative wages. This indicates that the main influence on labour services in this period was change in the composition of hours worked rather than change in relative wages. Further details about this method and results can be found in appendix C.

Figure 4.3 **Labour input indexes adjusted for component influences[a], males, 1982-83 to 1997-98**

Index 1982-83 = 100



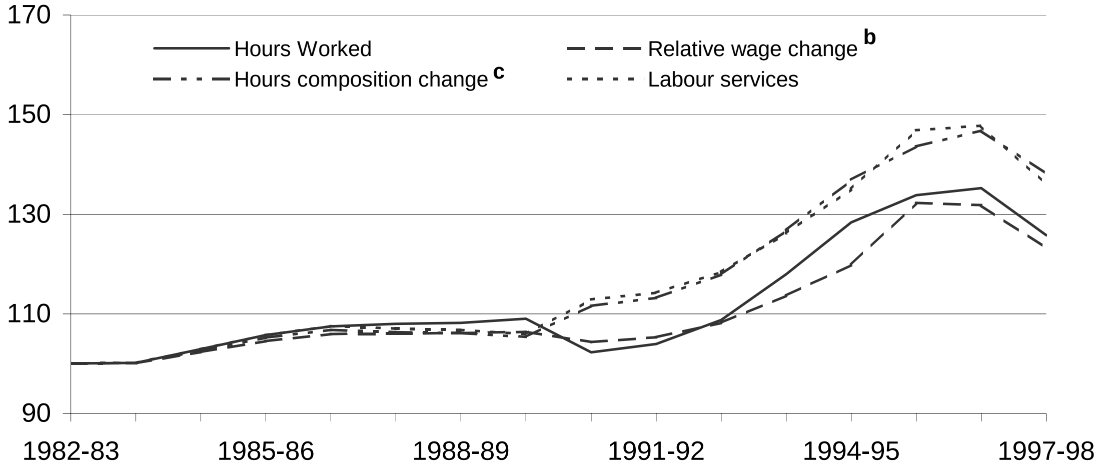
[a] Data used for component analysis cannot be fully reconciled with ABS published estimates for persons. The ABS made other adjustments to the data. Nevertheless, this analysis is considered indicative of the contributions from wage and composition change. [b] Composition of hours held constant. [c] Relative wages held constant.

Data source: Productivity Commission estimates based on ABS unpublished data.

[7] Indexes were calculated for males and females separately rather than for persons because of data limitations (see appendix C).

Figure 4.4 **Labour input indexes adjusted for component influences[a], females, 1982-83 to 1997-98**

Index 1982-83 = 100



a Data used for component analysis cannot be fully reconciled with ABS published estimates for persons. The ABS made other adjustments to the data. Nevertheless, this analysis is considered indicative of the contributions from wage and composition change. **b** Composition of hours held constant. **c** Relative wages held constant.

Data source: Productivity Commission estimates based on ABS unpublished data.

4.2 Influence of skill on productivity

Measurement of labour input as labour services rather than quantity of hours worked has implications for productivity estimates. Productivity growth can be thought of as the difference between output growth and input growth. If the measure of labour input is a labour services measure, and this shows stronger growth than an hours worked measure, there will be commensurately lower growth in measured productivity.

It should be noted that even after using a labour services measure of labour input, the growth accounting approach does not take full account of the effect of changes in the skill of the labour force. The growth accounting approach is more aligned with the neoclassical approach in which productivity growth is treated as exogenous. Labour and investment in human capital can only affect the level of output. However, there is a line of argument that education and skill development affects the rate of innovation and therefore the rate of output growth (box 4.2).

Box 4.2 **The influence of skill on productivity: a brief review of theory**

Dowrick (2002) provides an overview of the theoretical and empirical literature on how workforce skills fit into models of economic growth. He covers both neoclassical and endogenous growth approaches. He characterises the neoclassical growth model as relating inputs of labour and capital to output, with productivity growth exogenous — that is, determined by factors outside of production decisions and activities. Accumulation of capital is the engine of growth in the short run, but growth will eventually revert to a fixed rate determined by exogenous productivity growth, or technological progress.

Endogenous growth models differ from neoclassical models by assuming that factors within the production process, such as human capital accumulation, can determine the long-run growth rate. Dowrick points to three main features of human capital accumulation which allow it to influence long-run growth — complementarity, dynamic feedback and non-rivalry.

Complementarity of investment in human capital means that the productivity of any worker is enhanced not only by their individual level of skill but also by the average skill level amongst their fellow workers. Whilst an individual may have made the decision to invest in skills for their own benefit (through increased wages), there are positive network externalities to this investment. For example, learning to read and write is of greater benefit to an individual if others have the same skills.

Complementarity alone is not sufficient to drive growth. However, if there is sufficient positive dynamic feedback in education, the level of human capital can influence long-run growth. Dynamic feedback relates to the idea that as individuals learn and acquire more skills it becomes easier for them to acquire further knowledge and skills. Therefore the rate of change in human capital is, in part, a function of the stock of human capital that already exists.

For dynamic feedback to make human capital a driver of long-run growth the feedback effect needs to be sufficiently strong, and there needs to be no limit to the accumulation of human capital. Dowrick indicates that this may be possible when the distinction is made between embodied and disembodied human capital. Embodied human capital is the skills and abilities that are held by individuals, such as the ability to drive a car. Disembodied human capital is the world of knowledge and ideas that, once released in the public domain by an individual, do not necessarily disappear when they die. These ideas can have similar properties to public goods, such as non-rivalry. They are also cumulative. Ideas and knowledge in the pubic domain can be developed and built upon by others. Whilst embodied human capital presents itself in the relationship between education and wages, disembodied human capital has a wider effect on long-run growth.

(Continued next page)

Box 4.2 (continued)

Another feature of human capital, which allows it to influence long-run growth, is the effect on the absorption of technology. This feature, similar to dynamic feedback, suggests that the absorption of new technology is related to existing skills and abilities, both at the firm and individual level. Goodwin and Johnston (1999) suggest that a firm's capacity to absorb new technology from external influences relies on factors within the organisation, such as the level of educated labour. Cohen and Levinthal (1990) argue that the ability of the firm to exploit external knowledge is largely a function of the level of related knowledge and abilities. These abilities constitute the firm's 'absorptive capacity'. The firm's absorptive capacity will depend on the absorptive capacities of its individual members. Therefore, the investments made by the individual benefit the firm by enabling it to better utilise external technological influences.

Estimating the magnitudes of these influences of human capital on long-run growth is difficult, given data inconsistencies. Dowrick (2002) examined a number of studies that had corrected for data inconsistencies between countries. He concluded that an additional year of education in the adult population would lead to an increase in long-run economic growth of between 0.2 and 0.8 of a percentage point.

These linkages identified in endogenous growth theory can be considered as 'indirect' effects of human capital on long-run growth. The growth accounting framework used in the remainder of this chapter takes no account of these indirect effects, but rather only relates to the direct effect of a change in skill on labour inputs.

However, there may nevertheless be some partial allowance within the growth accounting framework. It could be argued that if the ability of skilled workers to absorb and develop technologies is reflected in their wages, some allowance for this effect on growth is taken into account. However, any unremunerated spillovers would not be captured.

Figure 4.5 shows ABS estimates of an experimental labour productivity index based on the labour services input index. The adjusted labour productivity index increased at a slower rate than the 'standard' labour productivity index based on hours worked. From 1982-83 to 1997-98, the labour services productivity index grew by 2 per cent a year, while the standard labour productivity index grew by 2.3 per cent a year over the same period. Growth in skill composition was therefore 0.3 per cent a year. The contribution of skill composition change to standard labour productivity growth was 0.2 of a percentage point (which is equal to the growth rate of skill composition multiplied by labour's share of total costs, as shown in box 4.1).

Figure 4.5 **Labour productivity indexes, 1982-83 to 1997-98**
Index 1982-83 = 100

Data source: Unpublished ABS data based on Reilly and Milne (2000).

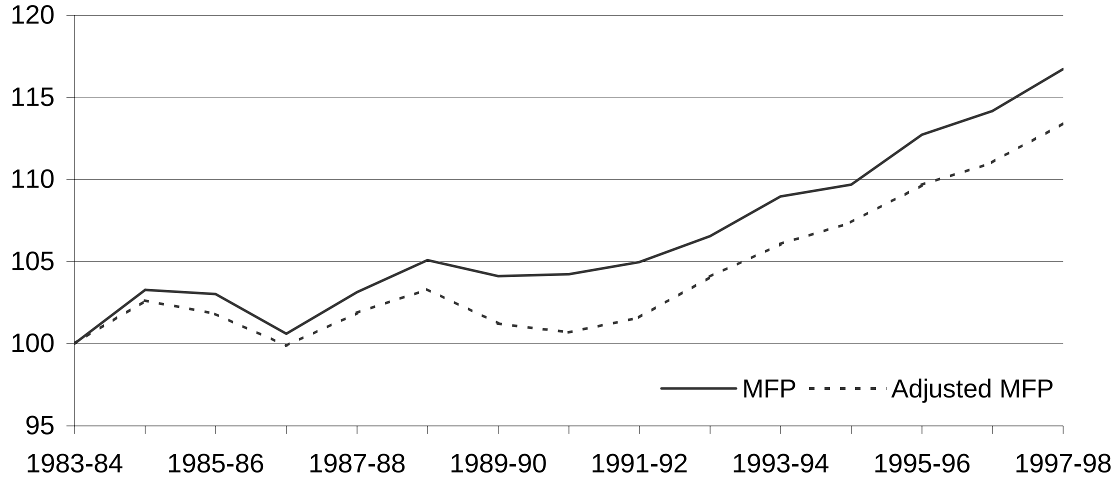
The labour services input index can also be used to account for a skill component of conventionally-measured multifactor productivity (MFP) growth. The ABS is undertaking further work on the experimental estimates before incorporating these changes into its official MFP estimates and it has not published any experimental MFP estimates. However, it is possible to use the ABS labour services index to calculate an adjusted MFP series.[8]

Figure 4.6 shows the difference in the MFP index once adjustments for change in skill composition have been made. Over the entire period (1983-84 to 1997-98), the change in skill composition contributed 0.2 of a percentage point to annual MFP growth of 1.1 per cent. Therefore the annual adjusted MFP growth for the period was 0.9 per cent. Table 4.2 indicates trends in four sub-periods.[9] The period with the highest skill composition contribution was 1986-87 to 1990-91, but there was a negative contribution in the following period. Later in the 1990s (1994-95 to 1997-98) productivity growth was strong at 2.1 per cent a year, although the contribution of skill composition growth to this MFP growth was only 0.3 of a percentage point.

[8] Taking the change in skill composition as the difference between the new labour services input index and the index of hours worked, the contribution to conventionally-measured MFP growth can be calculated (see appendix B). An increase in skill composition is a positive contribution to growth in labour inputs. This growth in inputs implies a reduction in MFP growth.

[9] These sub-periods do not correspond with the MFP peak-to-peak cycles normally used to examine MFP growth. These peak-to-peak periods are discussed in section 4.4.

Figure 4.6 **MFP and adjusted MFP indexes, 1983-84 to 1997-98**
Index 1983-84 = 100



Data sources: MFP index is from ABS (*Australian National Accounts 2000-01*, Cat. no. 5204.0). Adjusted MFP index is a Productivity Commission estimate based on ABS (*Australian National Accounts 2000-01*, Cat. no. 5204.0) and unpublished ABS data based on Reilly and Milne (2000).

