Youth wages and Employment

Staff Research Paper

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PREFACE

This paper was written by Anne Daly, Duc Nguyen-Hong, Damien Eldridge, Owen Gabbitas and Paulene McCalman under the direction of Philippa Dee. Anne Daly was employed under contract from the University of Canberra. The paper arose from Commission consultations on its research program, which led to specific requests for work on this topic by several government departments and other organisations. The paper was prepared accordingly by Commission staff as a technical exercise to help inform the forthcoming review of junior rates of pay by the Australian Industrial Relations Commission.

The paper has benefited from comments by Judith Sloan, Lynne Williams and Meredith Baker of the Productivity Commission, Phil Lewis of Murdoch University and staff of the Commonwealth Department of Workplace Relations and Small Business. The views expressed in this paper remain those of the authors. The authors thank Terry Maidment and Dave Cobau for their research and technical assistance.

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ABBREVIATIONS

ABS	Australian Bureau of Statistics
AGPS	Australian Government Publishing Service (now AusInfo)
AIRC	Australian Industrial Relations Commission
ANU	Australian National University
ANZSIC	Australian and New Zealand Standard Industrial Classification (industry classification used by the ABS from 1993 onwards)
ASIC	Australian Standard Industrial Classification (industry classification used by the ABS up to 1993)
AWE	Average Weekly Earnings survey (ABS Cat. No. 6302.0)
AWIRS 95	Australian Workplace Industrial Relations Survey 1995
BLMR	Bureau of Labour Market Research
DEETYA	Department of Employment, Education, Training and Youth Affairs
DIR	Department of Industrial Relations (now DWSRB)
DWRSB	Department of Workplace Relations and Small Business
GDP	Gross Domestic Product
LFS	Labour Force Australia survey (ABS Cat. No. 6203.0)
OECD	Organisation for Economic Co-operation and Development
SURE	Seemingly unrelated regression equations
WEEDA	Weekly Earnings of Employees (Distribution) Australia survey (ABS Cat. No. 6310.0)

SUMMARY

Background

Youth unemployment rates are among the highest in the economy. Lowering youth wages has been advanced as a means of reducing these unemployment rates. Under the Workplace Relations Act, the Australian Industrial Relations Commission is required to report by June 1999 on:

- the feasibility of replacing junior rates (specified in many Federal and State awards) with ‘non-discriminatory’ alternatives; and
- the consequences for youth employment of abolishing junior rates.

Little quantitative work has been undertaken in Australia on the role of youth wages in determining youth employment since the early 1980s. The current study arose from Commission consultations on its research program, which led to specific requests for work on this topic by several government departments and other organisations. The paper was prepared accordingly as a technical exercise to help inform the forthcoming review of junior rates of pay.

Focus of the study

This study focuses on youth employment (rather than *un*employment).

- It is primarily concerned with factors influencing the demand for youth workers. One factor is youth wages, although it is by no means the only one.
- The study is also concerned with the interaction between youth and adult employment. An important question is whether, and in what direction, a change in youth wages would influence adult employment.

Trends in youth employment and wages

The trends in youth employment over the last few decades have been striking. One key trend has been the decline in youth employment. Between 1966 and 1997, while adult employment rose significantly, the number of teenagers employed fell by 15 per cent.

Another trend has been the shift in the composition of teenage employment. Full-time employment has fallen, while part-time employment has increased (mainly in retail trade). The older age groups have not experienced significant changes in the proportion of full-time and part-time workers.

Teenage real wage costs (as measured by real hourly earnings) have increased slightly. This could explain, at least in part, the decline in full-time employment. But for teenage part-time workers, both real hourly earnings and total hours worked have risen. Increased demand for part-time workers resulting from extended trading hours in retail and other service industries could be one factor explaining this trend.

While the teenage wage has not changed much relative to the adult wage, teenage employment has declined relative to adult employment. For teenage full-time workers, wage costs and employment have both fallen relative to adults. For teenage part-time workers, wage costs and employment have both increased relative to adults. Neither trend is consistent with a strong degree of substitution between teenage and adult workers. Indeed, the trends suggest the opposite.

The observed patterns of youth wage costs and employment may also reflect non-wage factors, such as:

- changes in the scale of operation of industries employing youth workers; and
- increases in school retention rates, with consequent changes in the productivity of youth workers.

Non-wage factors need to be taken into account before an assessment can be made of the influence of youth wages on youth and adult employment.

Previous work

Previous studies of labour demand, to a greater or lesser extent, have attempted to correct for non-wage influences on employment. Australian studies suggest that, at the aggregate level, a 10 per cent cut in the real wage would raise overall employment by at least 4 per cent, and possibly by as much as 7 per cent. However, there are reasons for expecting the effect of wage changes on youth employment to differ from this overall average.

International and Australian studies that examine the relationship between youth wages and employment are of two types — those focusing on the minimum wage, and those focusing on substitution between different types of labour.

At face value, the minimum wage studies (primarily undertaken in the United States) suggest that the effect on employment of changes in the minimum wage is small. However, it is important to remember that even among teenagers, who are often the most affected by minimum wages, the proportion being paid the minimum wage is relatively small. Minimum wage studies do not say anything about what would happen if the wages of the remaining teenagers were changed relative to employees in other demographic groups.

Studies that can examine this question look at substitution between particular types of labour. The estimated responsiveness of youth employment to youth wages in these studies is considerably higher than the estimates from the minimum wage studies. The weight of evidence suggests a relatively large (much more than proportionate) decline in youth employment in response to an increase in the youth wage.

As noted, there are few Australian studies looking explicitly at the influence of youth wages on employment.

Results of this study

This study uses econometric analysis of a large cross sectional data set, the Australian Workplace Industrial Relations Survey 1995 (AWIRS 95). Using econometric techniques is one way of isolating the influence of wages from the influence of other factors affecting youth employment.

The analysis finds a significant negative relationship between youth employment and youth wages. The best estimates suggest that a 1 per cent increase in youth wages would lead to a decrease in youth employment of between 2 and 5 per cent in industries employing a relatively high proportion of youth.

The evidence of a relationship between youth and adult employment is much less robust. One reason is that the AWIRS 95 dataset does not contain information on the price of capital. Thus, the analysis cannot allow for substitution between (relatively unskilled) youth and capital. As a result, some tightly constrained specifications force more apparent substitution between youth and adult employment than might occur in practice. Looser specifications suggest a complementary relationship between youth and adults — both youth and adult employment would fall as youth wages rose. Nevertheless, the data limitations make it difficult to have confidence in this result.

The purpose of the study was to examine the determinants of youth employment in order to shed light on the possible implications of abolishing junior rates of pay in State and Federal awards. To the extent that replacing such awards with non-discriminatory alternatives would lead to an increase in youth wages, the results suggest quite strongly that there would be a more than proportionate reduction in youth employment. Data limitations make it difficult to make a reliable assessment of the effect on adult employment.

1 SCOPE OF THIS STUDY

In principle, the interaction of demand and supply determines employment outcomes both at the aggregate level and for specific sub-groups within the labour market.

In deciding employment levels, employers take into account a variety of labour-specific costs including wage rates, superannuation, workers' compensation and payroll tax. Demand for their product and relative costs of non-labour inputs also play a role in determining the demand for labour.

In deciding whether to seek employment, potential employees also consider a range of factors including wage rates, opportunities for on-the-job training, alternative uses of their time (such as participation in education) and remuneration other than through wages.

In turn, many of these factors are influenced by legislative requirements. As well, the interaction of demand and supply can have differential impacts across different groups or sectors.

One group of particular interest is youth. Many awards at both the Federal and State level specify junior rates of pay. Lowering youth wages has been advanced as a means of reducing youth unemployment rates. The Federal Workplace Relations Act 1996 requires the Australian Industrial Relations Commission (AIRC) to prepare a report of the Full Bench before 22 June 1999 on 'the feasibility of replacing junior rates with non-discriminatory alternatives' and asks it to assess 'the consequences for youth employment of abolishing junior rates' (Workplace Relations Act 1996, Sections 120B (1) and (2)).

In addition, a House of Representatives Standing Committee on Employment, Education and Training (1997) report identifies the need for empirical research on the relationship between changes in the level of wages and employment levels for youth.

Little quantitative work has been undertaken in Australia on the role of youth wages in determining youth employment since the study by the former Bureau of Labour Market Research (BLMR 1983). The current study arose from Commission consultations on its research program, which led to specific requests for work on this topic by several government departments and other organisations. The paper has been prepared accordingly as a technical exercise to help inform the forthcoming review of junior rates of pay.

The first purpose of this study is to isolate and examine the effect of youth wages on youth employment, controlling for as many as possible of the other influences on youth employment outcomes. This gives information on whether an increase in youth wages would reduce youth employment. Another purpose is to examine the interaction between youth and adult employment. This determines whether an increase in youth wages would raise or lower adult employment.

Young employees may be employed on junior rates of pay, 'training' rates or adult rates. The type of wage that applies will be influenced by factors such as award coverage, industry and occupation.

- Junior rates of pay in awards are set as proportions (typically rising proportions according to age) of an adult award rate. For example, an award may provide that 16 year olds receive 50 per cent of the relevant adult rate, with comparable figures for 17 year olds and 18 year olds being 60 per cent and 70 per cent, respectively. Most awards provide that adult rates apply at 21 years of age, but some provide that adult rates apply at 18 years of age.
- 'Training' rates apply to apprentices and trainees, who combine productive work with structured, accredited training.
- Young employees may receive adult rates if the award that covers them does not contain junior rates, or if they have reached an age at which adult rates apply under the award, or if their employer chooses to pay them at adult rates.

The Department of Workplace Relations and Small Business (DWRSB) has estimated that junior rates covered about 56 per cent of young people (under 21 years of age) in 1996. Adult rates and trainee wages were applicable to about 31 per cent and 13 per cent of young people, respectively (Reith 1998).

The importance of the industrial relations tribunals in creating a different wage distribution from that arising in a purely market-driven system has been discussed extensively elsewhere — Borland and Woodbridge (1998) give a recent survey. However, this study does not examine the influence of tribunal decisions on actual youth wages. It starts with actual earnings (made up of actual wages rates, overtime and penalty rates), and looks at their influence on youth and adult employment outcomes.

In addition, while junior rates of pay may apply up to a maximum age of 20, the data on actual earnings used in this study come from several sources, one of which groups young people into a 15 to 19 (or 'teenage') age category, the other of which groups them into a 15 to 20 age category. Consequently, the study does not adopt a single standard definition of 'youth'.

Importantly, however, the study does not restrict itself to looking only at those who receive junior rates of pay. Indeed, the variation in earnings and employment outcomes among those in different types of awards, enterprise bargains or other employment arrangements is an important piece of information with which to establish the influence of earnings on employment.

A full understanding of the youth labour market would ideally involve modelling both the demand and supply sides of the youth labour market. Given time and resource constraints, the focus of this study is on the demand side of the market. This approach is influenced by the principal question of this study — the relationship between wages and employment. It assumes that youth employment is primarily demand-determined. This is the case where there is some excess supply of labour resulting in unemployment. Given the particularly high rates of youth unemployment in recent years, this assumption seems reasonable.

Chapter 2 begins with a review of some of the key (wage and non-wage) influences on youth employment. It then looks at Australian trends in youth employment, and speculates whether these can be explained by wage trends or by non-wage factors. Chapter 3 then surveys studies from Australia and overseas that have formally investigated the influence of youth wages on employment. Chapter 4 examines the relationship between youth wages and employment further, using econometric analysis of a comprehensive dataset of employment outcomes at the workplace level for 1995. This analysis gives some relatively robust insights into the influence of youth wages on youth employment, but data limitations make it difficult to make a reliable assessment of the effect of youth wages on adult employment. Chapter 5 draws the key conclusions from this study.

2 RECENT TRENDS IN YOUTH EMPLOYMENT AND WAGES

Teenage employment represents 7 per cent of all employment in Australia. Much of this employment is of a part-time or casual nature.

This chapter provides an overview of trends in Australian teenage employment, while subsequent chapters try to explain these trends. This chapter looks at the employment and wages of 15 to 19 year olds in absolute terms, to try to discern any influence of teenage wages on teenage employment. It also looks at relativities in teenage/adult wages and employment, to try to identify any influence of teenage wages on adult employment.

Section 2.1 summarises the factors identified by economic theory as influencing labour demand. These include factors other than wages. Ideally, such non-wage factors will need to be controlled for if the effects of wages on youth employment are to be properly identified.