Table 4.2 **Growth in MFP and adjusted MFP, 1983-84 to 1997-98**

	MFP growth[a]	*Adjusted MFP growth*	*Contribution of skill composition change*
	% per year	% per year	% points
1983-84 to 1986-87	0.2	0.0	0.2
1986-87 to 1990-91	0.9	0.2	0.7
1990-91 to 1994-95	1.3	1.6	-0.3
1994-95 to 1997-98	2.1	1.8	0.3

a The sub-periods do not correspond with the MFP peak-to-peak cycles normally used to examine MFP growth. These peak-to-peak periods are discussed in section 4.4.

Sources: Productivity Commission estimates based on ABS (*Australian National Accounts 2000-01*, Cat. no. 5204.0) and unpublished ABS data based on Reilly and Milne (2000).

While the ABS has published its experimental estimates of quality-adjusted labour inputs, it has no immediate plans to incorporate the new measure into the official productivity estimates. It considers that more observations are needed to assess the results of the experimental series and to address issues of volatility in the series. However, these experimental estimates do allow some independent examination of the changes in skill composition and their effect on productivity.

In the United States there has also been a shift in skill composition in the 1990s towards skilled workers. As noted above, the BLS already includes skill composition changes in its method of forming productivity estimates. Between 1990 and 1995, annual MFP growth was 0.6 per cent and changing skill composition contributed 0.4 of a percentage point to output growth. In the late 1990s (1995 to 2000) the contribution of skill was 0.3 of a percentage point, with MFP growth of 1.2 per cent a year (BLS 2002). Therefore, there has been a decline in the contribution of skill composition to US MFP growth in the late 1990s. US MFP growth was stronger but the contribution of skill composition was slightly lower. Over the latest MFP peak-to-peak cycle, 1992 to 2000, skill composition change contributed 0.2 of a percentage point, with MFP growth of 1.1 per cent a year.[10]

4.3 International perspective

A recent study by Scarpetta et al. (2000) compared the magnitude of skill composition effects across countries. While these estimates provide useful comparison between countries, the estimation for Australia is not comparable with the ABS estimates in at least one important respect. The Scarpetta et al. study defines skill only in terms of educational attainment[11] without a measure of work experience.

The estimated shift in skill composition for Australia over the period 1985 to 1998 was 0.1 per cent a year. This compares with the average of 0.7 per cent a year for the other OECD countries in the study. Figure 4.7 shows labour productivity growth for 15 OECD countries over the period 1985 to 1998, indicating the contribution of skill composition change to labour productivity growth. Australia has low growth in skill composition compared with these other OECD countries over the period, but labour productivity growth close to the average.

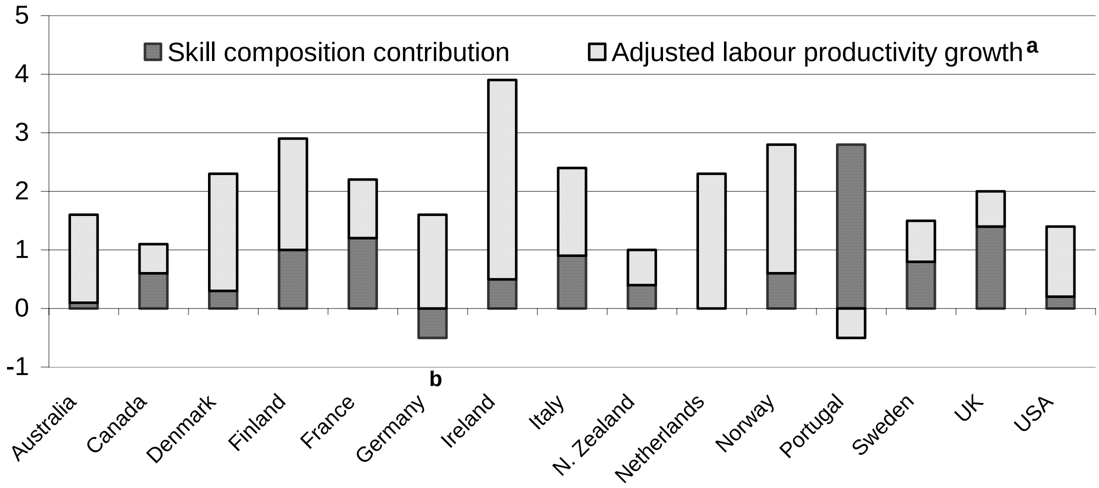
More generally, there does not appear to be a strong correlation across countries between strong labour productivity growth and movements in skill composition towards skilled workers. Some countries with large contributions of skill change, such as France, and the United Kingdom, do not have very high labour productivity growth. And Ireland, which has the highest labour productivity growth, does not have a very large skill contribution.

[10] Productivity Commission estimate, based on BLS data, of the MFP growth rate over a productivity cycle, the start and end points of which correspond to a productivity peak.

[11] It also uses only three categories of educational attainment (below upper secondary, upper secondary and tertiary education) rather than four (no qualifications, vocational qualifications, diplomas and degrees or higher).

Figure 4.7 **International comparison, contribution of skill composition change to labour productivity growth, 1985 to 1998**

Per cent per year



[a] The height of the bars is conventionally-measured labour productivity growth. Adjusted labour productivity growth is after factoring out the skill contribution. [b] West Germany in 1985 and unified Germany in 1998.

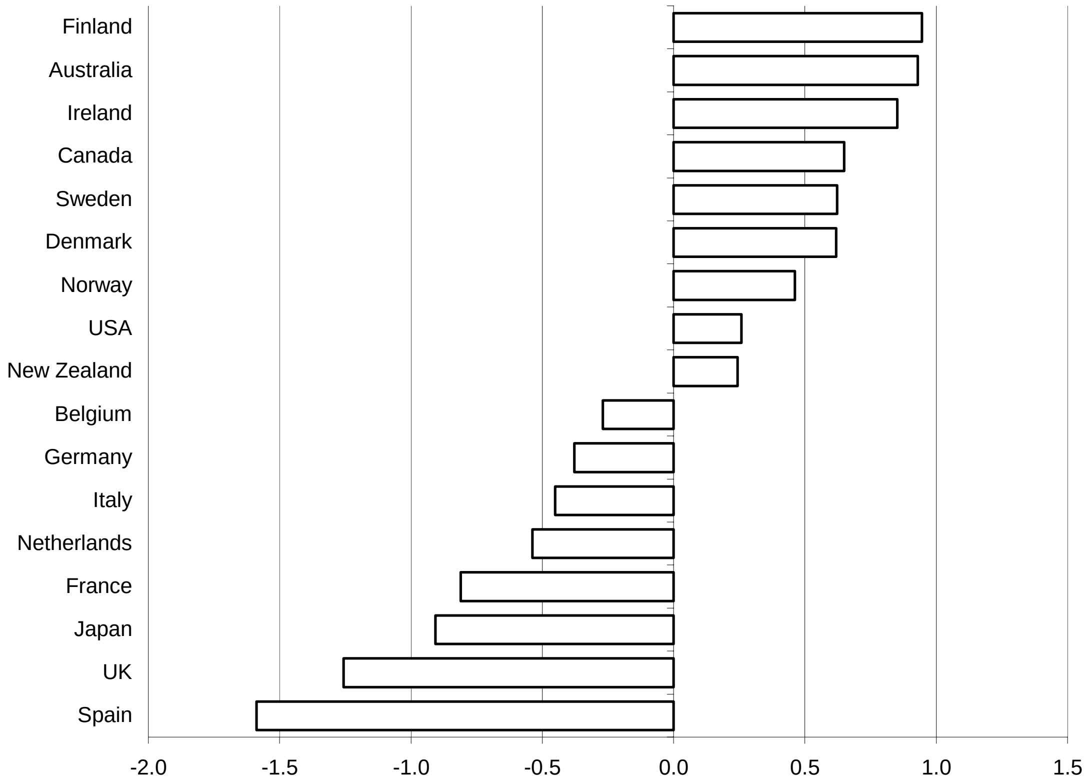
Data source: Scarpetta et al. (2000).

Some indication of the importance of the omission of work experience from the skill measure can be gained by comparing the estimates by Scarpetta et al. with US and Australian estimates including work experience over the 1985 to 1998 period. The BLS measure of skill composition growth for the United States is 0.4 per cent a year, compared with growth of 0.2 per cent a year when only accounting for educational attainment. The ABS experimental measure gives a skill composition growth of 0.3 per cent a year, compared with growth of 0.1 per cent a year when only accounting for educational attainment. This suggests that the contribution of work experience is equally if not more important than educational attainment in these two countries.[12]

12 The educational attainment data used in Scarpetta et al. (2000) are not the same data used by the BLS and the ABS. Therefore the difference between the measures is only indicative of the contribution of work experience.

Figure 4.8 **International comparison, change in MFP growth between the 1980s and the 1990s[a]**

Percentage points



[a] Change in MFP growth is the change in average annual MFP growth rate between the 1980s (1980 to 1990) and the 1990s (1990 to 1999).

Source: OECD (2001a, p. 21).

Figure 4.8 shows OECD estimates of the acceleration in trend MFP growth in the 1990s, compared with the 1980s, for a selection of OECD countries. Australia's productivity growth performance was stronger in the 1990s than the 1980s, with annual growth 0.95 of a percentage point higher in the 1990s than the 1980s on these estimates. In comparison with other countries in the sample, Australia's productivity growth in the 1990s was very strong. While Australia's MFP growth compares favourably with other countries, skill composition growth has been comparatively low. From this evidence, growth in skills does not appear to have been a major driver of Australia's productivity growth in this period. More generally, there does not appear to be a strong correlation across countries between acceleration in productivity growth and movement in skill composition towards skilled workers.

This suggests that other factors have been more important over this period than change in skills. This does not mean, however, that education and skills do not have importance, especially over the long term. Firstly, Dowrick (2002), in his review of the theoretical and empirical literature on how workforce skills influence economic growth, suggested that a conservative estimate of the increase in Australia's *long-run* economic growth rate, from an additional year of education in the adult population, is 0.3 of a percentage point.[13]

Secondly, even in the 1990s period examined the average *level* of education may have been important. Cross-country comparisons allow some insight into the indirect effects of higher skill levels. In a number of countries that have had relatively high average levels of education there has also been relatively strong diffusion of information and communications technology (ICT) — for example, Australia, Canada, the United States and the nordic countries.[14] This group of countries has also had an acceleration in MFP growth (figure 4.9).[15] These correlations raise the possibility that the rate of absorption or uptake of ICTs could be related, in part, to average education levels. And to the extent that ICTs are a factor in acceleration in MFP growth[16], levels of education may have contributed indirectly to productivity acceleration. However, the contribution of ICT uptake to productivity acceleration, while significant, is still relatively small. Parham (2002) noted that the gains from production and use of ICTs in the United States in the 1990s is up to 0.3 of a percentage point. Since Australia produces little ICT equipment, any effect in Australia would be largely due to ICT use. Using the United States as a benchmark, this suggests that the ICT-related gains in Australia would be smaller — perhaps 0.1 or 0.2 of a percentage point (Parham 2002).

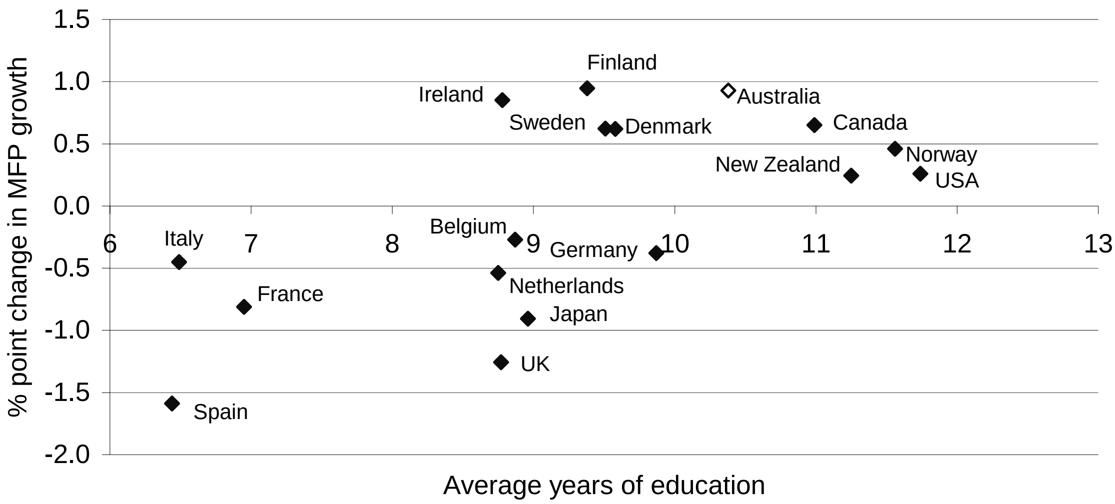
[13] Dowrick notes that an increase in the length of schooling of teenagers will only increase the average educational experience of the adult population as the new, better-educated cohorts enter the workforce, replacing older cohorts. This (short-run) transition can take four decades.

[14] Based on data on ICT expenditure as a percentage of GDP from OECD (2001b) and education data from Barro and Lee (2001), there is a strong positive correlation between ICT uptake in 1999 and average years of education in 1990 (0.66) across the group of countries shown in figure 4.8. The correlation between education level and ICT expenditure is consistent with higher average education levels allowing faster absorption of new ICTs.

[15] There is a strong positive correlation between average education level in 1990 (from Barro and Lee 2001) and MFP acceleration between the 1980s and 1990s (0.63). OECD data on average education level (Bassanini and Scarpetta 2001) are different to the Barro and Lee data and show a weaker correlation between the 1990 level and MFP acceleration (0.42). The correlation between average years of education and ICT uptake also changes (from 0.66 to 0.69).

[16] There is a positive correlation between acceleration in MFP growth and ICT expenditure as a percentage of GDP in 1999 (0.36) but it is not as strong as the other correlations.

Figure 4.9 **International comparison, change in MFP growth between the 1980s and the 1990s[a] and average years of education[b] in 1990**



[a] Change in MFP growth is the change in average annual MFP growth rate between the 1980s (1980 to 1990) and the 1990s (1990 to 1999). [b] Average years of education of the population aged 15 years and over.

Data sources: MFP data from OECD (2000b). Education data from Barro and Lee (2001).

4.4 Assessment

The ABS estimates presented in this chapter are still experimental, and are currently being refined before incorporation into the official productivity estimates is considered. The series developed by Reilly and Milne is not particularly long, and has been derived as a trend for some periods where insufficient data were available. Also, the use of potential rather than actual years of work experience is a weakness (although unavoidable because of lack of data). That said, the experimental series does accord with other evidence on the trend of increased skill level during the 1980s and 1990s.

This trend of increased skill can be analysed in the context of Australia's productivity performance during the 1980s and 1990s. As indicated previously, the greatest contribution of skill composition growth to MFP growth was in the late 1980s and early 1990s (1986-87 to 1990-91). This was a period of relatively slow MFP growth. During the period of MFP acceleration after 1993-94, change in skill composition made a very small contribution, just 0.04 of a percentage point contribution to conventionally-measured MFP growth of 1.7 per cent a year. Whilst indirect effects, especially absorption of technology, could still be very important — and have not been explicitly taken into account in the growth accounting approach

— an increase in skill does not appear to have had an immediate *direct* link to Australia's 1990s productivity surge.

The international perspective also suggests that education and skills have not had a major influence on productivity performance over this period. Other countries have also experienced an increase in skill, but have not had the same strong productivity acceleration that Australia has shown. And the available evidence regarding the *indirect* effects of increased skill levels on ICT uptake, suggests that, while important, these particular indirect effects over the 1990s have nevertheless been relatively modest.

While education and skills formation are important, especially over the long term, they have not been important — at least in a direct sense — in explaining the 1990s productivity surge in Australia or the variation in productivity performance across countries in the 1990s.

A Framework for supply and demand analysis and data specification

The framework used in chapter 3 is based on Nickell and Layard (1998). Their interest was in whether institutional factors explained the different labour market outcomes across OECD countries in the 1980s in response to increased demand for skilled labour relative to unskilled labour. They examined the different wage and unemployment outcomes in response to relative demand shifts and used these as indicators of the importance of institutional differences. For example, relatively large shifts in relative unemployment suggest relative wage rigidity. For this paper, the Nickell and Layard framework has been evaluated for the 1990s, to examine changes over time, and has also been extended to examine alternative data and assumptions.

A.1 Theoretical framework

Employers regard skill groups differently — workers in different skill groups have different marginal products and are not perfect substitutes. The Nickell and Layard framework explicitly incorporates skilled and unskilled labour and measures relative demand in terms of demand in each skill category weighted by relative wages (to reflect marginal products).

The Nickell and Layard framework is based on a constant elasticity of substitution production function including skilled and unskilled labour:

$$Y = F(K, [\delta N_1^{-\rho} + (1-\delta) N_2^{-\rho}]^{-1/\rho}) \qquad (1)$$

where Y = output, K = capital, N_1 = skilled labour, N_2 = unskilled labour, δ and *(1-δ)* are distribution parameters, which have to do with the relative factor shares of skilled and unskilled labour, and ρ is the substitution parameter, which determines the value of the (constant) elasticity of substitution.

The labour demand equations that follow from this production function are:

$$\partial Y / \partial N_1 = \delta (Y / N_1)^{\rho+1} \qquad (2)$$

$$\partial Y / \partial N_2 = (1-\delta)(Y / N_2)^{\rho+1} \qquad (3)$$

The rate of technical substitution between skilled and unskilled labour is given by

$$\text{MRTS}_{\text{N2N1}} = \frac{\partial Y/\partial N_1}{\partial Y/\partial N_2} = \frac{\delta (Y/N_1)^{(\rho+1)}}{(1-\delta)(Y/N_2)^{(\rho+1)}}$$

which can be rearranged as

$$\frac{\partial Y/\partial N_1}{\partial Y/\partial N_2} = \frac{\delta}{(1-\delta)}\left[\frac{N_2}{N_1}\right]^{\rho+1}$$

Assuming cost minimisation, the rate of technical substitution can be equated with relative wages. Equating the ratio of the wages for each skill group with the rate of technical substitution between skilled and unskilled workers is

$$\frac{W_1}{W_2} = \frac{\delta}{1-\delta}\left[\frac{N_2}{N_1}\right]^{1/\sigma} \qquad (4)$$

where W_1 = skilled wage, W_2 = unskilled wage and $\sigma = (1+\rho)^{-1}$, which is the elasticity of substitution between skilled and unskilled labour.

If L = total labour force and L_i = labour force of skill group i, then s = share of skilled workers in the labour force (L_1/L) and (1-s) = share of unskilled workers in the labour force (L_2/L). And if both sides of equation (4) are multiplied by $\left[\frac{N_1/L_1}{N_2/L_2}\right]^{1/\sigma}$ then (4) can be rewritten as

$$\frac{W_1}{W_2}\left[\frac{N_1/L_1}{N_2/L_2}\right]^{1/\sigma} = \frac{\delta}{1-\delta}\left[\frac{N_2}{N_1}\right]^{1/\sigma}\left[\frac{N_1/L_1}{N_2/L_2}\right]^{1/\sigma}$$

$$= \frac{\delta}{1-\delta}\left[\frac{L_2}{L_1}\right]^{1/\sigma}$$

$$= \frac{\delta}{1-\delta}\left[\frac{1-s}{s}\right]^{1/\sigma} \text{ since } L_2 = (1-s)L \text{ and } L_1 = sL$$

$$= \frac{\delta}{1-\delta}\left[\frac{s}{1-s}\right]^{-1/\sigma} \qquad (5)$$

And as $N_i = (L_i - U_i)$ and $U_i / L_i = u_i$, where U_i = unemployed persons in skill group i and u_i = unemployment rate of skill group i, equation (5) can be rewritten as

$$\frac{W_1}{W_2}\left[\frac{(L_1-U_1)/L_1}{(L_2-U_2)/L_2}\right]^{1/\sigma} = \frac{\delta}{1-\delta}\left[\frac{s}{1-s}\right]^{-1/\sigma}$$

$$\frac{W_1}{W_2}\left[\frac{1-(U_1/L_1)}{1-(U_2/L_2)}\right]^{1/\sigma} = \frac{\delta}{1-\delta}\left[\frac{s}{1-s}\right]^{-1/\sigma}$$

$$\frac{W_1}{W_2}\left[\frac{1-u_1}{1-u_2}\right]^{1/\sigma} = \frac{\delta}{1-\delta}\left[\frac{s}{1-s}\right]^{-1/\sigma} \qquad (6)$$

In log changes, equation (6) becomes a relative wage movement plus a relative unemployment movement (on the left-hand side) equal to the shift in the relative demand for skilled workers less the shift in the relative supply of skilled workers (on the right-hand side):

$$\Delta\ln(W_1/W_2)+(1/\sigma)\Delta\ln\left[(1-u_1)/(1-u_2)\right]=\Delta\ln(\delta/(1-\delta))-(1/\sigma)\Delta\ln(s/(1-s))$$

Multiplying both sides by σ

$$\sigma\Delta\ln(W_1/W_2)+\Delta\ln\left[(1-u_1)/(1-u_2)\right]=\sigma\Delta\ln(\delta/(1-\delta))-\Delta\ln(s/(1-s)) \qquad (7)$$

relative wage movement	+	relative unemployment movement	=	shift in relative demand for skilled workers	–	shift in relative supply of skilled workers

where δ = the adjusted share of skilled labour in total labour cost;

u_1 = skilled unemployment rate;

u_2 = unskilled unemployment rate;

W_1 = skilled wage rate;

W_2 = unskilled wage rate;

s = share of skilled workers in the labour force; and

σ = the elasticity of substitution between skilled and unskilled labour.

The right-hand side establishes whether, and the extent to which, there is a shift in relative excess demand for skilled labour. The left-hand side shows how the shift in relative excess demand can be divided between relative wage and relative unemployment effects. In rigid labour markets, relative unemployment effects will dominate. In flexible labour markets, relative wage effects will dominate. By examining the skilled labour market relative to the unskilled labour market it is possible to abstract from changes that affect the skilled and unskilled labour markets in a similar way.

Nickell and Layard (1998) note that a nice feature of their simple framework is that they can estimate δ by the adjusted share of skilled labour in total labour cost (solving (4) for δ).

$$\delta = W_1 N_1^{1/\sigma} \left[W_1 N_1^{1/\sigma} + W_2 N_2^{1/\sigma} \right]^{-1} \quad (8)$$

where δ = the adjusted share of skilled labour in total labour cost;

W_1 = skilled wage rate;

W_2 = unskilled wage rate;

N_1 = skilled labour;

N_2 = unskilled labour; and

σ = the elasticity of substitution between skilled and unskilled labour.

A.2 Data specification

To evaluate equations (7) and (8) the variables need to be defined.