Section 2.2 gives simple two-way comparisons of teenage wages and employment. The comparisons do not correct for other factors, so they are potentially misleading indicators of the *causal* links between teenage wages and employment. Therefore, section 2.3 discusses trends in some of the non-wage factors influencing teenage employment. However, it is difficult to take these factors properly into account using informal observation. This is better achieved using formal econometric techniques.

2.1 Determinants of employment in theory

According to economic theory, some of the key factors affecting the demand for a particular group of workers are:

- wages and non-wage labour costs (including the costs of hiring and firing);
- the level of demand for the goods and services produced;
- factors affecting worker productivity; and
- technological and regulatory changes.

Economic theory suggests that an increase in youth wages usually has a negative effect on youth employment. An increase in youth wages raises the cost of young workers, both absolutely and relative to other productive inputs. Firms may respond to such cost pressures by employing fewer young workers and more of the other factors — adult workers and/or capital. Firms may also reduce their scale of operation, a response that would reinforce the adverse effect on youth employment.

Non-wage labour costs also affect employment. Some non-wage costs are wage-related, such as payroll tax, superannuation and workers compensation. Over time, there have been few changes in these costs for young workers, relative to other categories of labour. The main change was the introduction in 1992 of an exemption from the superannuation guarantee levy for those less than 18 years old working part time.[1] This one-off change in the relative on-costs of young and adult workers is unlikely to explain any longer term deviations in youth relative to adult employment.

Another category of non-wage costs is the fixed costs of employment, such as training and hiring and firing costs. These could be important, given that young workers tend to be more mobile than adults. Thus, fixed costs may bias employment decisions against young workers, all other things being equal, since these costs will contribute proportionately less to overall average labour costs for workers who stay longer in a given job. On the other hand, many young workers are in unskilled jobs, where hiring and training costs are lower. Trends in youth relative to adult mobility are discussed later in the chapter.

If demand for a firm's output increases and the firm decides to increase its scale of operation, this would tend to increase employment of all categories of labour, for a given level of wages. One of the key empirical challenges is to separate out the influence of wages (shifts along a demand curve) from the influence of output changes (shifts of the demand curve) in explaining employment trends. In this respect, the formal econometric methods employed later in this paper have some distinct advantages over the more informal methods used in this chapter.

Productivity increases can lower production costs and increase the demand for labour in the long term. Productivity improvements can result from higher skills, increased training and education, technological changes and workplace reforms.

One of the key factors potentially affecting the productivity of youth workers over time has been the increase in the school retention rate. In the short term, this may have lowered the average productivity of full-time youth workers, as the increased retention left the full-time youth labour pool dominated by those who had left school at 15. Over time, however, the entry of 18 year old high

1 There may still be award-based superannuation obligations for these workers, although this would depend on the provisions in the particular award.

school graduates to the workforce could have raised the average productivity of full-time youth workers, as the pool then became dominated by those leaving school at 18. The increasing tendency of full-time students to work part time may also have raised the average productivity of the part-time labour pool. A second key empirical challenge is to separate out the effects on employment of:

- any improvements in productivity that higher average education may bring; and
- the higher wages that need to be paid to older youth workers.

Once again, the formal econometric methods used later in this paper have some advantages over the informal methods used here.

Technological and regulatory changes can also influence both output and productivity levels, hence affecting employment. Some of the key technological and regulatory changes affecting those industries in which youth employment is concentrated are discussed in more detail in later sections.

2.2 Main trends

This section looks first at available ABS Labour Force Survey data on the *number* of teenagers (aged 15 to 19) employed and their *weekly earnings*. It argues that these data are not appropriate measures of employment and wages. The remainder of the section examines teenage employment and wages using estimated information on *hours paid* and *hourly earnings*. These data are based on the ABS Survey, Weekly Earnings of Employees (Distribution) Australia (WEEDA), which is a supplementary survey to the Labour Force Survey. The data used in this chapter are described in more detail in Appendix A.

Trends in the number of employed youth

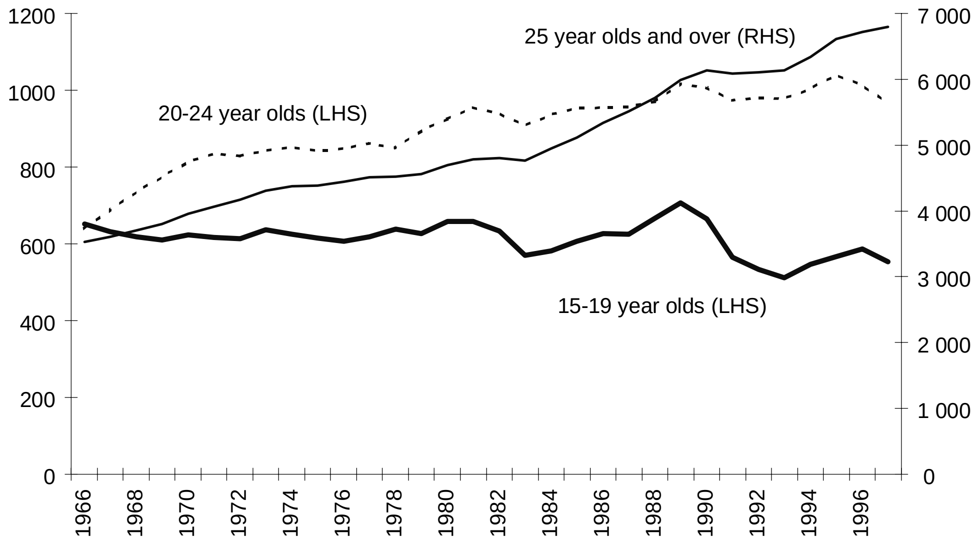
The Labour Force Survey (ABS Cat. No. 6203.0) provides data on the number of employed teenagers available since the 1960s. This is the only data source that can shed some light on the long term trends in youth employment.

In August 1997, there were 553 400 employed teenagers, representing 7 per cent of all employment in Australia.[2] They were evenly divided between males and females.

2 The Labour Force Survey was initially conducted quarterly but is now conducted monthly. This paper uses the August data as they are the least affected by seasonal factors.

There have been significant changes over the past three decades. Since the mid-1960s, adult employment (both 20 to 24 year olds and 25 year olds and over) has generally increased (Figure 2.1). By contrast, teenage employment has tended to decline. Between 1966 and 1997, teenage employment fell by 15 per cent. This decline translates into a significant reduction in the teenage employment to population ratio — both in absolute terms (from 63 per cent in 1966 to 43 per cent in 1997), and relative to adults (despite slower population growth for teenagers than for adults).

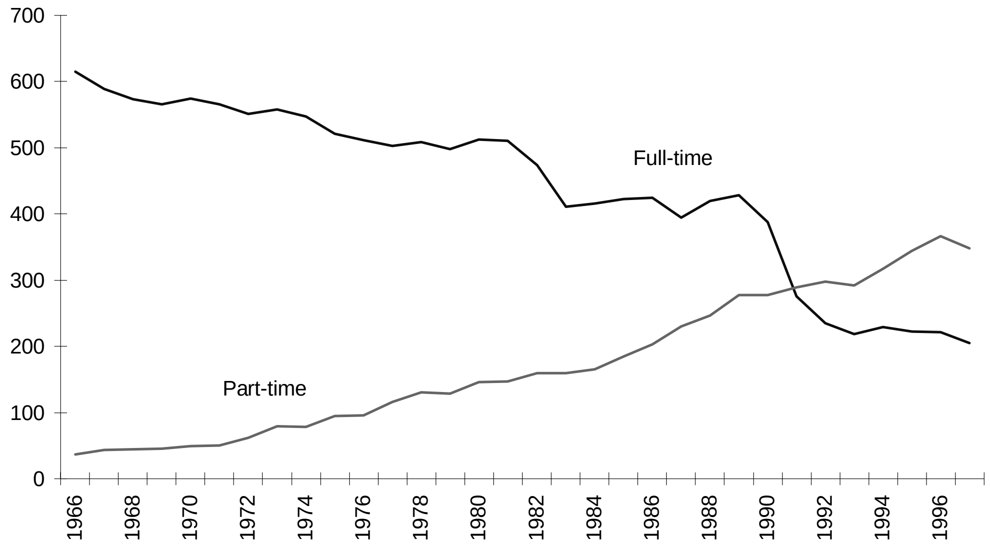
Figure 2.1: Employment by age groups, 1966 to 1997 (Number of employed persons ('000), August)



Source: ABS Cat. No. 6203.0.

Another important change has been the decline in teenage full-time employment and the rise in teenage part-time employment (Figure 2.2). This has occurred in absolute terms and as a proportion of the teenage population. As a result, teenage employment status has fundamentally changed. In the mid-1960s, most teenage workers were employed full-time (over 90 per cent). In 1997, full-time employment accounted for a much smaller share (37 per cent).

Figure 2.2: Teenage employment, 1966 to 1997
(Number of employed persons ('000), August)



Source: ABS Cat. No. 6203.0.

As the BLMR's study of youth employment in 1983 observed, the decline in teenage full-time employment preceded the recession in the 1970s, suggesting that factors other than the recession were at work. Similarly, teenage full-time employment has not recovered from its sharp fall in the early 1990s, despite the subsequent pick up in economic activity.

The increase in teenage part-time employment has coincided with an increase in adult part-time employment. However, much of the teenage part-time employment is of a casual nature — defined by the ABS as employment which is not entitled to annual or sick leave. Unpublished ABS data in Wooden (1998) reveal that casual employees working less than 35 hours a week accounted for 56 per cent of youth employees in 1996. The comparable figure for adults was 13 per cent.

Adult employment has shown different patterns. Both full-time and part-time employment of those aged 25 and over has increased since the mid-1960s. Although full-time employment of 20 to 24 year olds has varied over time, it remains higher in 1997 than in 1966. Unlike teenagers, the older age groups have not experienced significant changes in the proportion of full-time and part-time workers.

Trends in weekly earnings

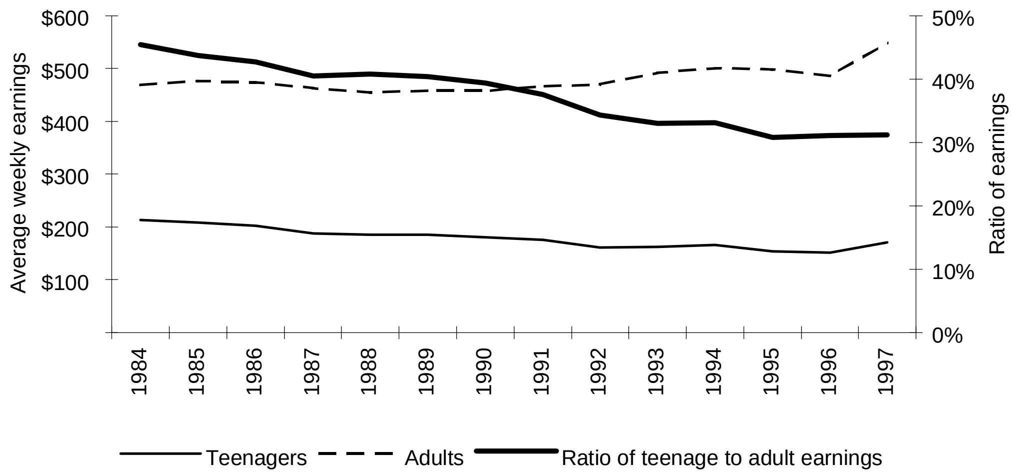
The decline in teenage employment might be related in part to changes in teenage wages. If teenage wage costs have increased in absolute terms, this could have reduced teenage employment directly. If teenage wage costs have risen *relative* to those for adults, the fall in teenage employment could reflect the substitution of adult for teenage workers.

Published information on teenage wages is limited. In a recent report on youth employment, the House of Representatives Standing Committee on Employment, Education and Training (1997) drew attention to the lack of information on youth wages and employment. Nevertheless, studies based on *weekly earnings* have shown that:

- the average weekly earnings of full-time teenage employees relative to those of the 35 to 44 age group declined between 1975 and 1994 (McGuire 1994 and Borland and Wilkins 1997); and
- the average weekly earnings of teenage full-time employees relative to those aged 20 and over have fallen since 1983 (DIR 1997).

These estimates were based on data from the WEEDA survey. It points to declining trends in real teenage weekly earnings, both absolutely and relative to other categories of labour (Figure 2.3).

Figure 2.3: Real average weekly earnings, 1984 to 1997 (August)



Note: Real earnings were estimated by applying the implicit GDP deflator to nominal earnings. This production-based deflator captures the output prices relevant for firms' hiring decisions.