Skill classification

Nickell and Layard (1998) define skill in terms of educational attainment and this is the definition used in this paper. Direct measurement of skill is difficult and proxies, such as educational attainment, have their disadvantages (see Barnes et al. 1999 for a discussion of alternative measures). However, one advantage of the use of educational attainment in this framework is that it is a characteristic of the person rather than their employment. This allows easier classification of the unemployed than for some other skill measures.[1]

In this paper, educational attainment has been classified using a hybrid of the different ABS classifications over the 1980s and 1990s. Over this period, the ABS used two main educational attainment classification systems. In 1993, the ABS Classification of Qualifications (ABSCQ) system was introduced, replacing the ABS educational classification system. The classification system used in this paper is a hybrid of these two ABS systems and is detailed in table A.1. It combines some

[1] Data for one other measure of skill, occupation, was subject to several reclassifications over the time period examined and compiling a consistent series would be difficult. Also, while the latest ABS occupational classification system can be easily mapped into skill groups this was not the case for earlier versions, which in some cases were more industry-based than skill-based.

ABS educational categories to construct reasonably comparable data over time.[2] Remaining breaks in series are outlined in box A.1.

Two alternative skill groupings based on educational attainment are used in this paper. The first is skilled/unskilled, with skilled defined as 'with post-school qualifications' and unskilled defined as 'without post-school qualifications'. The second is high-skilled/other, with high-skilled defined as degree or higher and other being all remaining categories of educational attainment. The skilled/unskilled classification is obviously a broader definition of skill than the high-skilled/other classification. Neither level of aggregation will allow identification of skill shortages or surpluses in particular occupations or industries.

Table A.1 **Educational attainment classification system**

Classifications used in this paper		*Corresponding ABS educational classification categories*[a]	*Corresponding ABSCQ categories*[b]
Skilled		**With post-school qualifications**	
High-skilled	Degree or higher	Degree or equivalent	Higher degree Post-graduate diploma Bachelor degree
Other (part)	Other qualifications	Trade qualification or apprenticeship Certificate or diploma Other qualification	Undergraduate diploma Associate diploma Skilled vocational Basic vocational
Unskilled		**Without post-school qualifications**	
Other (part)	Completed secondary school[c]	Completed highest level of secondary school available	Completed highest level of school
Other (part)	Did not complete secondary school[c]	Did not complete highest level of secondary school available Never attended school	Did not complete highest level of school Never attended school

a Prior to 1993. **b** From 1993. **c** These categories include people currently attending tertiary institutions. People still at school are excluded from the analysis in this paper as a result of data limitations.

Sources: Based on ABS (*Labour Force Status and Educational Attainment, Australia*, Cat. no. 6235.0; *Transition from Education to Work, Australia*, Cat. no. 6227.0).

[2] Adjustments made in this process are detailed below.

Box A.1 Breaks in data series

There are several breaks in the data cross-classified by educational attainment group. Full details of these breaks are provided in ABS (1997). Only the main breaks are outlined here.

The major break in series is the introduction of Australian Bureau of Statistics Classification of Qualifications (ABSCQ) in 1993. The hybrid classification system outlined in table A.1 partially adjusts for this break in series. However, even after this adjustment, the introduction of ABSCQ still has major implications for the comparability of data over time.

The ABSCQ system made a distinction between recognised qualifications and other qualifications, which was not made in the previous classification system. Qualifications earned as a result of less than one semester of full-time study were excluded from estimates of recognised qualifications under ABSCQ. Before 1993, they were included as valid qualifications (ABS 1997). At the same time, the ABS changed the wording of the questionnaire to refine the concept of *educational* qualifications, asking whether the respondent had completed an educational qualification rather than obtained a qualification. The combination of these changes lowered estimates of the attainment of post-school qualifications by about 400 000 to 500 000 of the 15-64 year old population in 1993 (ABS 1993).

For this paper, using this information about 1993, this particular classification change was reversed for the 1999-2000 data, rather than updating the two earlier periods. An equivalent proportion of those 'without post-school qualifications' under the new classification in 1999-2000 were moved back into the 'with post-school qualifications' category. The midpoint of the range 400 000 to 500 000 was taken and expressed as a percentage of the 15-64 population in 1993. This percentage was applied to the 1999-00 data. This adjustment is based on the assumption that there has been no change in the proportion of the population with one semester qualifications over time.

In addition to adjusting employed, unemployed and labour force numbers, average hours and wages were also recalculated based on the adjusted numbers. All these adjustments to the data affected the skilled/unskilled skill split used in this paper, but not the high-skilled/other skill split. The people whose highest qualification was a one semester qualification would not be part of the high-skilled group under either of the ABS classification systems.

Data

Equations (7) and (8) are evaluated for changes over the periods 1981-82[3] to 1989-90 and 1989-90 to 1999-00, using data from the ABS Survey of Income and Housing Costs (SIHC) and Labour Force Survey (LFS). The details of assumptions and data for each element of the equation are provided below.

Employment, unemployment and labour force numbers (N, U, L)

Labour has both quantity and quality dimensions. The total amount of labour input available in an economy depends on the total hours of labour that a population is willing to supply and on the average quality of each hour of labour (which will depend on the skill level and work effort).

In this paper, the skill dimension is examined explicitly with skilled and unskilled labour being treated as separate markets. Nickell and Layard (1998) measured employment, unemployment and labour force in terms of numbers of people. The framework is evaluated in terms of numbers of people (the numbers employed approach) for the 1990s to allow for comparison with the Nickell and Layard results for the 1980s. However, the framework is also re-estimated using hours worked rather than persons (the hours worked approach). Use of hours worked (or hours available to work in the case of the unemployed) allows the shift towards an increased proportion of part-time work to be accounted for in the measurement of demand and supply changes. For example, a given number of employed persons may reflect a varying number of hours worked, depending on the proportion of the workforce working part-time. Estimates using hours worked are made for both the 1980s and 1990s.

For employed persons, actual hours worked are used as a proxy for desired hours. For unemployed persons, data on whether unemployed persons are seeking full-time or part-time jobs is available. It is assumed that unemployed persons in each educational attainment category and full-time/part-time status category are willing to work the same average hours as their employed counterparts.

Both actual hours worked and unemployed numbers reflect an interaction of demand and supply influences. Some factors related to this that cannot be accounted for in this analysis include underemployment (people working shorter hours than they would choose) and discouraged jobseekers (people who would be willing to work but are not actively looking for employment because they perceive the probability of obtaining it is low).

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3 Detailed data for earlier periods are not available.

The ABS supplementary surveys to the LFS — Transition from Education to Work (for May from 1989) and the Educational Attainment Survey (for February before 1989) provide data on worker numbers cross-classified by educational attainment. The numbers of workers are used in conjunction with the average hours worked data[4] from the SIHC[5], to measure employment in hours worked, unemployment in hours available to work and labour force in hours. Adjustments for breaks in series are summarised in box A.1.

Wage ratio (W_1/W_2)

For the Nickell and Layard (numbers employed) approach, weekly wages for skilled and unskilled workers are used to calculate a relative wage ratio. However, for the hours worked approach the relative wage ratio is based on average hourly wage rates. This helps remove some changes in the relative wage ratio resulting from changes other than in returns to skill, such as different changes in the proportion of part-time workers across skill groups.

The SIHC is the only source of wage data cross-classified by educational attainment and is conducted on an irregular basis. Weekly average earned income from the SIHC is used together with average hours data from the same survey to calculate an average hourly wage rate by skill (education) group.[6] Income earned by all employed (wages and salaries plus own business income) is used to 'match' the total employed numbers.

In the SIHC, average earned income is measured on a current weekly income basis (most recent pay). The survey is conducted over 12 months of each year so estimates derived from the survey do not refer to any given week, but are representative of weekly income during the survey year. For wages and salaries, *usual* weekly income is used so that the estimates are not distorted by amounts not usually received weekly (for example, leave loading). For own business income,

4 The hours data have several limitations. Actual 'usual' weekly hours is the measure available from the SIHC. SIHC hours data are used to match the usual weekly wages data from this survey in the calculation of hourly rates of pay over time (see wage ratio section). SIHC hours data are available only for employees (which represent around 85 per cent of total employed). This is assumed to be representative of hours for all employed, particularly when used as a ratio for educational attainment groups rather than in absolute terms. However, to the extent that those excluded work different hours to their employee counterparts in each education group, this estimate will be biased. Also, SIHC data for 1981-82 for hours were not available, so estimates were made using the trend in LFS data for actual hours.

5 Previously known as the Income Distribution Survey (IDS).

6 As noted in box A.1, the 1999-00 data is adjusted for the break in educational attainment classification.

current income is derived from financial year income received and the number of weeks the business operated during that year. It is assumed that all profits are distributed.

Share of labour costs (δ)

The share of labour costs as specified in equation (8) is evaluated using the SIHC wage data discussed above and the number employed from the LFS.[7]

Elasticity of substitution (σ)

The elasticity of substitution between skilled and unskilled labour (σ) measures the responsiveness of the skilled/unskilled labour combination to a change in the relative wage rates of these two inputs.

There are no readily available estimates of this elasticity for Australia (for further discussion see Freebairn 1998 and Vickery 1999). And no clear indication of the appropriate elasticity is provided by international studies, which have produced a wide range of estimates (see, for example, Hamermesh 1993).

Following Nickell and Layard (1998), σ is given assumed values (1, 2, 0.5). The effect on equation (7) of differing values of σ is to alter the weight of the supply shock relative to the demand shock. A value of σ greater than 1 (σ less than 1) means that the supply shock carries a lower (higher) weight than the demand shock.

A.3 Results

Nickell and Layard examined nine OECD countries over various periods from the mid-1970s to the early 1990s. For Australia they found that relative demand and relative supply shifted by similar amounts, with an increase in relative supply only slightly greater than the increase in relative demand between 1978-79 and 1989-90. This was in contrast to a number of other OECD countries, such as the United Kingdom and the United States, where increases in relative demand outstripped

[7] Employment numbers on both sides of equation (7) must match, so total employed from the LFS (rather than the SIHC) is used. Total employed from the SIHC is smaller than for the LFS as a result of a number of exclusions. In 1999-00, the SIHC was run as a part of the LFS so there are only small differences in the number employed (the main difference being that the SIHC excludes persons living in special dwellings, for example hotels, boarding houses and institutions). In earlier periods there are more exclusions from the SIHC. As δ is a share term and the wage data from the SIHC are considered representative of the larger LFS population (since exclusions are not particularly related to educational attainment group) there should not be a significant bias.

increases in relative supply by significant amounts. They also found that the fact that changes in relative demand outstripped supply by much more in the United States, than elsewhere, explained why relative skilled wages rose by far more than European countries, without recourse to special arguments about differences in labour market institutions.

As discussed above, for this paper the Nickell and Layard framework has been evaluated for both the 1980s and 1990s. The analysis has also been extended by using both the Nickell and Layard measures of labour and skill and alternative measures of these variables. Equation (7) is evaluated for a range of data specifications as shown in table A.2. For each of the skill splits there are two alternative methods of measuring the labour force variables — hours worked and number of workers. In each case, results are presented for a range of assumed values for the elasticity of substitution between skilled and unskilled labour (σ).

The results for the range of different data specifications are presented in tables A.3 and A.4. The tables are organised as follows. Columns 1 to 4 show average annual percentage changes in each of the elements of equation (7) under the assumption of an elasticity of substitution of 1. Column 5 provides the resulting average annual percentage change in relative demand less relative supply (which is equal to the sum of the movements in relative wages and relative unemployment). Columns 6 and 7 provide the equivalent results to column 5, but for the alternative elasticity assumptions of 2 and 0.5.

The results refer to relative movements in demand, supply, wages and unemployment. But, if the relative movement is zero, this does not mean there has been no movement in the labour market in absolute terms. This simply indicates that the factors affecting the labour market have not affected the skilled market differently to the unskilled market.

A further point about the relative unemployment movement column is that a negative movement in this term indicates an increase in relative unemployment rates. Because this term is $(1\text{-}u_1)/(1\text{-}u_2)$, it will be negative (positive) if u_1 rises (falls) faster than u_2.

Table A.2 **Alternative methods and skill classifications**

Method	*Skill classification*
Number of workers	Skilled/unskilled High-skilled/other
Hours worked	Skilled/unskilled High-skilled/other

Table A.3 Changes in the demand for and supply of skilled workers relative to unskilled workers (number of workers method), 1980s and 1990s

Per cent per year

Period	1 Change in relative demand $\sigma\Delta\ln(\delta/(1-\delta))$	2 Change in relative supply $\Delta\ln(s/(1-s))$	3 Relative wage movement $\sigma\Delta\ln(W_1/W_2)$	4 Relative unemployment movement $\Delta\ln((1-u_1)/(1-u_2))$	5 Net change[a] (1-2 = 3+4) $\sigma = 1$	6 Net change[a] (1-2 = 3+4) $\sigma = 2$	7 Net change[a] (1-2 = 3+4) $\sigma = 0.5$
Skilled relative to unskilled workers							
1981-82 to 1989-90	3.76	3.41	0.40	-0.05	0.35	0.74	0.15
1989-90 to 1999-00	3.52	3.73	-0.29	0.07	-0.22	-0.5	-0.07
Nickell & Layard (1998) 1978-79 to 1989-90	3.90	4.03	-0.18	0.05	-0.12	-0.32	-0.04
Recalculation of Nickell & Layard (1998) 1981-82 to 1989-90	3.99	3.56	0.43	0.00	0.43	0.85	0.22
High-skilled relative to other workers							
1981-82 to 1989-90	4.24	3.83	0.39	0.04	0.42	0.8	0.23
1989-90 to 1999-00	7.09	7.01	0.00	0.09	0.08	0.08	0.09

[a] Components may not add to total due to rounding.

Sources: Nickell and Layard (1998) and Productivity Commission estimates based on unpublished ABS data from the Labour Force Survey and Survey of Income and Housing Costs.

Table A.4 Changes in the demand for and supply of skilled workers relative to unskilled workers (hours worked method), 1980s and 1990s

Per cent per year

Period	1 Change in relative demand $\sigma\Delta\ln(\delta/(1-\delta))$	2 Change in relative supply $\Delta\ln(s/(1-s))$	3 Relative wage movement $\sigma\Delta\ln(W_1/W_2)$	4 Relative unemployment movement $\Delta\ln((1-u_1)/(1-u_2))$	5 Net change[a] (1-2 = 3+4) $\sigma = 1$	6 Net change[a] (1-2 = 3+4) $\sigma = 2$	7 Net change[a] (1-2 = 3+4) $\sigma = 0.5$
Skilled relative to unskilled workers							
1981-82 to 1989-90	3.76	4.23	-0.40	-0.06	-0.47	-0.87	-0.27
1989-90 to 1999-00	3.52	3.72	-0.28	0.07	-0.21	-0.49	-0.07
High-skilled relative to other workers							
1981-82 to 1989-90	4.24	4.54	-0.29	0.00	-0.29	-0.58	-0.15
1989-90 to 1999-00	7.09	6.96	0.04	0.09	0.13	0.17	0.11

[a] Components may not add to total due to rounding.

Source: Productivity Commission estimates based on unpublished ABS data from the Labour Force Survey and Survey of Income and Housing Costs.

Number of workers method

Table A.3 presents results for the number of workers measure of labour. Both skill classifications, together with the Nickell and Layard original estimates for the 1980s, are included.

Rows 1 and 2 of table A.3 show the estimates for the 1980s (1981-82 to 1989-90) and 1990s (1989-90 to 1999-00), calculated on a similar basis to Nickell and Layard (1998). In the 1980s, the increase in relative demand was greater than the increase in relative supply, with a consequent increase in relative wages. In the 1990s, the opposite was the case. Relative unemployment rates were virtually unchanged in both periods.

Looking at the elements of the relative demand term in equation (8), the increase in relative demand in the 1980s was mainly the result of significantly faster growth in skilled employment than unskilled employment. The extent to which wages growth for skilled workers exceeded that for unskilled workers was much less. In the 1990s, unskilled wages grew faster than skilled wages, but unskilled employment fell in absolute terms while skilled employment grew significantly.

Row 3 of the table provides the results Nickell and Layard published for the period 1978-79 to 1989-90. These estimates show relative supply increasing faster than relative demand. This is the opposite to the estimates for the period 1981-82 to 1989-90.[8] The results are therefore sensitive to the starting year chosen but are still very close to balance between changes in relative demand and relative supply in both cases. Row 4 provides a re-estimation based on Nickell and Layard published data for the equivalent of the period used in this paper, 1981-82 to 1989-90.[9] The results based on the data used for this paper (row 1) are consistent with this re-estimation (although slightly different as a result of improvements in the consistency of the data between 1981-82 and 1989-90).

At the bottom of table A.3, the equivalent results for the alternative skill split (high-skilled/other) are presented. Overall, the results for this narrower skill split show larger increases particularly in relative demand, but also in relative supply, than for the broader skill split. Growth for high-skilled workers was faster than growth for other workers.

[8] It was not possible to obtain the detailed 1978-79 data (particularly for wages) to fully replicate the Nickell and Layard results. The earliest period for which all the necessary data (for both the number of workers method and the hours worked method) could be obtained was 1981-82.

[9] It was possible to use data published in Jackman et al. (1997), on which Nickell and Layard (1998) was based, to produce estimates for 1981-82 to 1989-90.

For the 1980s, the results for this narrower definition of skill show relative demand grew faster than relative supply to a greater extent than for the broader definition of skill. For the 1990s, the results show a different direction of change to those for the broad skill split, with relative demand growing marginally faster than relative supply. Relative demand and relative supply both grew significantly faster for the high-skilled/other split than the skilled/unskilled split, but with relative demand growing slightly faster than relative supply.

Hours worked method

The results for the alternative method based on hours worked are presented in table A.4. The hours worked method affects all terms in equation (7) except the relative demand term.[10] The results for the 1990s are very similar to those based on the number of workers, showing an increase in relative supply greater than the increase in relative demand. The similarity of results is due to only minor movement in the average hours worked of skilled workers relative to unskilled workers. However, for the 1980s, when there was more movement in this ratio, the results based on hours worked are quite different to those based on the number of workers.

For both skill splits, the 1980s results on an hours worked basis show a larger increase in relative supply than relative demand (the opposite to results based on the number of workers). Relative hours increased as a result of a higher growth in hours for the skilled (high-skilled) group than for the unskilled (other) group. When measured on an hourly basis, this increase in relative hours increases the change in relative supply and lowers the relative wage.[11]

A.4 Summary

Overall, in both the 1980s and 1990s, changes in relative demand and relative supply kept pace with each other to a large extent. While the different definitions of skill and labour units do affect whether relative demand growth is slightly greater than relative supply growth or the opposite, the differences are small, particularly when data limitations are considered. The differences between the results for the narrow and broad definitions of skill highlight that growth is the fastest in the high-skilled end of the labour market.

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[10] Because relative demand is measured as the adjusted share of labour costs, use of hours worked and hourly wages does not affect this share except through adjustment using the elasticity of substitution.

[11] The limitations related to hours worked data are discussed in footnote 4.

The response to the differences that do exist between growth in relative demand and relative supply is through the wage movement. However, the magnitude of the changes in the 1980s and 1990s is small. There is virtually no change in relative unemployment movement throughout the results.

B Accounting for skill composition change in a productivity growth framework

A growth accounting framework has been developed by the Australian Bureau of Statistics (ABS) and the Bureau of Labor Statistics (BLS) in order to account for changing skill composition in productivity estimates. As discussed in chapter 4, this method allows changes in the skill profile of the labour force to be incorporated into the labour input measure, and therefore into the estimate of multifactor productivity (MFP) growth. The method described below is a summary of a detailed discussion in BLS (1993).

B.1 Incorporating different types of labour

The production process can be summarised by a production function, which describes how much output specific quantities of capital and labour can generate. A production function which does not account for different types of labour would take the following form:

$$q = f(k_1, k_2, H, t) \tag{1}$$

Output (q) is a function of the two types of capital, a single type of labour input (H), and the technology available at time t. Typically there are several different types of capital, though for simplicity in this example it is assumed there are only two different types (k_1 and k_2). In this production function, output is not affected by changes in the type of labour used — labour is treated as a homogeneous input, ignoring productive differences among workers.

This production function can be adjusted to account for different types of labour. Equation (1) can be modified to include several different types of labour input, though again for simplicity in this example only two different types are included, (h_1 and h_2). This is written as:

$$q = g(k_1, k_2, h_1, h_2, t) \tag{2}$$

In this production function a single type of labour input (*H*) is replaced by two types of labour input. Therefore, each type of labour input can have a different effect on output.

In a growth accounting framework, the growth rate of output is related to the growth rate of each input and productivity. By taking the logarithm and then the derivative with respect to time, equation (2) can be expressed in terms of growth rates:

$$\dot{q}/q = \partial g/\partial k_1 * \dot{k}_1/k_1 + \partial g/\partial k_2 * \dot{k}_2/k_2 + \partial g/\partial h_1 * \dot{h}_1/h_1 + \partial g/\partial h_2 * \dot{h}_2/h_2 + \dot{A}/A \qquad (3)$$

The term A is multifactor productivity. For any input, for example h_i, the dot notation denotes the growth rate of the variable. The term $\partial g/\partial h_i$ refers to the partial derivative of the logarithm of the production function with respect to the input, h_i, and is the output elasticity.

Rearranging equation (3) gives an expression for the growth rate of multifactor productivity:

$$\dot{A}/A = \dot{q}/q - \partial g/\partial k_1 * \dot{k}_1/k_1 - \partial g/\partial k_2 * \dot{k}_2/k_2 - \partial g/\partial h_1 * \dot{h}_1/h_1 - \partial g/\partial h_2 * \dot{h}_2/h_2 \qquad (4)$$

It is assumed that the production function exhibits constant returns to scale and that factor input markets are in competitive equilibrium. By assuming cost minimising behaviour, it can be demonstrated that each factor's output elasticity will equal its share of total costs (factor shares). Designating s_{ki} and s_{hi} as factor shares for capital and labour inputs, respectively, equation (4) can be written as:

$$\dot{A}/A = \dot{q}/q - s_{k1} * \dot{k}_1/k_1 - s_{k2} * \dot{k}_2/k_2 - s_{h1} * \dot{h}_1/h_1 - s_{h2} * \dot{h}_2/h_2 \qquad (5)$$

Where the factor shares are:

$$s_{ki} = P_{ki} * k_i / \sum ij(P_{ki} * k_i + P_{hj} * h_j)$$
$$s_{hj} = P_{hj} * h_j / \sum ij(P_{ki} * k_i + P_{hj} * h_j)$$

P_{ki} and P_{hj} are the prices of capital and labour services for the i^{th} asset and the j^{th} type of labour, and k_i and h_j are quantities of those capital and labour services. Therefore, the factor shares are just the proportion of total factor costs that each different type of capital and labour is paid.

It is assumed that there is Hicks neutral technical change, therefore technical progress leaves the ratio of marginal products of labour and capital unchanged. It is also assumed that there is separability of inputs, allowing unambiguous aggregates of capital and labour input. Therefore, aggregates of labour and capital can be written as:

$$\dot{K}/K = s_{c1} * \dot{k}_1/k_1 + s_{c2} * \dot{k}_2/k_2 \tag{6a}$$

$$\dot{L}/L = s_{l1} * \dot{h}_1/h_1 + s_{l2} * \dot{h}_2/h_2 \tag{6b}$$

Therefore, the growth in labour is the sum of the growth in each type of labour multiplied by the factor share of that type, and growth in capital is the sum of the growth in each type of capital multiplied by their factor shares. Now with aggregate measures of labour and capital, equation (5) can be written more simply:

$$\dot{A}/A = \dot{Q}/Q - s_k * \dot{K}/K - s_l * \dot{L}/L \tag{7}$$

where s_l and s_k are labour's and capital's shares of total costs. This now relates productivity growth to growth in output minus growth in inputs.