Source: ABS Cat. No. 6310.0. (unpublished data).

Falls in demand for teenage workers?

If teenage wages and employment have both declined over time, perhaps wages do not play an important role in influencing teenage employment. One possible counterargument is that falls in the demand for teenage workers (shifts of the demand curve) have led directly to falls in their wages.

Borland and Wilkins (1997) suggest that changes in labour demand have had stronger effects than changes in labour supply on the age-earnings structure in Australia. In particular, there have been large decreases in the relative demand for younger (including 15 to 19 year olds) and older workers, corresponding to decreases in the relative weekly earnings of those groups between 1975 and 1994. The authors suggest that this can be interpreted as an increase in the relative demand for workers with higher skills.

Teenage wages and productivity

As noted above, an important development in the youth labour market has been the increase in teenage school retention. This has raised the average age at which teenage full-time workers enter the labour market. At the same time, a rising proportion of full-time students are also working part time.

An important issue is whether the data on teenage wages reflect the actual costs of employing teenagers. There are concerns that although the relative wages of teenagers may have fallen, teenage productivity may have declined over time and the effective costs to employers may have actually increased (Sweet 1995 and Wooden 1998).

Under the present system of junior rates, because school leavers are now older on average, they are paid a higher rate of pay than previously. However, it has been argued that their productivity may have been improved less by staying on at school than it was previously by gaining work experience. The fall in the relative wage may simply reflect falls in the relative productivity of teenage full-time workers (Wooden 1998). Nevertheless, employers are known to value maturity in their youth workers. To the extent that maturity develops with age, the older full-time workers may be more valued by employers. However, employers also have the option of choosing full-time students who work part-time. The characteristics of this latter group (above average human capital, a good attitude to work, and a willingness to work flexible hours — see also Dawkins and Norris 1995) may be seen as even more desirable. There appear to be some complex changes occurring that warrant further study.

Employment and real wages

Clearly, analysis of the demand for youth labour would need to take into account non-wage factors such as productivity that influence youth employment (Section 2.3). However, there are also issues in the choice of appropriate data to use as measures of labour demand and wages.

Conceptually, labour services are better measured by *total hours worked* — the product of workers and hours per worker.[3] As workers differ in the number of hours they work and employers can vary their mix of full-time and part-time workers, the number of workers (head counts) could be a misleading measure of labour demand. In particular, the increase in the number of teenage part-time workers could mask possible changes in the demand for labour services. Based on ABS advice, total *hours paid* rather than total *hours worked* was chosen as the preferred measure of employment from the WEEDA survey.[4]

There are similar difficulties in using average weekly earnings as a measure of wage costs. Average weekly earnings may decline because of a reduction in hours worked, rather than a fall in wage cost per hour, particularly given the large increase in the proportion of teenagers working part time. In this study, WEEDA weekly earnings data were divided by hours paid to arrive at a measure of *hourly earnings* in main job. Relative wages were derived as the ratio of 15 to 19 year olds' hourly earnings to adult (20 years and over) hourly earnings.

Changes in total hours worked and hourly earnings

Since the late 1980s, total teenage employment, measured by hours paid, has fallen substantially (Figure 2.4). This has been due to the decline in teenage full-time employment. While teenage part-time employment has increased, this has not been sufficient to offset the decline in full-time employment.

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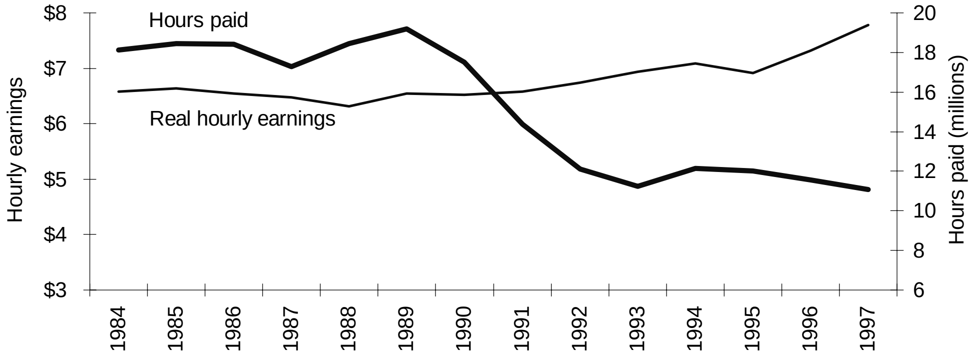
3 However, even the question of whether workers and hours can be aggregated in this fashion is not clear-cut. See Hamermesh (1993, p. 45) for a discussion of this issue.

4 In WEEDA, both hours paid and earnings are measured over the last pay period, while hours worked are measured over the survey reference week. Thus hours paid and earnings are comparable, but hours worked and earnings are not. The hours paid and earnings data used in this study are for main job. The data were provided for full-time and part-time workers separately, reclassified using the standard definition whereby full-time workers are those who work 35 hours or more during the survey week (otherwise, the full-time/part-time split in the WEEDA survey is based on self-perception since 1988).

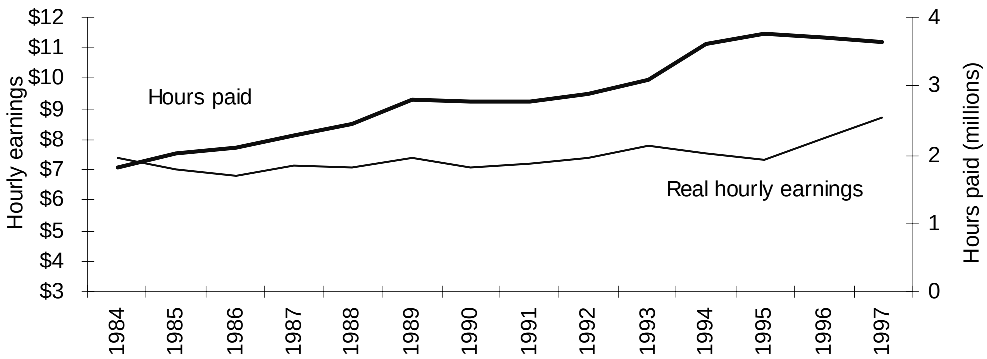
Figure 2.4: Total hours paid and average hourly earnings of teenage employees, 1984 to 1997 (August)

Total employment



Full-time employment

Part-time employment



Note: Real hourly earnings were estimated by applying the implicit GDP deflator to hourly earnings. This production-based deflator captures the output prices relevant for firms' hiring decisions.

Source: ABS Cat. No. 6310.0 (unpublished data).

The average weekly hours of teenage full-time and part-time employees have been relatively stable over time. Between 1984 and 1997, average paid hours of full-time employees fell slightly, from 40 hours per week to 39 hours per week. Average paid hours of teenage part-time employees remained at 11 hours a week over the same period.

Between 1984 and 1997, the decline in teenage employment was associated with an apparent increase in teenage wage costs, as measured by hourly earnings (as opposed to weekly earnings), particularly since 1989, the period over which the main declines in employment occurred. Over the full period, real hourly earnings of all teenage employees rose by 18 per cent. Real hourly earnings rose for part-time and full-time employees, and males and females.

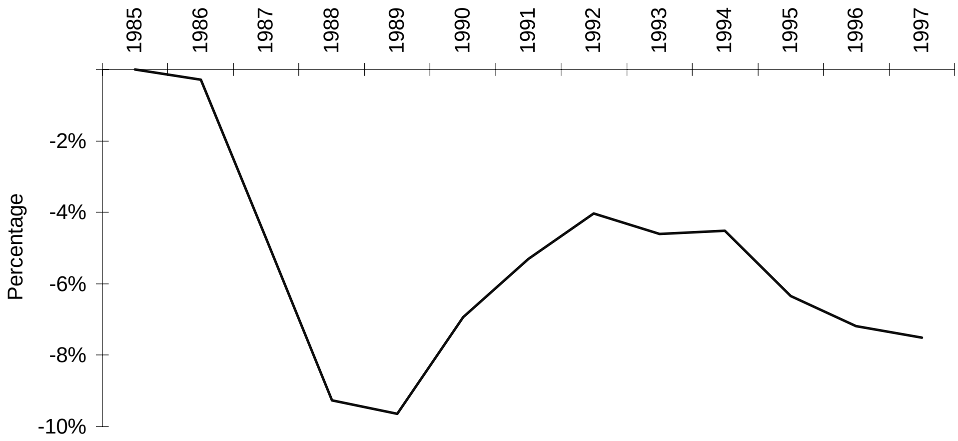
While hourly earnings appear to be negatively related to employment for teenage full-time employees, rising wage costs do not appear to have affected teenage part-time employment adversely — part-time teenage employment more than doubled between 1984 and 1997. Hourly earnings of part-time employees are also typically higher than hourly earnings of full-time employees. This reflects the high level of casual employment within part-time employment, and the associated casual loading.

It may seem surprising that these data show real hourly earnings of teenage employees rising, given that real award rates for full-time adults fell by 7.5 per cent from August 1985 to June 1997 (Figure 2.5), and that junior awards are fixed fractions of adult awards. But most of the fall in the real adult award rates occurred between 1986 and 1988, during which there was explicit 'wage discounting'. The real award rate index actually recovered significantly over the period August 1989 to August 1992, before drifting down again since then.

Several other factors could account for the difference. An obvious one is that total hourly earnings comprise more than award rates of pay — they represent some average of award and non-award, ordinary time and overtime rates, with and without casual loadings. Since casual work has become more prevalent, casual loadings would contribute to an upward drift in real average hourly earnings across all teenage workers (though this could be more than offset by reduced non-wage costs, such as from annual and sick leave).[5] Nevertheless, there is also an upward drift in the real hourly earnings of teenage full-time and part-time workers separately.

5 Dawkins and Norris (1990) compare casual premia with those (primarily non-wage) costs associated only with permanent employees in more detail.

Figure 2.5: Real award rates of pay, full-time adult workers (change from 1985)



Note: Defined as the Index of Award Rates of Pay (Base 1985) deflated by the implicit GDP deflator .
Source: ABS Cat. No. 6312.0.

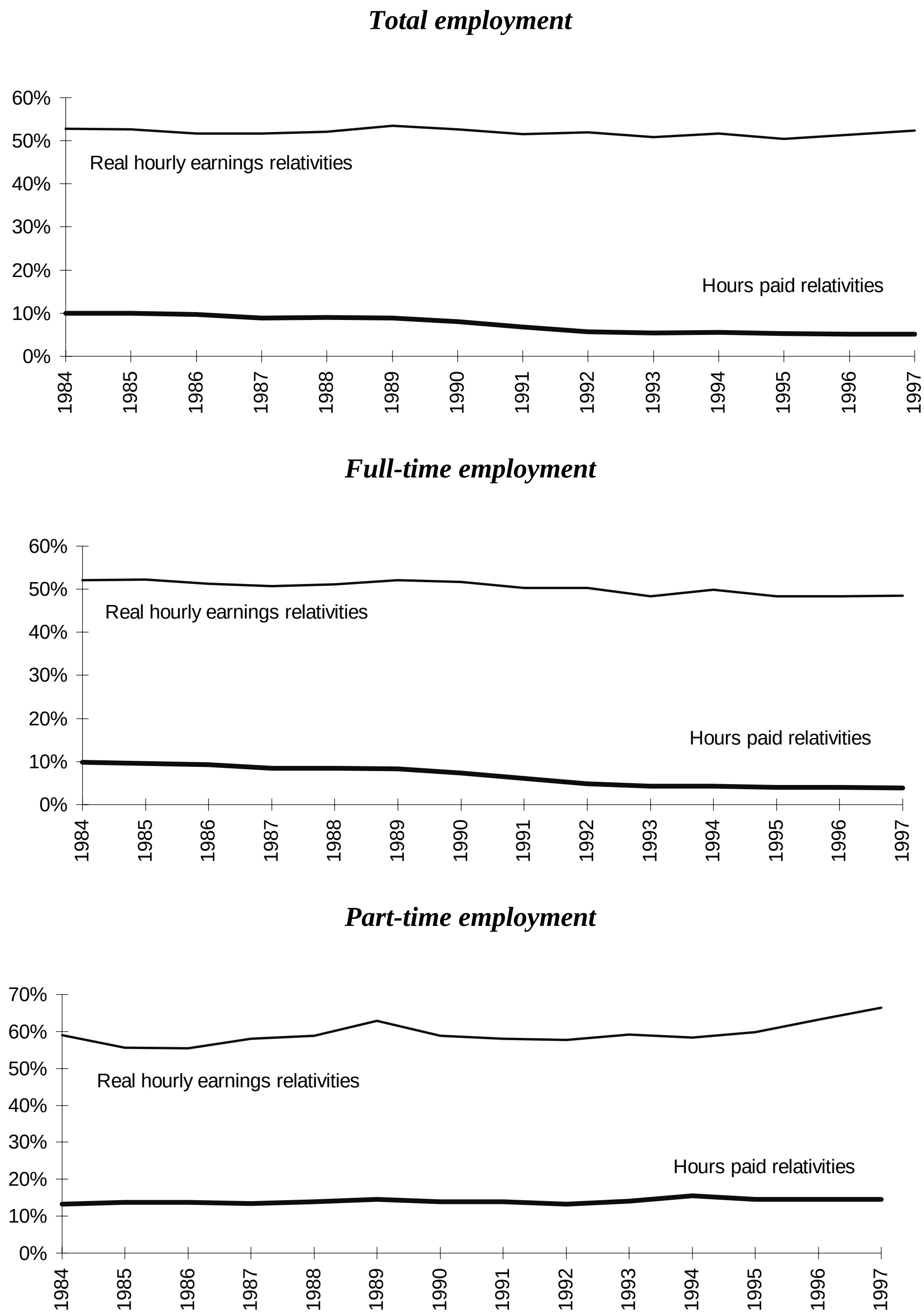
The relatively aggregate WEEDA data may also show apparent movements in real hourly earnings arising from compositional changes — for example, changes in the age, industry or occupation mix of employment — rather than from changes in the hourly wage *rates* of a given category of employees. This point was stressed by the BLMR (1983).