Incorporating a Tornqvist index

Changes in multifactor productivity as well as aggregate labour and capital inputs are measured with Tornqvist indexes. Therefore the form of equation (7) must be altered. Instantaneous growth rates, such as $\dot{L}/L$, are replaced by annual rates of change. In the Tornqvist index, these are measured as differences in successive natural logarithms, that is,

$$\Delta \ln L = \ln L_t - \ln L_{t-1}$$

Using this new method, growth in labour and growth in capital (equations (6a) and (6b)) can be rewritten as:

$$\Delta \ln L = \sum_j 1/2 * (s_{lj}(t) + s_{lj}(t-1)) \Delta \ln h_j \tag{8a}$$

$$\Delta \ln K = \sum_i 1/2 * (s_{ci}(t) + s_{ci}(t-1)) \Delta \ln k_i \tag{8b}$$

Therefore, the growth in labour from period t-1 to period t is the sum of the change in each labour share over the period multiplied by the change in each type of labour.

This adjustment is also made to the expression for multifactor productivity. The Tornqvist index of multifactor productivity growth is:

$$\Delta \ln A = \Delta \ln Q - 1/2 * (s_k(t) + s_k(t-1)) * \Delta \ln K - 1/2 * (s_l(t) + s_l(t-1)) * \Delta \ln L \quad (9)$$

This expression for productivity is similar to that in equation (7), but is now in terms of log changes over specific periods.

Changes in the index of skill composition (*LC*) are defined as the difference between changes in aggregate labour input index (*L*) and the simple sum of the hours of all persons (*H*).

$$\Delta \ln LC = \Delta \ln L - \Delta \ln H \quad \text{or,}$$

$$= \Delta \ln L / H \quad (10)$$

Skill composition has an important interpretation in terms of its role in explaining the differences between equations (1) and (2). In equation (1), labour is considered as a single homogeneous input (*H*). MFP growth using this method can be expressed as $\dot{B}/B$, given by:

$$\Delta \ln B = \Delta \ln Q - 1/2 * (s_k(t) + s_k(t-1)) * \Delta \ln K - 1/2 * (s_l(t) + s_l(t-1)) * \Delta \ln H \quad (11)$$

where the change is labour is given by the change in homogeneous labour only. Comparing equations (11) and (9), the difference between the two approaches can be given by:

$$\Delta \ln B = \Delta \ln A + 1/2 * (s_l(t) + s_l(t-1)) * \Delta \ln LC \quad (12)$$

Therefore, the log change in multifactor productivity is now a function of the skill composition index. Rearranging this equation gives an expression for MFP growth when accounting for skill composition change:

$$\Delta \ln A = \Delta \ln B - 1/2 * (s_l(t) - s_l(t-1)) * \Delta \ln LC \quad (13)$$

Therefore, adjusted MFP growth will be lower than unadjusted MFP growth given a shift in skill composition towards skilled workers, for example through growth in the skill level of the workforce.

B.2 Adjusting MFP for skill composition

The ABS estimated a new experimental index for labour input that allowed for heterogeneous labour, thereby accounting for changes in skill composition (Reilly and Milne 2000). From this index it is possible to derive an adjusted labour productivity index and an adjusted MFP index, based on the framework described above. The result from this exercise can be found in chapter 4.

Adjusting MFP growth for skill composition change involves estimating the contribution of skill composition to MFP growth. From the growth accounting framework it is assumed that growth in inputs for MFP ($\dot{I}/I$) is growth in capital ($\dot{K}/K$) plus growth in labour ($\dot{L}/L$), multiplied by their respective income shares (s_k and s_l):

$$\dot{I}/I = s_k \dot{K}/K + s_l \dot{L}/L$$

Assuming that growth in labour inputs is the sum of growth in total hours ($\dot{H}/H$) and change in skill composition ($\dot{LC}/LC$):

$$\dot{I}/I = s_k \dot{K}/K + s_l (\dot{LC}/LC + \dot{H}/H)$$

Multiplying the change in skill composition by the labour share gives the contribution of skill composition to MFP growth. MFP growth rates can be adjusted for the contribution of skill composition, and a new index determined using the adjusted growth rates.

The experimental adjusted MFP index in chapter 4 was derived using the ABS experimental quality-adjusted labour input index. Change in skill composition was calculated by subtracting growth in the hours worked index from growth in the adjusted index. This growth was then multiplied by the labour income share to get the contribution of skill composition growth to MFP growth. The ABS (conventionally-measured) MFP index was then adjusted for this contribution to derive an experimental adjusted MFP index.

C Influences on skill composition change

In chapter 4 the influences on the ABS labour services input measure were identified. It was concluded that it has been mainly change in the composition of hours worked, rather than change in relative wages, that has led to skill composition change in the 1980s and 1990s. The method of separating these influences is detailed in this appendix, along with some more detail about the underlying trends in hours worked and wages between skill groups.

C.1 Methodology

The ABS experimental labour services input series, as described in the ABS staff paper Reilly and Milne (2000), is a product of taking hours worked, cross-classified by education and potential work experience groups, and weighting them by an estimation of relative wages for each group. A shift in the skill composition of labour input towards the skilled can be due to a combination of changes in the composition of total hours worked across skill groups and changes in relative wages across skill groups. With unpublished ABS data on each of these components it has been possible to examine the relative importance of each of these changes for males and females separately.[1]

Estimating hours worked and wages

For this estimation, ABS data on average hours worked and numbers in the workforce cross-classified by four education classifications and five experience levels (10 year groups) were used. Total hours worked for each of the 20 skill groups was calculated. The data for hours worked by skill groups are from the Income Distribution Survey (IDS) for years up to 1990 and the Survey of Income and Housing Costs (SIHC) from 1994 onwards. The IDS was only undertaken every four years so the data for years between the survey years (1982, 1986 and 1990) have been interpolated, as have the years between 1990 and 1994. This interpolation

[1] It was not possible to also do this components analysis for persons. This would require the ABS to re-estimate wages for persons rather than on the gender basis that was originally used.

was done using the trend of hours worked from the Labour Force Survey (LFS). Total hours worked from the IDS/SIHC is different to total hours worked from the LFS, on which the productivity estimates are based. Therefore, the IDS/SIHC data have been benchmarked to the LFS to get the adjusted series. The result is a series with the trend of the LFS, but with the IDS/SIHC proportions between skill groups.

In order to get hours worked by gender, the benchmarked hours worked series was divided using the proportions of male and female hours from the IDS/SIHC. One complication with this method was that for the years where there was no IDS data the proportions needed to be interpolated. The method used for the estimates presented in this chapter was to average the change in the proportions between the data points over the four year period, in effect apportioning some of the total change to each year.[2]

Reilly and Milne estimated wages for each of the skill groups using regressions for the male wage and the female wage. Using revised ABS estimates of the regression coefficients in Reilly and Milne (2000), and assuming the midpoint year of each potential experience category, it has been possible to calculate approximate estimates of the wages used by the ABS. These approximate wages exclude the variables for part-time work and regional effects, which were in the Reilly and Milne regression but were not statistically significant.

Estimating the adjusted indexes

With hours worked and wages for the skill groups it is possible to assess the changes in one whilst keeping the other constant. This indicates whether it is the change in composition of the hours worked or the change in the relative wages that has had the greatest impact on skill composition change. From the raw data a standard, unweighted, hours worked index has been calculated. From this basis, three adjusted indexes can be estimated.

For all three adjusted indexes the unweighted growth in hours from the LFS survey still applies, as indicated by the hours worked index. The following adjustments are made to this hours worked trend. First, an index that only adjusts for changes in the composition of hours is calculated by maintaining the relative wages for the skill groups constant at the 1982-83 level and allowing the composition of hours to vary. The resulting index shows the effect of this movement in hours. For example, a

2 This differs slightly from the method used by Reilly and Milne. For the years where the IDS proportion was not available, the next available year was used (for example, for 1983, 1984 and 1985 the 1986 proportion was used, instead of apportioning the change across the four year period). For females this method results in sharp movements in the hours worked as the proportions jump significantly in the first year of interpolation.

movement of hours to high-skilled groups results in a shift in skill composition towards skill due to the higher wages these hours are assigned. Second, an index that only adjusts for changes in relative wages is calculated by holding the composition of hours between skill groups constant at their 1982-83 level and allowing wages to vary across the period. This index shows the effect of any change in relative wages — growth in wages of skilled workers relative to those of unskilled workers will lead to a shift in skill composition towards the skilled. Third, from the raw data a fully adjusted index is estimated where both the composition of hours and relative wages are allowed to change. This index is an approximation of the ABS labour services input series. The indexes presented here are somewhat different to the ABS series due to a number of approximations made in estimating the weights, the use of unadjusted data, the use of broader definitions for the skill groups and the simplification of the methodology.[3]

C.2 Results

As indicated in chapter 4, it has been change in the composition of hours rather than change in relative wages that has led to skill composition change. This has been true for both males and females.

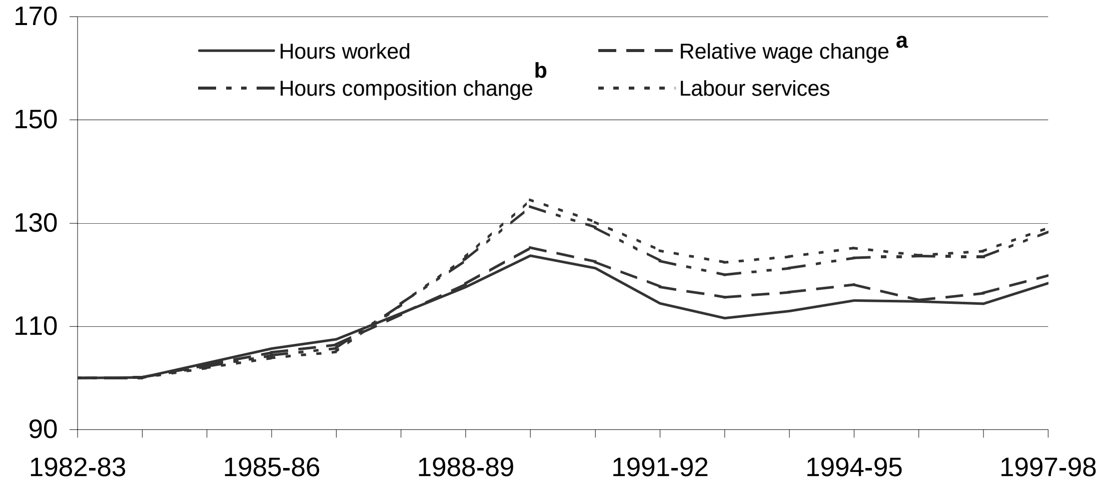
The trend for males is similar to that for persons, because hours worked by males make up the largest proportion of total hours. Figure C.1 indicates that the majority of the change in skill composition for males has come from changes in the composition of hours worked rather than change in relative wages. During the period of strongest compositional shift towards skill, from 1986-87 to 1990-91, there was also strong growth in the index identifying only change in the composition of hours. The index showing changes in relative wages shows significantly slower growth, only just above that of hours worked. These results indicate that while the wages of high-skill groups relative to low-skill groups have not changed significantly for males, there has been strong relative growth in the hours worked in high-skill groups, which is driving skill composition change. This relative growth in hours for the high-skill groups is, in part, due to the ageing of the

[3] Midpoints were used in estimating the potential experience years for the weight regressions. Also, for both the weights and the hours, 10 year potential experience brackets were used rather than the 5 year brackets used by the ABS. This was to reduce the amount of unpublished data required. The ABS also made adjustments to the raw data for survey inconsistencies over time that could not be replicated in this paper — in particular the ABS removed some wage outliers and adjusted 1990-91 data for misclassification of education levels. In addition, the ABS estimated the labour services input index using a Tornqvist index, which was not used in the estimations in this paper.

population. As the population ages, hours worked in the higher potential experience groups grows, implying an increase in skill.

Figure C.1 **Labour input indexes adjusted for component influences, males, 1982-83 to 1997-98**

Index 1982-83 = 100

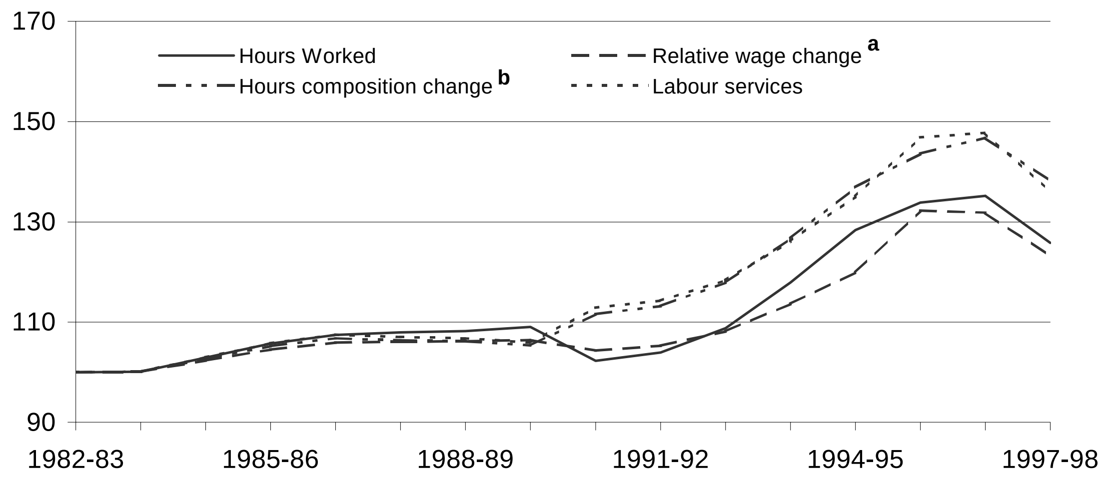


[a] Composition of hours held constant. [b] Relative wages held constant.

Data source: Productivity Commission estimates based on unpublished ABS data.

Figure C.2 **Labour input indexes adjusted for component influences, females, 1982-83 to 1997-98**

Index 1982-83 = 100



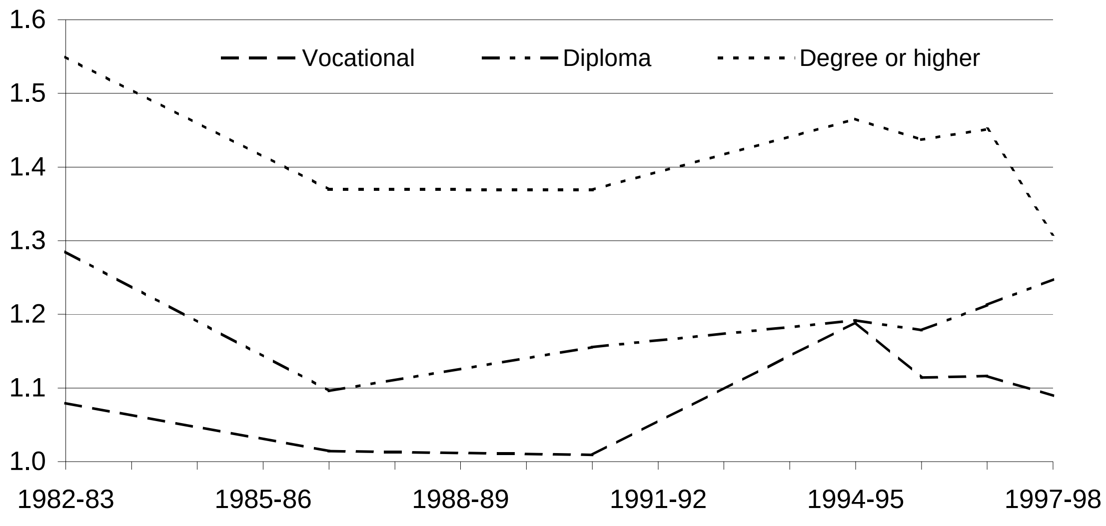
[a] Composition of hours held constant. [b] Relative wages held constant.

Data source: Productivity Commission estimates based on unpublished ABS data.

The results for females show a very different trend to that for persons — hours worked by females are the minority proportion of total hours. Figure C.2 shows hours worked by females grew gradually in the 1980s, then declined during the recession of the early 1990s before growing strongly after 1991-92. There was a significant compositional shift towards skilled workers during the recession, most likely due to the loss of employment being concentrated in low-skilled groups. For females, as for males, it appears that the change in skill composition has been primarily driven by a change in the composition of hours — a movement of hours to the high-skill groups. Interestingly, changes in relative wages appear to have had a negative influence on skill composition, with the index of relative wage change below the hours worked index for the majority of the period. This indicates that there has been a fall in the wages for skilled females relative to unskilled females.

A closer look at trends in the data shows that, while there is some volatility in the wage data, relativities between wage returns for both experience and education levels have been reasonably stable. The most noticeable trend is that for females there has been a fall in the relative wage return to education. Between 1982-83 and 1997-98 wages of females with a bachelor degree or higher level of qualification fell relative to the wages of those with no qualifications (figure C.3). For males there was also a slight fall.

Figure C.3 **Wages by education group, females, 1982-83 to 1997-98[a]**
Ratio to 'no qualifications' group

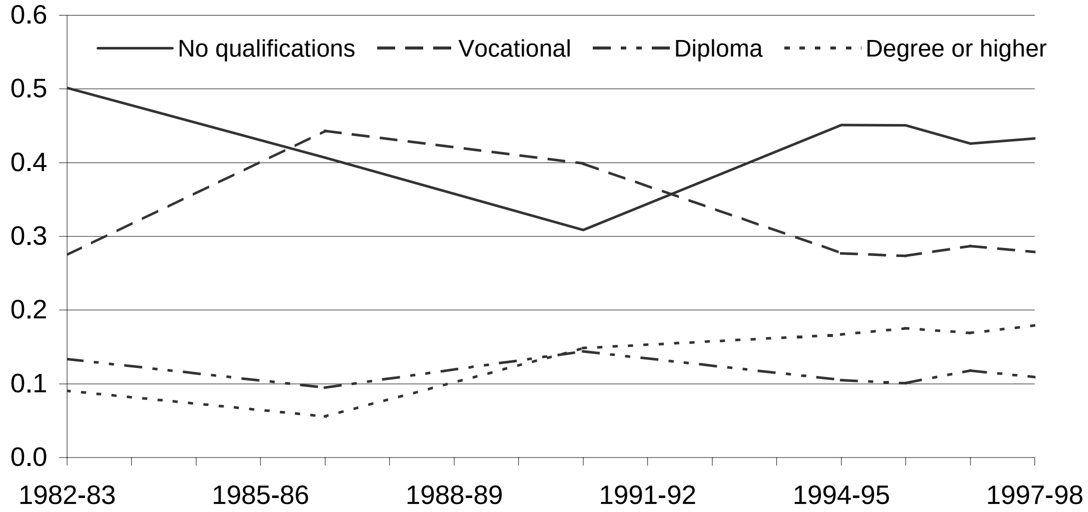


[a] Based on data for 1982-83, 1986-87, 1990-91, 1994-95, 1995-96, 1996-97 and 1997-98, with intervening years interpolated. Data for 1990-91 are considered by Reilly and Milne (2000) to be flawed due to data collection problems.

Data source: Productivity Commission estimates based on unpublished ABS data.

The trends in hours worked, for males (figure C.4) and females (figure C.5), show growth in the proportion of hours worked by those workers with the highest education qualification (bachelor degree or higher).

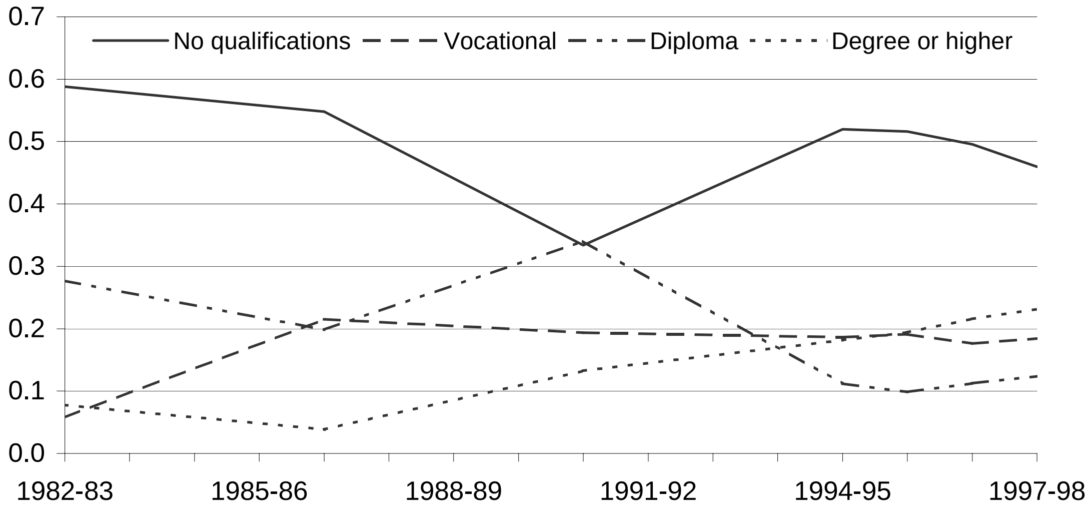
Figure C.4 **Hours worked by education group, males, 1982-83 to 1997-98[a]**
Proportion of total hours worked by males



[a] Based on data for 1982-83, 1986-87, 1990-91, 1994-95, 1995-96, 1996-97 and 1997-98, with intervening years interpolated. Data for 1990-91 are considered by Reilly and Milne (2000) to be flawed due to data collection problems.

Data source: Productivity Commission estimates based on unpublished ABS data.