Not all compositional changes should be discounted. If an individual firm or industry finds that compositional changes affect the average wage costs for otherwise identical workers, the hiring responses are a legitimate measure of the labour demand response. However, compositional changes may also affect the *quality* of the youth workers, and this non-wage factor would have to be corrected for in a more formal analysis of the effects of wages on employment. Such factors are discussed in more detail below.

Relative employment and earnings

The aggregate WEEDA data suggest that the increase in teenage hourly earnings between 1984 and 1997 did not translate into a rise in the wage costs of all teenage employees relative to adults (Figure 2.6). Indeed, adult hourly earnings increased at a faster rate, so that teenage relative earnings fell slightly over this period (0.7 per cent). This trend is also apparent in the ABS's EEH survey data (DIR 1997). The small change in the teenage relative wage was accompanied by a much greater reduction in relative teenage employment. The ratio of teenage hours paid to adult hours paid fell by 49 per cent.

Figure 2.6: Teenage/adult hours and earnings relativities, 1984 to 1997 (August)



Note: Calculated as ratio of teenage to adult real hourly earnings and ratio of teenage to adult total weekly hours paid.

Source: Commission estimates based on ABS Cat. No. 6310.0.

For teenage full-time employees, both relative earnings and relative employment declined. Between 1984 and 1997, their relative hourly earnings fell by 7 per cent, while their relative employment fell by 60 per cent.

For teenage part-time employees, relative employment and hourly earnings showed upward trends. Their relative earnings rose by 13 per cent, while their relative employment rose by 10 per cent between 1984 and 1997. Most of the increase in relative earnings occurred in recent years.

A key question, however, is whether the rise in the real hourly earnings of part-timers reflects an increase in their productivity. As noted above, there is an increasing trend of full-time students working part-time, and students often have characteristics valued by employers. If the rise in real part-time hourly earnings is more than compensated by an increase in productivity, this could explain the upward trend in teenage part-time employment.

The aggregate data suggest that teenage females have experienced declines in both employment and hourly earnings relative to adult females. While teenage males have experienced some reductions in employment relative to adult males, their relative hourly earnings have tended to remain fairly stable.

Sectoral developments

The aggregate data presented above can hide important differences in teenage employment across industries. Variations in production technology, input ratios and the price responsiveness of final demand may account for some of these differences. Capital intensive industries would tend to employ fewer workers, including teenage workers, at a given level of hourly earnings. Industries in which output demand is very sensitive to price in turn would tend to have demands for teenage workers that are relatively sensitive to hourly earnings.

Industry distribution of teenage employment

Teenage employment is now concentrated in a few service industries. In August 1997, the retail trade industry accounted for more than half of teenage employment in Australia (Table 2.1). By employment status, the industry accounted for 69 per cent of teenage part-time employment and 26 per cent of teenage full-time employment.

Table 2.1: Sectoral distribution of teenage employment (head count basis, per cent of total)

	Full-time		*Part-time*		*Total*	
ANZSIC industries	*1984*	*1997*	*1984*	*1997*	*1984*	*1997*
Retail trade	25.9	26.0	68.3	68.5	37.9	53.2
Accommodation, cafes & restaurants	2.6	4.4	7.2	11.2	3.9	8.7
Manufacturing	21.3	15.7	5.2	3.4	16.7	7.9
Construction	5.6	12.8	1.2	1.1	4.3	5.3
Property & business services	4.6	8.3	1.5	3.3	3.7	5.1
Personal & other services	2.8	4.4	2.3	2.9	2.7	3.4
Cultural & rec services	1.1	2.8	2.1	3.3	1.3	3.1
Wholesale trade	4.9	6.9	1.8	0.9	4.0	3.1
Agriculture, forestry & fishing	3.7	5.6	1.7	1.4	3.1	2.9
Health & community services	7.7	3.9	3.5	2.0	6.5	2.7
Education	1.0	1.6	3.1	1.5	1.6	1.6
Transport & storage	2.7	2.9	0.3	0.2	2.0	1.2
Government admin & defence	4.7	1.6	0.3	0.0	3.4	0.6
Finance & insurance	7.3	1.2	1.3	0.1	5.6	0.5
Communication services	0.7	0.7	0.0	0.2	0.5	0.4
Mining	1.2	1.0	0.0	0.0	0.8	0.4
Electricity, gas & water	2.4	0.2	0.1	0.0	1.7	0.1
All industries	*100.0*	*100.0*	*100.0*	*100.0*	*100,0*	*100.0*

Source: ABS Cat. No. 6310.0.

The retail trade industry employed teenagers predominantly on a part-time basis (82 per cent of its teenage employment). Most of this part-time employment is casual. Unpublished ABS data obtained by the DIR (1996, supplementary information) reveal that in 1995, 92 per cent of part-time youth employees in retail trade worked on a casual basis. The majority of full-time employees were permanent workers (78 per cent).

Other industries that account for relatively large shares of total teenage employment include accommodation, cafes and restaurants; and manufacturing (9 per cent and 8 per cent, respectively). Construction and property and business services account for a share of 5 per cent each. Manufacturing and construction are important employers of teenage full-time workers.

Important shifts in the industry distribution of teenage employment have occurred since 1984. Industries which have gained increased shares of teenage employment are retail trade; accommodation, cafes and restaurants; construction; property and business services; personal and other services; and cultural and recreational services. The most significant change is the greater share accounted for by retail trade (up from 38 per cent in 1984 to 53 per cent in 1997).

Several industries have had significant falls in their shares of teenage employment. The most notable reductions have been in manufacturing; health and community services; finance and insurance services; and government administration and defence. The reduction in apprenticeships would have contributed to the declines in the manufacturing share of teenage employment.

Total hours worked and hourly earnings

The decline in teenage full-time employment discussed earlier is mirrored at the industry level (Table 2.2). Between 1984 and 1997, teenage full-time employment (both employees and hours paid) declined in most industries, including retail trade. Exceptions to this decline were construction and cultural and recreational services. All industries, however, experienced increases in hourly earnings, and at a slower pace, increases in real hourly earnings.

Increases in hourly earnings of teenage part-time employees also occurred across industries. But despite this, certain service industries recorded significant growth in teenage part-time employment (both employees and hours paid). These were retail trade; accommodation, cafes and restaurants; property and business services; personal and other services; and cultural and recreational services.

The overall employment changes between 1984 and 1997 reflect some important contributions by particular industries. The decline in teenage full-time employment was primarily due to the falls in teenage full-time employment in retail trade (26 per cent) and manufacturing (26 per cent).[6] The growth in teenage part-time employment came mostly from retail trade and accommodation, cafes and restaurants. Between 1984 and 1997, hours paid of teenage part-time employees increased by 1.9 million, of which retail trade and accommodation, cafes and restaurants accounted for 75 per cent and 16 per cent, respectively.

6 Commission estimates based on each sector’s percentage contribution to the absolute decline in full-time teenage employment.

Table 2.2: Change in teenage employment and earnings, 1984 and 1997 (percentage change)

Selected ANZSIC industries	*No. of employees*	*Hours paid*	*Hourly earnings*	*Real hourly earnings*[b]
Full-time employment				
Retail trade	-52.5	-54.0	98.7	18.8
Accommodation, cafes & restaurants	-19.6	-22.7	78.8	6.9
Manufacturing	-65.2	-66.0	81.7	8.6
Construction	8.2	2.1	77.9	6.3
Property & business services	-15.3	-24.5	96.0	17.2
Personal & other services[a]	-57.8	-61.6	142.2	52.7
Cultural & recreational services	25.7	12.1	126.9	35.6
Wholesale trade	-33.9	-35.1	105.2	22.6
Agriculture, forestry & fishing	-28.1	-30.8	70.3	1.8
Other industries	-77.6	-78.0	88.3	12.6
All industries	*-52.8*	*-54.6*	*88.6*	*12.7*
Part-time employment				
Retail trade	110.7	130.0	106.9	23.7
Accommodation, cafes & restaurants	225.0	210.2	68.0	0.5
Manufacturing	38.7	-6.8	77.9	6.4
Construction	94.8	23.4	155.3	52.6
Property & business services	355.9	237.5	101.9	20.7
Personal & other services[a]	141.3	123.8	96.2	23.7
Cultural & recreational services	233.3	225.9	83.8	9.9
Wholesale trade	6.5	-12.4	95.2	16.7
Agriculture, forestry & fishing	64.3	65.4	114.1	28.0
Other industries	-3.6	-39.5	58.7	-5.1
All industries	*109.9*	*102.7*	*96.8*	*17.6*

a 1985 instead of 1984.

b Real hourly earnings in 1989–90 prices, calculated by deflating nominal earnings by the implicit GDP deflator.

Source: ABS Cat. No. 6310.0 and Commission estimates.

Relative employment and earnings

Table 2.3 shows changes in employment and hourly earnings of teenagers relative to adults by industry between 1984 and 1997.

Typically, the relative wages of teenage part-time employees are higher than those of full-time employees, reflecting the high proportion of casual workers among teenage part-time workers, and their casual loading.

For teenage full-time workers, there is mixed evidence of a negative relationship between relative employment and relative hourly earnings. Teenage full-time employment declined relative to adult full-time employment in all industries. Importantly, the relative wage of teenage full-time employees rose in retail trade; personal and other services; cultural and recreational services; and wholesale trade. In the remaining industries, falls in teenage relative full-time employment were accompanied by falls in the relative wage.

Teenage part-time employment increased relative to adult part-time employment in several service industries. These were retail trade; accommodation, cafes and restaurants; property and business services, personal and other services; and cultural and recreational services. With the exception of accommodation, cafes and restaurants, there were also increases in the teenage relative wage in these industries.

2.3 Factors influencing these trends

The previous section suggested that teenage full-time wage costs (as measured by real hourly earnings), have increased slightly over time, while teenage full-time employment (as measured by total hours paid) has fallen. By contrast, in several service industries where the majority of youth workers are employed, teenage part-time employment has increased, despite rising wage costs. This pattern may not be inconsistent with a negative influence of wage costs on employment, if it is the result of other non-wage factors influencing the demand for teenage labour. These factors could include institutional and technological changes, and changes in teenage productivity.

Table 2.3: Changes in teenage/adult hours paid and hourly earnings relativities, 1984 and 1997 (per cent)

Selected ANZSIC industries	Hours paid relativities			Hourly earnings relativities		
	1984	*1997*	*% change*	*1984*	*1997*	*% change*
Full-time employment						
Retail trade	28.5	11.9	-58.3	58.9	60.1	2.1
Accommodation, cafes & restaurants	9.8	5.1	-47.9	67.8	60.3	-11.0
Manufacturing	9.2	3.3	-63.9	57.4	53.4	-6.9
Construction	9.5	8.2	-13.3	56.8	52.7	-7.2
Property & business services	9.0	2.6	-70.7	50.5	44.1	-12.7
Personal & other services[a]	17.4	4.7	-72.9	43.4	60.9	40.4
Cultural & recreational services	9.0	5.6	-37.4	44.5	52.8	18.6
Wholesale trade	6.6	3.7	-43.7	51.0	53.5	4.8
Agriculture, forestry & fishing	16.5	9.3	-43.7	62.9	57.6	-8.4
Other industries	5.9	1.4	-77.0	52.9	47.8	-9.6
All industries	*9.8*	*3.9*	*-59.9*	*52.1*	*48.5*	*-6.8*
Part-time employment						
Retail trade	52.4	53.6	2.4	68.2	78.6	15.2
Accommodation, cafes & restaurants	12.3	20.0	62.0	81.1	80.1	-1.3
Manufacturing	11.3	8.6	-24.0	68.8	65.5	-4.7
Construction	11.0	8.3	-24.3	41.9	62.0	47.8
Property & business services	3.1	4.4	42.5	64.2	65.1	1.4
Personal & other services[a]	10.4	14.4	38.2	63.3	74.5	17.8
Cultural & recreational services	12.2	17.2	40.6	49.7	65.8	32.5
Wholesale trade	5.6	3.1	-45.6	72.1	76.7	6.4
Agriculture, forestry & fishing	16.3	12.6	-22.3	55.1	90.6	64.4
Other industries	3.8	1.4	-63.8	57.1	52.0	-8.8
All industries	*13.2*	*14.6*	*9.9*	*59.0*	*66.4*	*12.6*

a 1985 instead of 1984.

Note: Calculated as ratio of teenage to adult real hourly earnings and ratio of teenage to adult total weekly hours paid.

Source: ABS Cat. No. 6310.0.

The previous section also suggested that in at least some industries, falls in teenage relative to adult full-time wage costs have been accompanied by falls in teenage relative to adult full-time employment. In many of the major youth-employing industries, increases in teenage relative to adult part-time wage costs have been accompanied by increases in teenage relative to adult part-time employment. Neither piece of evidence suggests that adult and teenage employees are substitutes, in the sense that a rise in the relative wage costs of one group leads to an increase in the relative employment of the other. Indeed, the evidence suggests the opposite. However, this observed pattern of teenage/adult interaction may also reflect non-wage factors.

Non-wage factors need to be taken into account before a final assessment can be made of the influence of teenage wage costs on teenage and adult employment.

Institutional and technological changes

Institutional factors

A number of developments since the late 1970s may explain the growth in teenage part-time employment in the retail trade industry.

Deregulation and competitive pressures have led to the introduction of extended trading hours for both the work day and the work week. Changes in consumer demand and competition among retailers have also favoured more convenient and extended shopping hours. The longer trading hours have meant a direct increase in demand for additional labour in the industry, for both teenagers and adults.

Retail trade and other personal services industries are also characterised by variable demands. Weekend shopping and lunch hours, for example, generate peaks in the demand for services. However, remaining restrictions on hours worked and penalty rates impose higher costs for work outside standard hours. Lower teenage wages could also be an important factor. In these industries, employers are likely to favour part-time and casual employment outside normal hours and in meeting peak demands, while maintaining full-time employment in standard hours of work. An analogy is in electricity generation, with the use of high marginal cost plants for base load and low marginal cost plants for peak load.

The growth of part-time employment could also be consistent with individual preferences. For many teenagers, part-time work is necessary to finance their education. In May 1997, nearly 80 per cent of those teenagers in part-time employment were attending educational institutions full-time. Conversely, 32 per cent of those employed full-time were attending educational institutions part-time (ABS Cat. No. 6227.0). Thus, by rostering teenage workers outside of normal hours and for relatively short periods during peak hours, employers could be not only meeting their own requirements at least cost, but also meeting the work preferences of their employees.

These developments may make it more difficult for employers to substitute adult full-time workers for teenage part-time workers in the event of a change in their relative wage costs.[7] A key empirical question is whether they would still respond to an increase in youth wages by switching towards adult workers, or whether instead they would explore more technology-intensive and less labour-intensive techniques, at the expense of both teenage and adult workers. This is explored in more detail in Chapter 4.

Technological changes

In the long term, technological changes raise worker productivity and output. This could increase the demand for labour, including youth.

In the short term, technological changes could account for the falls in teenage full-time employment in particular industries. Because teenagers tend to be low skilled, introduction of new technologies is likely to affect teenage employment adversely. For example, the adoption of new office technologies such as word processing and computer technology could have replaced many clerical jobs traditionally belonging to teenagers. Nevertheless, technological changes also affect low skilled adult employment.

The effects of technological changes on youth employment also depend on the attainment of skills from education and training. Youth educational attainment and skills are discussed below.

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[7] Hamermesh (1993, pp. 44–55) shows formally how employers' decisions over workers and hours need to take supply factors into account. Interestingly, he also (p. 133–4) cites a careful study by König and Pohlmeier (1989) that finds a complementary relationship between workers and hours.

Other factors

Productivity changes

As indicated earlier, concerns have been raised about a possible decline in the relative productivity of youth workers. The rise in school retention rates has raised the average age at which teenagers leave school. This could reduce the average work experience of teenage labour, although the increased schooling could raise their level of skills.

Direct measures of worker productivity classified by age are not available. Information on occupational categories, educational attainment and training provides mixed evidence of changes in teenage productivity.

Teenagers typically work in unskilled occupations. In 1996, the ABS adopted a new classification of occupations which is related to skills. For example, clerical, sales and service workers are classified into those with advanced, intermediate and elementary skills. The data show that the majority of teenagers are elementary clerical, sales and service workers, and labourers and related workers (58 per cent). This is a relatively high proportion compared with other age groups (Table 2.4).

Table 2.4: Employed persons by occupation, August 1997 (per cent)

Occupation	*15-19 years*	*20-24 years*	*25 years and over*
Managers and administrators	0.4	1.6	9.0
Professionals	1.3	11.7	19.8
Associate professionals	3.0	7.6	11.7
Tradespersons and related workers	12.9	17.2	13.1
Advanced clerical, sales and service workers	1.5	5.0	4.8
Intermediate clerical, sales and service workers	15.0	22.0	15.8
Intermediate production and transport workers	7.8	7.8	9.5
Elementary clerical, sales and service workers	38.4	15.1	7.0
Labourers and related workers	19.6	12.0	9.4
Total	*100.0*	*100.0*	*100.0*

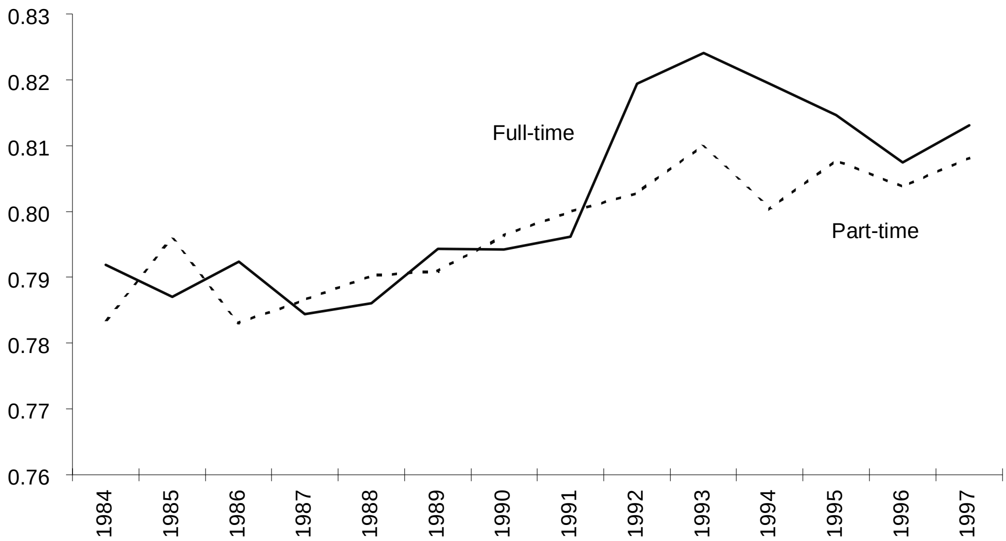
Source: ABS Cat. No. 6203.0.

Based on the previous ABS classification of occupations, it appears that the composition of teenage employment has changed towards less skilled occupations. The proportion of teenagers employed as clerks fell from 18 per cent to 9 per cent between 1986 and 1997. The proportion of teenagers employed as tradespersons also fell from 20 per cent to 14 per cent. In contrast, the share of teenage workers in sales and personal services increased from 32 per cent to 44 per cent over the same period, while the corresponding share of labourers and related workers rose from 22 per cent to 28 per cent.

Another proxy measure of productivity is the level of educational attainment. Figure 2.7 shows weighted average indices of the number of years of schooling needed to achieve final qualification, expressed as ratios of teenage educational attainment to adult educational attainment. The methodology in estimating educational attainment is discussed further in Appendix A.

Teenage relative to adult educational attainment appears to have increased. Between 1984 and 1997, it rose for both full-time and part-time teenage workers. These increases have also occurred in industries that are major employers of youth.

Figure 2.7: Ratio of youth educational attainment to adult educational attainment, 1984 to 1997



Source: Commission estimates based on ABS Cat. No. 6227.0.

The rise in the educational attainment of teenage relative to adult workers suggests that youth relative productivity is likely to have risen. However, educational attainment represents an imperfect measure of productivity. The measure does not take into account the work-related experience and skills and differences in the quality of various types of education.

Data from the ABS 1993 Survey of Training and Education indicate that youth workers tend to receive more unstructured on-the-job training from employers. In 1993, 92 per cent of teenage workers received some form of on-the-job training, compared with 70 per cent for the workers aged 25 and over. However, participation in formal training was less for youth workers. Teenage employment also tended to be concentrated in small businesses across industries, with the exception of wholesale and retail trade (Wooden 1998). Wooden (1998) suggests that the low skill requirements in small businesses may not offer significant opportunities for formal or structured on-the-job training, but small businesses are ideally suited, at least from the perspective of employers, for unskilled, inexperienced workers.

Fixed costs of employment

Young people are highly mobile. This can produce high fixed costs of employment to employers, both when young people quit their jobs voluntarily, or when some need to sacked (for example, because inexperienced workers are difficult to assess in advance). A measure of the hiring and firing costs to employers is given by ABS data on the number of persons who worked and have changed employers one or more times during the year.[8] A weighted average index has been derived to measure the frequency of changes of employers for young and adult workers (see Appendix A for details).

Teenage workers are more mobile than workers aged 25 years and over (Figure 2.8). However, workers aged 20 to 24 years show the highest mobility rates. Teenage relative mobility fell in the late 1980s, but has remained relatively stable in recent years. It is therefore unlikely that relative youth mobility has caused increases in the relative fixed costs associated with hiring and firing.

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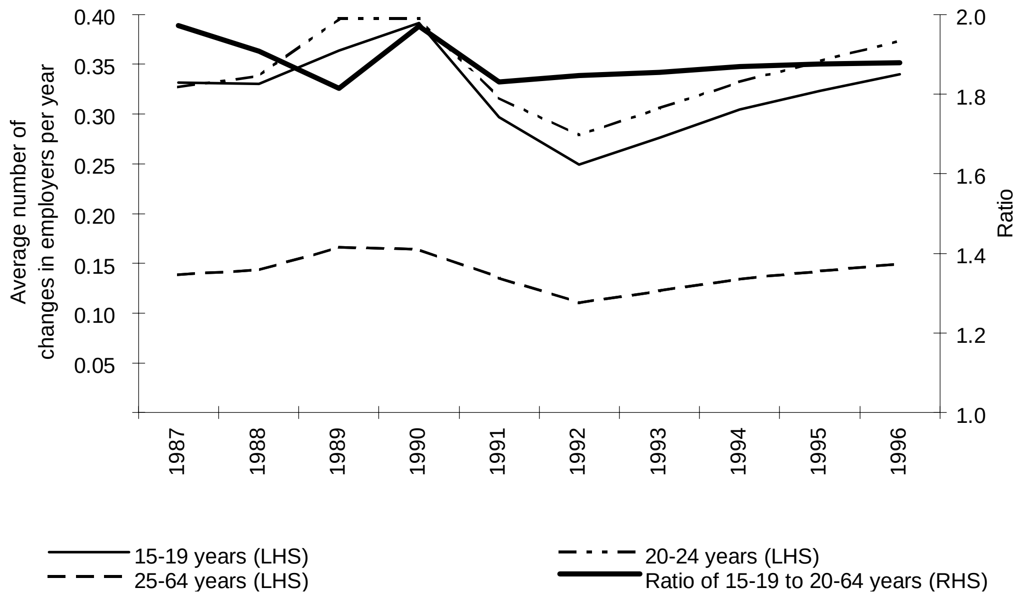
8 The absolute mobility data include those who change jobs because their employer went out of business, as well as those who change jobs through quits, retrenchments, etc. The former reason for job change may be less relevant for teenage employment decisions, but its inclusion may not affect the teenage/adult relative mobility data much.