Figure C.5 **Hours worked by education group, females, 1982-83 to 1997-98[a]**
Proportion of total hours worked by females



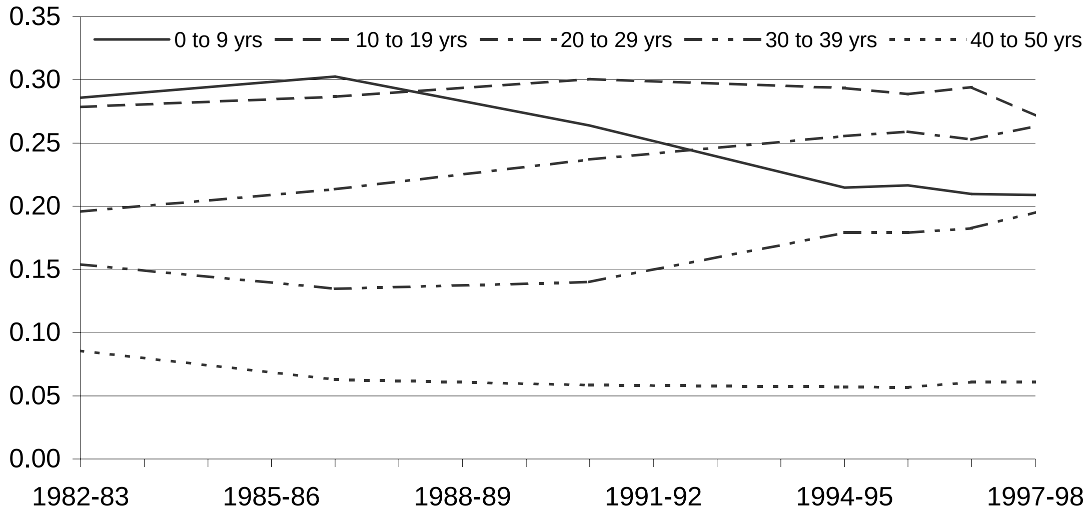
[a] Based on data for 1982-83, 1986-87, 1990-91, 1994-95, 1995-96, 1996-97 and 1997-98, with intervening years interpolated. Data for 1990-91 are considered by Reilly and Milne (2000) to be flawed due to data collection problems.

Data source: Productivity Commission estimates based on unpublished ABS data.

The trend in hours worked by potential experience groups shows a fall, for both males and females, in the proportion of hours worked by those with 0 to 9 years experience. For males, the groups with increasing proportions have been 20 to 29 years and 30 to 39 years (figure C.6). This was also the case for females, but there was also growth in the 10 to 19 years group (figure C.7). These trends are most likely driven by the ageing of the population (Reilly and Milne 2000). The changes in the composition of hours between experience groups had a significant influence on skill composition change, because those groups with growth in the proportion of total hours worked are also the groups with the higher wage rates, and are therefore weighted more heavily in the labour services index.

Figure C.6 **Hours worked by potential experience group, males, 1982-83 to 1997-98[a]**

Proportion of total hours worked by males

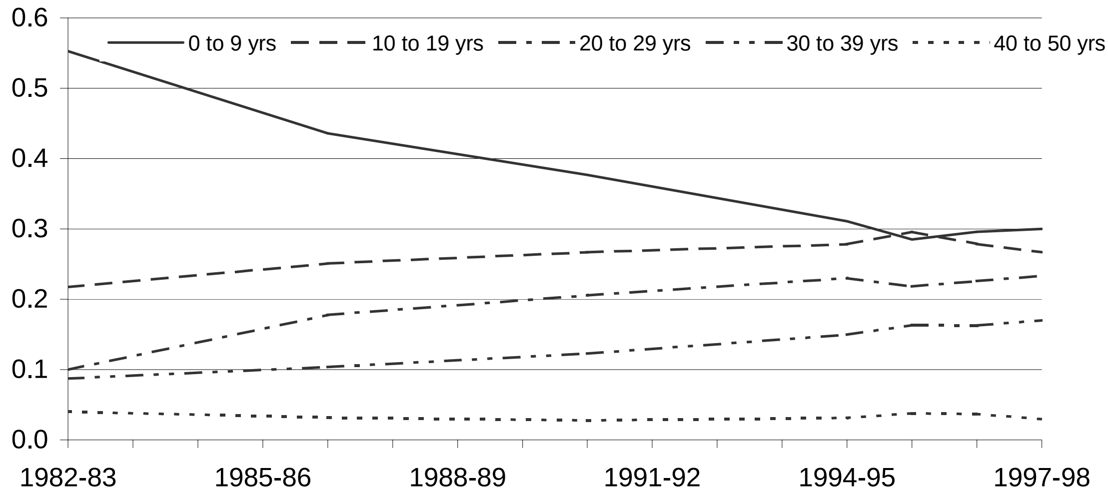


[a] Based on data for 1982-83, 1986-87, 1990-91, 1994-95, 1995-96, 1996-97 and 1997-98, with intervening years interpolated.

Data source: Productivity Commission estimates based on unpublished ABS data.

Figure C.7 **Hours worked by potential experience group, females, 1982-83 to 1997-98[a]**

Proportion of total hours worked by females



[a] Based on data for 1982-83, 1986-87, 1990-91, 1994-95, 1995-96, 1996-97 and 1997-98, with intervening years interpolated.

Data source: Productivity Commission estimates based on unpublished ABS data.

References

ABS (Australian Bureau of Statistics) 1993, *Transition from Education to Work, Australia,* Cat. no. 6227.0, May, ABS, Canberra.

—— 1997, *Transition from Education to Work, Australia*, Cat. no. 6227.0, May, ABS, Canberra.

—— 1998, *Link between First and Second Editions of Australian Standard Classification of Occupations*, ABS Information Paper, Cat. no. 1232.0, May, ABS, Canberra.

—— 2001, 'Further developments in the analysis of productivity growth in Australia', in *Australian National Accounts: National Income, Expenditure and Product,* Cat. no. 5206.0, September Quarter.

Barnes, P., Johnson, R., Kulys, A. and Hook, S. 1999, *Productivity and the Structure of Employment*, Productivity Commission Staff Research Paper, AusInfo, Canberra.

Barro, R. and Lee, J-W. 2001, *International Data on Educational Attainment: Updates and Implications*, Centre for International Development Working Paper no. 42, Human capital updated files, http://www2.cid.harvard.edu/ciddata (accessed 23 May 2002).

Bassanini, A. and Scarpetta, S. 2001, *Does Human Capital Matter for Growth in OECD Countries? Evidence from Pooled Mean-Group Estimates*, Economics Department Working Paper no. 282, OECD, Paris.

Berman, E., Bound, J. and Machin, S. 1998, 'Implications of skill-biased technological change: international evidence', *Quarterly Journal of Economics*, November, pp. 1245–79.

BLS (Bureau of Labor Statistics) 1993, *Labor Composition and US Productivity Growth, 1948-90*, US Department of Labor, Bureau of Labor Statistics, Bulletin 2426, US Government Printing Office, Washington DC.

—— 2002, *Multifactor Productivity Trends, 2000*, US Department of Labor 02-128, Washington DC, 12 March.

Borland, J. 1998, *Earnings Inequality in Australia: Change, Causes and Consequences*, Centre for Economic Policy Research Discussion Paper no. 390, Centre for Economic Policy Research, Australian National University, Canberra.

——, Gregory, B. and Sheehan, P. 2001, ‘Inequality and economic change’ in Borland, J., Gregory, B. and Sheehan, P. (eds), *Work Rich, Work Poor: Inequality and Economic Change in Australia*, Centre for Strategic Studies, Victoria University Press, Melbourne, pp. 1–20.

Cohen, W. and Levinthal, D. 1990, ‘Absorptive capacity: a new perspective on learning and innovation’, *Administrative Science Quarterly*, vol. 35, pp. 128–52.

de Laine, C., Laplagne, P. and Stone, S. 2000, *The Increasing Demand for Skilled Workers in Australia: The Role of Technical Change*, Productivity Commission Staff Research Paper, AusInfo, Canberra.

Dowrick, S. 2002, Ideas and Education: Level or Growth Effects? Lessons from the Cambridge Counter-revolution and Implications for Australian Economic Growth, Paper presented at the National Bureau of Economic Research 13th Annual East Asian Seminar on Economics (Productivity), Melbourne, 20–22 June.

EPAC (Economic Planning Advisory Commission) 1996a, *The Changing Australian Labour Market*, Commission Paper no. 11, AGPS, Canberra.

—— 1996b, *Future Labour Market Issues for Australia*, Commission Paper no. 12, AGPS, Canberra.

Freebairn, J. 1998, ‘Microeconomics of the Australian labour market’ in Debelle, G. and Borland, J. (eds), *Unemployment and the Australian Labour Market*, Proceedings of a Conference, 9–10 June, Reserve Bank of Australia/Centre for Economic Policy Research, Australian National University, RBA, Sydney, pp. 110–34.

Goodwin, M. and Johnston, R. 1999, ‘The place of absorptive capacity in national innovation systems: the case of Australia’, *Science and Public Policy*, vol. 26, no. 2, pp. 83–90.

Gordon, R. 2000, ‘Raising the speed limit: US economic growth in the information age: comment’, *Brookings Papers on Economic Activity*, no. 1, pp. 212–22.

Greenspan, A. 2000, Structural Change in the New Economy, Paper presented to the National Governors’ Association, 92nd Annual Meeting, Pennsylvania, 11 July, http://www.bog.frb.fed.us/boarddocs/speeches/2000/20000711.htm (accessed 13 July 2000).

Hamermesh, D. 1993, *Labor Demand*, Princeton University Press, Princeton, New Jersey.

Jackman, R., Layard, R., Manacorda, M. and Petrongolo, B. 1997, *European versus US Unemployment: Different Responses to Increased Demand for Skill?*, Centre for Economic Performance Discussion Paper no. 349, London School of Economics, London.

Machin, S. and Van Reenen, J. 1998, ‘Technology and changes in skill structure: evidence from seven OECD countries’, *Quarterly Journal of Economics*, November, pp. 1215–44.

McLachlan, R., Clark, C. and Monday, I. 2002, *Australia’s Service Sector: A Study in Diversity*, Productivity Commission Staff Research Paper, AusInfo, Canberra.

Nickell, S. and Layard, R. 1998, *Labour Market Institutions and Economic Performance*, Centre for Economic Performance, London School of Economics and Political Science, London.

OECD (Organisation for Economic Co-operation and Development) 1994, *OECD Jobs Study, Evidence and Explanations, Pt II — The Adjustment Potential of the Labour Market*, OECD, Paris.

—— 1996, *Technology, Productivity and Job Creation*, vol. 2, *Analytical Report*, OECD, Paris.

—— 1998a, *OECD Employment Outlook June 1998*, OECD, Paris.

—— 1998b, *Technology, Productivity and Job Creation — Best Policy Practices*, OECD, Paris.

—— 2000a, *A New Economy? The Changing Role of Innovation and Information Technology in Growth*, OECD, Paris.

—— 2000b, *OECD Economic Outlook No. 68*, vol. 2000/2, OECD, Paris.

—— 2001a, *The New Economy: Beyond the Hype*, The OECD Growth Project, OECD, Paris.

—— 2001b, *OECD Science, Technology and Industry Scoreboard 2001*, OECD, Paris, section B.2, http://www1.oecd.org/publications/e-book/92-2001-04-1-2987//Module_B_data/DataB2.1.2_e.xls (accessed 6 September 2002).

Pappas, N. 1998, ‘Changes in the demand for skilled labour in Australia’, in Sheehan, P. and Tegart, G. (eds), *Working for the Future*, Centre for Strategic Economic Studies, Victoria University Press, Melbourne, pp. 253–92.

Parham, D. 2002, Australia’s 1990s Productivity Surge and its Determinants, Paper presented at the National Bureau of Economic Research 13th Annual East Asian Seminar on Economics (Productivity), Melbourne, 20–22 June.

Reilly, R. and Milne, W. 2000, Quality Adjusted Labour Inputs, ABS paper presented at the 29th Annual Conference of Economists, Gold Coast, 3–6 July.

Scarpetta, S., Bassanini, A., Pilat, D. and Schreyer, P. 2000, *Economic Growth in the OECD Area: Recent Trends at the Aggregate and Sectoral Level*, Economics Department Working Paper no. 248, OECD, Paris.

Spenner, K. 1990, 'Skill: meanings, methods and measures', *Work and Occupations*, vol. 17, no. 4, pp. 399–421.

Vickery, J. 1999, *Unemployment and Skills in Australia*, Reserve Bank of Australia Research Discussion Paper, RBA, Sydney.