Figure 2.8: Youth and adult job mobility



Source: Commission estimates based on ABS Cat. No. 6209.0.

2.4 Conclusion

There has been a marked decline in teenage employment since at least the late 1980s. This decline is associated with a fall in teenage full-time employment. Teenage part-time employment has increased, but mainly in the retail trade industry.

The available data suggest that the real wages of teenage full-time workers (as measured by real hourly earnings) have increased. If so, this could explain, at least in part, the fall in full-time employment. Teenage part-time employment has exhibited different patterns — both hourly earnings and total hours worked have risen. An increase in demand for part-time workers (for example, from extended trading hours in retail trade and other services industries) has been used to explain these trends.

While the teenage relative to adult wage has not changed significantly since 1984, teenage relative employment has declined. Both relative employment and relative wages of teenage full-time employees have fallen. In contrast, relative employment and relative wages of teenage part-time employees have increased. Neither trend suggests a strong degree of substitution between teenage and adult workers in response to a change in their relative wages.

The information presented in this chapter is not conclusive evidence of the relationship between youth employment and wages. There is a need to take into account more formally the variety of factors that determine youth employment. This is examined in the next two chapters.

3 A LITERATURE REVIEW

This chapter surveys the more formal Australian and international evidence on the relationship between youth wages and employment levels for young people and adults. All the studies, to a greater or lesser extent, attempt to correct for non-wage influences on employment. Some examine the evidence from ‘controlled’ or ‘natural’ experiments. Others use econometric techniques that control for other factors in a way spelt out in more detail in the next chapter.

While most economists would expect an increase in the youth wage to reduce youth employment, the extent of this effect, and even its direction, have been hotly debated. The chapter also highlights some related issues. It begins by summarising the results of aggregate studies of labour demand in Australia. It then focuses on more specific results of relevance to the demand for youth labour. These include minimum wage studies and studies of substitution between different age categories of labour. First, however, it is necessary to describe the measures of wage responsiveness being reported.

3.1 Measures of wage responsiveness of labour demand

There are two key measures of interest. The *own wage elasticity of demand for youth employment* measures the percentage change in youth employment that would arise from a one per cent increase in the youth wage. If this elasticity is small, a large increase in the wage will have little effect on youth employment. If the elasticity is large and negative, even a small increase in the wage would decrease youth employment substantially.

The *cross wage elasticity of demand for adult employment* measures the percentage change in adult employment that would arise from a one per cent increase in the youth wage. If the elasticity is positive, then youth and adult workers are substitutes in production — an increase in the youth wage will increase employment of adults. However, if the cross wage elasticity is negative, the two groups are complements — an increase in the youth wage will reduce the employment of adults.

Empirical studies often report instead the *cross wage elasticity of demand for youth employment* — the percentage change in youth employment that would arise from a one per cent increase in the adult wage. This will have the same sign (although not necessarily the same size) as the cross wage elasticity of demand for adult employment — they both indicate whether youth and adult workers are substitutes or complements.

When interpreting measures of own and cross wage elasticities of demand for youth employment, it is critical to know what is held constant when the youth wage is varied. One set of measures holds output constant. The resulting own and cross wage elasticities measure only the substitution effects of youth workers being replaced by adult workers, or by capital or other non-labour factors of production, as youth wages rise.

Alternative elasticities hold output prices rather than output quantities constant.[1] These elasticities capture not only substitution effects, but also a scale effect of any change in the firm's output level arising from the change in the youth wage (see Elliott 1991 and Hamermesh 1993 for further discussion). A rise in youth wages would typically increase costs and reduce output, putting further downward pressure on youth employment. Thus, own wage elasticities that do not hold output constant tend to be larger than those that do hold output constant.

As noted below, many of the elasticities from other studies reported in this chapter are output constant elasticities. They can be seen as measuring the impact of changes in wages over a relatively short period, before output plans are revised. Over a longer period, the 'own' employment responses would tend to be larger than those reported here.

3.2 Australian aggregate labour demand studies

Studies of aggregate labour demand in Australia began in the 1970s. There have been a series of specific studies looking at the effects of real wages and output on employment, and other studies based on the major macroeconomic models. Lewis and Seltzer (1996, p. 41) in their recent survey of labour demand concluded that:

> … the results for Australia suggest an elasticity of demand for labour with respect to wages (or real unit labour costs) of about 0.6 to 0.8, at the higher end of the scale of elasticities estimated for other countries.

In a more recent paper, Lewis (1998) used more sophisticated techniques to address some of the shortcomings of earlier work. He estimated two separate labour demand equations, one analysing quarterly employment (ie persons

[1] Output constant elasticities come from labour demand functions derived in a cost function framework. Elasticities that do not hold output constant come from labour demand functions derived in a profit function framework.

employed) for the period 1959 to 1997 and one analysing quarterly hours worked for the period 1966 to 1997. He concluded that the output constant elasticity of demand for labour with respect to the real wage was -0.08 and the total elasticity of demand was -0.7, the latter result being very similar to those of earlier studies.

Debelle and Vickery (1998) also present recent estimates of the long-run elasticity of employment with respect to the real wage for Australia. They used quarterly data for the period 1979 to 1997 when estimating the determinants of aggregate hours worked. Their estimated long-run real wage elasticity of employment was -0.4, smaller than earlier estimates. They attribute the difference between their results and earlier results to the choice of sample period and model specification. Over a longer time period, 1969 to 1997, they estimate a significantly higher elasticity of -0.67. They argue that the real wage elasticity has declined since the mid 1980s, and has been fairly constant over the 1990s.

The aggregate evidence for Australia therefore suggests a 10 per cent real wage cut would increase employment by 4 per cent, and possibly up to 7 per cent. However, this aggregate picture may conceal quite different outcomes for particular groups. There are a number of reasons to expect outcomes for youth to be different from those for the average worker. Young workers are relatively inexperienced and may lack maturity. Their unskilled work may be readily replaced by capital. Their inexperience will also work against them where employers have the choice of more experienced workers. Where a ‘last in first out’ rule is applied in redundancies, young people are likely to be disproportionately represented among those losing their jobs. In addition, firms may be keen to retain their experienced workforce during times of economic downturn (labour hoarding) so the employment adjustment is likely to fall on those trying to enter the labour market, notably young workers. The following sections survey the evidence from two groups of studies which may be particularly relevant to youth — minimum wage studies and studies which focus on substitution between workers of different ages.

3.3 Minimum wage studies

Historically, policy makers have been keen to use minimum wages as a mechanism for protecting the working poor. Individual countries have different institutional arrangements for the minimum wage — some are age based, some based on regions or States and others, as in the Australian system, based on occupations, enterprises or industries. As youth employment tends to be concentrated in unskilled occupations, many studies of the effects of minimum wages on employment have focused on the position of youth.

Much of the literature on the effects of minimum wages on employment comes from the United States. Federal minimum wages are set in nominal terms by the US Congress at irregular intervals. So, for example, between January 1981 and April 1990, there was no increase in the minimum rate. The current Federal minimum wage is $US5.15 per hour and this applies to 90 per cent of non-supervisory and non-farm employees. As of August 1996, there is also a subminimum wage for employees under 20 years of age of $US4.25, although in practice this is not often used (Katz 1998). For employees who earn tips, the employers are only required to pay $US2.13 per hour, on the assumption that the addition of tips will bring the total payment up to the Federal minimum rate of $US5.15. Minimum wages are also set at the State level in the United States and in some States, these minimums are above the Federal levels. In these cases, the State minimum applies.

While changes in the minimum wage are hotly debated in the Congress, it is estimated that only about 5.4 per cent of all US wage and salary earners are paid at or below the Federal minimum.[2] This is very different from the Australian situation, where it is estimated that about 30 per cent of all employees rely on award safety net adjustments (DIR 1997), and about 56 per cent of young people (under 21 years of age) are covered by junior rates of pay (Reith 1998).

Where a small proportion of employees are paid the minimum rate, it can be expected to have a small impact on the average wage and therefore on employment. As the proportion of workers whose pay is directly determined by the minimum wage regulations increases, so the effect of a change in the rate on employment would be expected to increase. Hamermesh (1993, p. 191) summarised this aspect of the debate in the following terms:

> The minimum wage produces little loss of employment if it is kept low. The higher the effective minimum wage, the greater the impact of the policy.

Because the coverage of the Federal minimum wage in the United States is so low, its estimated impact on employment would greatly underestimate the effect on youth employment in Australia of changes in junior rates of pay.

Early studies of the effect of minimum wages on youth employment and unemployment tended to confirm the predictions of economic theory that an increase in the real wage would reduce employment, although not by a substantial amount. Brown, Gilroy, and Kohen (1982) summarised about 20

2 Based on unpublished tabulations from the Central Population Survey compiled by the US Bureau of Labour Studies and provided by DWRSB.

time series studies as showing that a 10 per cent increase in the minimum wage would reduce teenage employment by 1 to 3 per cent. A later study by the same authors (1983) puts their best estimate at the lower end of this range. Studies for the 1980s, summarised by Hamermesh (1986 and 1993) confirm these earlier results and suggest that as the real value of the minimum wage in the United States was reduced over the 1980s, its effect on employment declined even further. Neumark and Wascher's (1992) study of the period 1973–89 shows similar elasticities to those reported in earlier studies. They argue that a 10 per cent increase in the minimum wage would reduce teenage employment by 1 to 2 per cent.

In the 1990s, a series of case studies or 'natural experiments' in the United States questioned this consensus. The results of this work are summarised in Card and Krueger (1995). The case studies focused on comparisons of employment outcomes where one group had experienced a rise in the minimum wage and a control group had not. For example, employment was compared in New Jersey and Pennsylvanian fast food restaurants at the time when there had been an increase in the minimum wage in New Jersey, but no change in neighbouring Pennsylvania. A series of telephone interviews with fast food outlets was conducted before and after the New Jersey increase. The authors found that employment had risen in the New Jersey outlets over the nine month period between the first and second interviews, a result contrary to the predictions of conventional economic theory. Their other reported case studies and reworking of existing studies also questioned the conventional wisdom.

Card and Krueger (1995) emphasised the difference between a small change in the minimum wage and the likely consequences of a large change. They concluded:

> … we suspect that the standard model does provide a good description of some labor markets, and does correctly predict the effect of the minimum wage on some firms. We also suspect that, at sufficiently high levels of the minimum wage, the predicted employment losses of the standard model will be borne out. Nevertheless, we believe that the evidence presented in this book is compelling enough to justify rethinking the nature of low-wage labour markets, and the applicability of the standard model for describing the effects of modest levels of the minimum wage. (p. 355)

Card and Krueger (1995) devote a chapter to explaining their perverse result. They argue that the explanation can be found in the presence of monopsony in the labour market and in the problems of imperfect information and search costs. In the monopsony model, the employer has sole buying power in the labour market, and faces an upward sloping supply curve of labour because workers have few alternatives. If unregulated, the employer will pay workers less than the value of their marginal product, and less than they would be paid in a perfectly competitive market. Employment is also less than under perfect competition, because not as many workers are willing to work at a less than perfectly competitive wage. In this case the imposition of a minimum wage may raise employment, by increasing the number of workers willing to work at the going wage. The employer will be willing to hire them, so long as the minimum wage is still below the value of their marginal product. However, even where monopsony is present, if the wage is set above the competitive market rate, it will reduce employment. Card and Krueger also argue that raising the minimum wage may act as a shock to employers and encourage them to organise the workplace more efficiently.

The studies summarised by Card and Krueger have been critically reviewed by many economists (see for example, Brown 1995, Hamermesh 1995, Kennan 1995, Maloney 1997, Sloan 1996, Welch 1995). While it is not proposed here to provide a full critique of the studies, among the criticisms which have been levelled are the following. Perhaps the most important is the apparent shortcomings in the methods used to collect and analyse the data. For example Welch (1995) argues that in conducting the phone questionnaires in the New Jersey-Pennsylvania study, insufficient care was taken in defining terms (eg part-time, full-time) and checking the information supplied.

It has also been argued that the case studies focus on the short run and say nothing about the long-run effects of the changes in minimum rates (Brown 1995). It is possible that while changes in the minimum wage have little effect on employment in the short run, in the long run when firms are able to vary capital, there may be quite different results.

A third argument is that the monopsony model is not convincing for unskilled labour, particularly in the fast food industry (Hamermesh 1995 and Lewis 1997). It is argued that it is difficult to believe that individual employers of small numbers of workers in relatively densely populated areas face an upward sloping supply curve. Rather, it is argued, they could expect to employ as much labour as they require in these low skilled occupations at the going wage. Related to this is the argument that the fast food industry is not typical and it would be unwise to generalise the results to the whole of the economy. For example, the fast food industry is dominated by franchises, with employment ratios often dictated by the franchisor, independent of local conditions.

The argument that the experiments were natural experiments has also been criticised, because they did not hold everything else constant (Hamermesh 1995). The fact that the minimum wage changes had been debated over a long period and that firms were given advance warning of their date of implementation, means that any employment adjustment could have taken place before the period over which the data were collected.

Card and Krueger (1997) have responded to these criticisms by re-estimating results using official data from the US Bureau of Labor Statistics and reworking the Neumark and Wascher data. They confirm their earlier results but conclude rather cautiously, that:

> The increase in New Jersey's minimum wage probably had no effect on total employment in New Jersey's fast-food industry, and possibly had a small positive effect. (p. 30)

The results from the United States have prompted studies of the effect of minimum wages in other countries. In a survey article on the European experience, Dolado et al (1996) concluded that the aggregate employment effects of the minimum wage are not particularly large in the four countries studied — France, the Netherlands, Spain and the United Kingdom. However, the authors argued, there is some evidence of an adverse employment effect for young workers.

Country specific studies have produced conflicting results. In studies of the effects of minimum wages on youth employment in France, Bazen and Martin (1991) and Benhayoun (1994) conclude that the outcomes are uncertain and sensitive to the estimation techniques that have been employed.

In Great Britain, minimum wages in specific industries were regulated by the Wages Councils. A series of studies looking at the effects of the abolition in the early 1990s of the Wages Councils suggest that these changes have not led to employment increases in the industries which were previously covered (Low Pay Commission 1998, Appendix 11). Earlier British studies, however, supported the hypothesis that increases in the minimum wage reduced employment in the particular sector covered by the Wage Council.

Other European studies have placed more emphasis on the negative effects on employment of various minimum wage arrangements. Van Soest (1994) reports on two approaches to studying the effects of minimum wages in the Netherlands, the first based on time series data and the second on cross sectional data. The time series study produced inconclusive results on the effect of minimum wages on the employment and unemployment of 14 to 24 year olds. However, his estimates based on cross section data were more robust. He used cross section data from the Dutch Socio-Economic Panel 1984 and 1987 to estimate a multinomial choice model in which the minimum wage, among other variables, was used to predict whether individuals fell into the categories of employed, unemployed or in full-time education. An additional category of 'housewife' was included for females. He concluded that the estimated elasticities of employment with respect to the minimum wage for males and females in the 16 to 23 age group in 1984 and 1987 were about -0.5. Other studies for Portugal and Greece, summarised in Bazen and Benhayoun (1995), also suggest a negative relationship between minimum wages and employment.

Maloney (1997) presents some recent evidence from New Zealand on the employment effects of minimum wages on young adults (aged 20 to 24 years) and teenagers aged 15 to 19 years. Teenagers were exempt from minimum wage provisions until March 1994, when a special teenage minimum was introduced. Using quarterly data over the period 1984–96, Maloney concluded that a 10 per cent increase in the minimum wage for young adults would reduce their employment by 3.8 per cent. However, he found no evidence that the introduction of a minimum wage for teenagers in 1994 influenced their employment. He argued that the teenage minimum was set so low relative to the average wage that it may have had no employment effect and that it probably had operated for too short a time to have influenced outcomes. These results have been challenged by Chapple (1997), who argues that they are not robust and should be used with caution.

The complexities of the Australian system of wage determination make the modelling of minimum wage effects very difficult, as there is not one minimum rate applying nationally. However, Mangan and Johnston (1997) have attempted this exercise and present some results based on both cross section and time series data. In their time series estimation, they modelled the employment/population ratio of those aged 15 to 19 years as a function of the minimum wage and a number of control variables for the period 1980 to 1994–95. The relative minimum wage for youth was defined as the ratio of the junior award wage to average weekly earnings for those aged over 20 years. Although the results show a small negative effect of the relative youth wage on employment, the estimated coefficients were statistically insignificant so this part of the study is inconclusive. The second part of the study was based on Van Soest's study of the Netherlands and used unit record data from the Population Census to predict labour force status for youth. Four outcomes were identified — employed full-time, employed part-time, unemployed and not in the labour force. The results show a negative relationship between relative junior wages and employment, although the estimated coefficients were smaller than in Van Soest's study.

The most recent comprehensive study of the effects of minimum wages on employment is presented in the OECD *Employment Outlook* for June 1998 (OECD 1998). It used a pooled cross section time series approach to examine the effects of national minimum wage regulations in nine countries over the period 1975–96. The study concludes that:

> … minimum wage rises have a negative impact on teenage employment although the magnitude of the reported elasticity varies significantly, from -0.3 to -0.6 when

> Spain and Portugal are excluded, and from 0 to -0.2 when they are included in the regression. (OECD 1998, p. 46)

There were data problems for both Spain and Portugal, hence their exclusion from some of the estimated regressions. The estimated elasticities for teenagers were the largest of any of the demographic groups identified.

The impact of minimum wage changes on employment remains a controversial issue. While there is disagreement about the likely effects on employment of a small change in the minimum rate, there seems greater agreement that large changes are likely to affect employment. Many of the studies that argue for a limited effect on employment are focused on the short run, but it is important to also consider the longer run implications of minimum wages. There are substantial lags in the adjustment process and it takes time for capital-labour substitution to take effect. Finally, studies that focus on minimum wages — set at low levels and affecting only a small proportion of the workforce — are likely to understate significantly the employment effects of wage changes affecting much larger groups.

3.4 Age-based labour substitution studies

In the US studies of the effects of the minimum wage on employment, it is important to remember that while a significant proportion of those receiving the minimum wage are teenagers, there are also adult workers on these rates. Any change in minimum wages applies to both groups, so there is no change in the wage relativity between youth and adults in the unskilled occupations in which the minimum wage applies. However, the abolition of junior rates in Australia would produce a change in this relativity which may have important implications for youth employment. As noted earlier, about 56 per cent of Australia's employees under the age of 21 were paid junior rates in 1996, 13 per cent were paid as trainees or apprentices and 31 per cent were paid at adult wage rates (Reith 1998). This section summarises some of the evidence on substitution between different age categories of labour. It begins with the international evidence and then considers the Australian evidence in more detail.

Hamermesh's (1993) comprehensive study of labour demand provides a useful survey of the estimates of own wage elasticities and cross wage elasticities for youth. Table 3.1 presents the results for estimated output constant own wage and cross wage elasticities for some of the studies surveyed by Hamermesh which seem most relevant to this study.[3]

Table 3.1: Estimates of output constant own and cross wage elasticities by age

Study	*Description*	*Age groups*	*Own wage*	*Cross wage*
Anderson (1977)	Manufacturing, annual, 1947–72, US, capital and 3 types of labour, translog production function approach	16-24 25-44 45+	-7.14 -3.45 -3.99	All > 0
Grant (1979)	SMSAs (US geographic areas), 1970 cross section, US, 3 labour types, translog production function approach	14-24 25-44 45+	-9.68 -2.72 -2.48	All > 0
Hamermesh (1982)	Aggregate, annual, 1955–75, US, capital and 2 labour types, translog cost function approach	14-24 25+	-0.59 -0.01	All > 0
Layard (1982)	Manufacturing, annual, 1949–69, UK, fixed capital and 4 labour types, translog cost function approach	M<21 F<18 M 21+ F 18+	-1.25 -0.31 -0.35 -1.59	All >0 except F<18 vs F 18+

Source: Hamermesh (1993, Table 3.9).

The evidence shows a relatively large own wage elasticity for youth, much larger than the output constant elasticity obtained by Lewis (1998). In most studies, the various age categories of labour were found to be substitutes for each other, hence the positive sign on the cross wage elasticities. However, Hamermesh concluded that this issue was an important area for further study and many questions remained to be answered (Hamermesh 1993, p. 136).

This area of research has received scant attention in Australia. The results of the most comprehensive study by the Bureau of Labour Market Research are now quite old (BLMR 1983, Lewis 1985). A pooled cross section time series approach was used to estimate the relationship between employment of youth relative to adult employment and the earnings of youth compared with adults in the same industry. The estimation period was 1976–81 and 17 industries were distinguished. The authors place limited confidence in the size of the

3 The studies reported here are those estimated in a systems context, and therefore likely to give reliable estimates of cross wage effects. See Appendix C for more details of systems estimation.

elasticities estimated but much greater confidence in their signs. The results are summarised in Table 3.2.

Table 3.2: Estimates of labour demand elasticities, Australia

	1 per cent change in the wages of:			
Change in demand for:	*Males < 21 years*	*Females < 21 years*	*Males 21+ years*	*Females 21+ years*
Males < 21 years	-1.80	0.15	0.62	1.03
Females < 21 years	0.25	-4.58	1.62	2.72
Males 21+ years	0.04	0.07	-0.59	0.48
Females 21+ years	0.24	0.39	1.62	-2.25

Source: BLMR (1983, Table 7.2).

The cells on the diagonal are estimates of the own wage elasticity of full-time employment, holding other input prices and output constant. They are all negative and show the largest own wage elasticities for females, particularly those aged less than 21 years. The off-diagonal cells are cross wage elasticities and their positive signs suggest that these categories of labour are substitutes for each other — that is, the increase in the relative wage of young males, say, will increase the employment of each of the other categories of labour. One feature of this study is that it did not make provision for substitution between labour categories and non-labour factors of production, such as capital. As will be discussed in Chapter 4, this may lead to an overstatement of the degree of substitutability between different categories of labour.

A more limited study of the relationship between youth wages and employment, prepared for the Queensland Government also provides support for a negative own wage elasticity for both full-time and part-time youth workers (Economic Planning and Impact Consultants 1995).

Other Australian studies of the youth labour market, while not formally estimating a relationship between youth wages and employment, have emphasised its importance. Wooden (1998) argues that policy makers need to ensure that the structure of youth wages promotes employment prospects rather than detracting from them. Of concern is the fact that the rising school retention rates may have effectively raised the cost of unskilled teenage labour compared with the past. Under the system of age-based awards, employers may find themselves paying more for the typical 18 year old school leaver now than for the typical 15 year old school leaver twenty years ago. For this argument of Wooden’s to hold, young people must gain less in terms of employment skills from their additional years of education, relative to the required increase in wages.

Australian critics of these arguments have appealed to the studies of Card and Krueger (1995) to argue that reducing relative wages for young people is unlikely to generate more employment. Their main argument for raising the real wages of young employees is based on equity considerations. Young people, it is argued, should receive equal pay for work of equal value (see for example Harcourt 1997, Pocock 1998 and Belchamber 1998).

3.5 Related results: the demand for apprentices

An important issue in the youth labour market in Australia is the employment of apprentices. While the proportion of young people undertaking apprenticeships has fallen dramatically since the early 1970s, apprenticeships offer an important method for developing skills in particular occupations, such as electricians and plumbers. Merrilees (1984) examined the determinants of the demand for apprentices in five trades (metal, electrical, building, printing and motor mechanics) and considered the success of the CRAFT scheme in promoting the intake of apprentices. He concluded that:

> For all trades output dominates the explanation of apprentice intake levels. In two trades (metal and electrical) relative labour costs were also important, though in two other trades (printing and motor mechanics) they had no effect at all. (p. 247).

Dockery, Norris and Stromback (1998) present calculations of the social rate of return to apprenticeship training and argue that employers pay a surprisingly large proportion of the costs. While not estimating a formal model of demand for apprentices, they argue that shifting a greater proportion of the costs onto the apprentices themselves in the form of lower wages, would encourage employers to take on more apprentices.

3.6 Conclusion

While few would wish to argue that the only determinant of the decision to employ youth was the real wage, economic theory has emphasised its importance. The aggregate Australian results presented here for labour demand suggest that a 10 per cent cut in the real wage would raise employment by at least 4 per cent, and possibly by as much as 7 per cent.

There are reasons for expecting the effect of wage changes on youth employment to differ from this average. This chapter has surveyed two main types of international and Australian studies which have attempted to estimate the relationship between youth wages and employment — those focusing on the minimum wage, and those in a production function context which focus on substitution between different types of labour. The minimum wage studies have been included in this survey because the pay of many young workers is affected by minimum wage regulations.

On their face value, the results of the minimum wage studies (primarily undertaken in the United States) suggest that the elasticity of employment with respect to changes in the minimum wage is small. This result may reflect the short time horizon of the studies. However, it is important to remember that even among teenagers, the proportion of employees being paid the minimum wage in the United States, where most of the studies have been conducted, was only 23 per cent in 1996 (OECD 1998). These studies do not say anything about what would happen if the wages of the remaining 77 per cent of teenagers were changed relative to employees in other demographic groups.

Studies that can answer this question are based on a production function framework and look at substitution between particular types of labour. The estimated own wage elasticities for youth compared with adult workers are considerably higher than the estimates for the effects of changes in the minimum wage rate on youth employment. The weight of evidence suggests a relatively large own wage elasticity for youth. In most studies, the various age categories of labour are found to be substitutes for each other.

While there remain many unanswered questions on the relationship between wages and employment, the balance of evidence presented here suggests that a large increase in the relative wages of teenagers could be expected to have a negative effect on their employment.

4 THE DEMAND FOR YOUTH LABOUR: A CROSS SECTIONAL STUDY

To establish a formal relationship between youth employment and its determinants, it is necessary to estimate econometrically a youth labour demand function, using a dataset with observations on employment, wages and the other determinants of employment.

Econometric analysis uses whatever in-sample variation there is in the dataset to establish an 'average' relationship between changes in each determinant — wages, say — and changes in employment, holding the influence of the other determinants constant. The analysis isolates the influence of wages from the other determinants of employment by using only that in-sample variation in wages that is unique to wages — it ignores that covariation in wages shared with the other determinants of employment. Econometric analysis is therefore more powerful:

- the more in-sample variation there is in the determinants of interest; and
- the less covariation there is between these determinants and other factors whose in-sample variation may need to be controlled for; or alternatively
- the less in-sample variation there is in these other factors, obviating the need for control.

This chapter describes the econometric estimation of youth labour demand equations, using the Australian Workplace Industrial Relations Survey 1995 (AWIRS 95), a cross sectional dataset at the workplace level.

One key advantage of using a cross sectional dataset is that it reduces the amount of in-sample variation in other factors that otherwise need to be controlled for. Chapter 2 pointed to the confounding influence of increases in school retention rates over time for isolating the influence of wages on employment. With a dataset taken across workplaces at a given point in time, there is less need to control for in-sample variation in factors such as educational attainment or mobility. Nevertheless, educational attainment can still differ across workplaces at a give point in time, and is controlled for in this analysis.

A second advantage of AWIRS 95 is that, because it is workplace-based rather than household-based, it also contains information on adult employment in each workplace. Employers are likely to make decisions on adult and youth employment jointly, and it is important for the econometric analysis to take this into account. Using the AWIRS 95 dataset allows youth and adult demand equations to be estimated jointly in a 'systems' estimation, thus recognising their interdependence.

A disadvantage of the AWIRS 95 dataset is that it does not contain information on the costs of non-labour inputs to production, particularly capital. This means that the estimation cannot take fully into account all the possible interactions between youth employment and capital use. In particular, it cannot estimate the impact on youth employment of an increase in the cost of capital.

This is not to say that capital is ignored altogether. There are some production processes in which the *allocation* of employment between youth and adults is independent of capital, even if the *total amount* of employment does depend on capital. In such processes, labour demands are described as being *weakly separable* (Chambers 1988). In using the AWIRS 95 dataset to estimate a system of labour demand equations, it is necessary to assume weak separability. Such an assumption may not hold in reality, however, and the influence of the assumption on the results is discussed later in the chapter.

The next section describes the theoretical framework of a cost minimising firm and the key assumptions from which the system of labour demand equations is derived. It sets out the econometric model to be estimated and the important econometric considerations necessary in estimating the demand system. Section 4.2 describes the AWIRS 95 dataset, while section 4.3 reports the empirical findings on the relationship between youth wages and employment.

4.1 Modelling the demand for labour

The demand for labour (or factor inputs) differs from the demand for consumer goods. Consumers purchase goods and services because of the benefits received from consumption. Their main interest is to purchase the combination of goods and service that maximises their economic well-being, subject to their income. By contrast, a firm's primary objective is to produce a given quantity of goods and services at minimum cost, using factor inputs, such as labour, with a specified production technology. Hence, the quantity of factor inputs demanded is derived from the production of goods and services. To model the demand for factor inputs, in particular labour, it is necessary to specify a firm's cost function and derive the respective input demand curves.

A firm's costs can be modelled using many functional forms.[1] One of the more flexible functional forms is the translog, which is a second order Taylor's series approximation in logarithms to any arbitrary cost function (see Appendix C for more details). The major benefit of using the translog cost function is that it places very few restrictions on the underlying production technology. For example, the substitution elasticities between factor inputs are not constrained to be constant or equal to 1, nor are factor inputs restricted to being substitutes only. This is an important feature of this empirical work, as Chapter 2 left open the question of whether there might be complementarity or substitution between youth and adult employment.

A firm's minimum total labour cost function may be represented in translog form as:

$$\begin{aligned} \ln C(\underline{w},q,\underline{z}) = \quad & a_0 + \sum_{i=1}^{n} a_i \ln w_i + a_q \ln q + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij} \ln w_i \ln w_j + \sum_{i=1}^{n} a_{iq} \ln w_i \ln q \\ & + \frac{1}{2} a_{qq} (\ln q)^2 + \phi(\underline{w},q,\underline{z}) \end{aligned} \qquad (1)$$

where

$$\phi(\underline{w},q,\underline{z}) = \sum_{j=1}^{m} \delta_j z_j^* + \sum_{j=1}^{m}\sum_{i=1}^{n} \lambda_{ij} \ln(w_i) z_j^* + \sum_{j=1}^{m} \xi_j \ln(q) z_j^* + \frac{1}{2}\sum_{j=1}^{m} \gamma_j (z_j^*)^2 \ ;$$

and
- i — types of labour inputs, $i=\{1,2,.....n\}$;
- C — total labour cost;
- w_i — hourly wage for labour type i;
- q — total hours worked;[2] and
- z_j^* — environmental variables (eg education), $j=\{1,2,.....m\}$.

Note that without the assumption of weak separability, C would be total costs rather than total labour costs, q would be total output and the w_i would include the price of capital.

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[1] A cost function approach was chosen over a profit function approach because the AWIRS 95 dataset does not have data on output prices.

[2] In a single-stage but weakly separable technology, total hours worked should be seen as a proxy for output. In a nested or two-stage production technology, in which the composition of labour is decided first, and the total amount of labour relative to other factors of production decided second, total hours worked would be the appropriate scale variable. Either way, because q is total hours worked rather than output, the elasticities estimated in this chapter are only approximately output constant.

Certain restrictions should be imposed to ensure the total labour cost function is consistent with economic theory. For example, it is generally assumed that the cost function is homogenous of degree 1 in input prices. That is, if all input prices were to increase by the same proportion (eg double), there would be no change in the relative price of inputs and hence no change in the level of demand for these inputs.[3] For equation (1) to be homogenous of degree 1 in input prices, the following restrictions would need to hold:

$$\sum_{i=1}^{n} a_i = 1 \qquad (2)$$

$$\sum_{j=1}^{n} a_{ij} = 0 \qquad (3)$$

$$\sum_{i=1}^{n} a_{iq} = 0 \qquad (4)$$

In addition, in a well-behaved cost function, the parameters are *symmetric* (ie $a_{ij} = a_{ji}$).

The optimal cost minimising input demand functions are obtained by differentiating the cost function (equation 1) with respect to input prices.[4] This gives cost share equations:

$$s_k = a_k + \sum_{i=1}^{n} a_{ki} \ln w_i + a_{kq} \ln q + \sum_{j=1}^{m} \lambda_{kj} z_j^* \qquad (5)$$

where $k \in i$; and

s_k is labour type *k*'s share of total labour costs.

The corresponding own wage and cross wage elasticities are, respectively:[5]

$$\varepsilon_{ii} = \frac{a_{ii} + s_i(s_i - 1)}{s_i} \qquad (6)$$

$$\varepsilon_{ij} = \frac{a_{ij} + s_i s_j}{s_i} \qquad (i \neq j) \qquad (7)$$

3 Nevertheless, the minimum cost of producing the given output would have increased.

4 This transformation is known as Shephard's lemma. Refer to Appendix C for the derivation.

5 Refer to Appendix C for the derivation.

Estimation

Several important considerations need to be taken into account when estimating the parameters of the cost share equations (equation 5).

First, it is necessary to estimate the parameters (a_{ij}) as a system of equations, as the disturbances in the share equations (ie deviations observed around the exact share relationships) will include common factors. There are considerable efficiency gains in jointly estimating the parameters and simultaneously allowing for contemporaneous correlation in the disturbance (ie common factors). Furthermore, it is necessary to estimate the cost share equations as a system to impose cross equation symmetry restrictions.

In this study, there are three types of labour — youth (y), adult male (am) and adult female (af). Because of practical limitations (to be explained shortly), only three types of labour could modelled. The decision to aggregate youth male and youth female employees together was based on preliminary investigations indicating small differences in the relationship between employment and wages for male and female youth. This finding is supported by Wooden (1996), who observed that the composition of the labour force across the sexes is much more equal among the young than among older cohorts.

By including a relative education attainment variable (ed_y), adding an additive and normally distributed disturbance term (e_k) and imposing symmetry, the system of labour cost share equations is:[6]

$$\begin{aligned} s_y &= a_y + a_{yy}\ln w_y + a_{yam}\ln w_{am} + a_{yaf}\ln w_{af} + a_{yq}\ln q + \lambda_{yy} ed_y + e_y \\ s_{am} &= a_{am} + a_{yam}\ln w_y + a_{amam}\ln w_{am} + a_{amaf}\ln w_{af} + a_{amq}\ln q + \lambda_{amy} ed_y + e_{am} \\ s_{af} &= a_{af} + a_{yaf}\ln w_y + a_{amaf}\ln w_{am} + a_{afaf}\ln w_{af} + a_{afq}\ln q + \lambda_{afy} ed_y + e_{af} \end{aligned} \quad (8)$$

Second, the estimation method applied needs to take account of the *censoring* of the dependent variable. A dependent variable is censored when the values in a certain range are transformed to a single value. In the above system of equations, the cost share can only take positive values or be zero, but cannot be

6 Relative youth education is defined as the difference between the average number of years of education for youth and the average number of years of education for all employees. A priori, the coefficient on relative youth education in the youth cost share equation should be positive. The sum of the coefficients on relative youth education across all equations should be zero (because cost shares must always sum to unity). This constrains the coefficient on relative youth education in at least one of the other equations to be negative.

negative. This is a significant issue in the AWIRS 95 dataset, as 75 per cent of workplaces do not employ youth, and thus have a youth cost share of zero.

Censoring creates a statistical problem in estimation, as the disturbance term (e_k) is usually assumed to have a mean of zero, implying that the fitted values of s_k would be able to take positive and negative values. If e_k is constrained so that the cost share has to be at least zero, the distributions of e_k and s_k are no longer symmetric, and have an underlying distribution that is a mixture of discrete and continuous moments. This type of model is a censored or *tobit* model, and ordinary least squares estimation is biased and inconsistent (Greene 1991).

In this study, the tobit model was estimated using a full information maximum likelihood estimator, which defines the log-likelihood function in a way that incorporates both the discrete and continuous components of the distribution.

The final estimation issue worth considering is the linear independence of the system of equations (equation 8). This system possesses the special property that the sum of the dependent variables (ie cost shares) equals one. The implication of this property is that there are only two linearly independent disturbance terms and as a result, the full system cannot be estimated.

The solution to this problem is to 'drop' an arbitrary equation and then estimate the remaining two share equations as a bivariate tobit system.[7] The parameters from the 'dropped' equation can be derived from the estimated parameters and the restrictions outlined above (equations (2) to (4)). In general, as long as maximum likelihood estimation procedures are employed, all parameter estimates and diagnostics should be invariant to the choice of which equations are directly estimated (Greene 1993). However, this property does not always hold exactly in a bivariate tobit estimation system when there are a significant proportion of zero observations on the dependent variable. Nevertheless the estimated coefficients are generally invariant to one or two decimal places and where the differences are larger, there is no impact on the conclusions drawn. Both systems of equations are reported below.

As the focus of this chapter is the estimation of the determinants of youth employment, the youth equation is retained and one of the adult equations is dropped. The system of equations (equation 8) are transformed to incorporate the within equation homogeneity restriction (equation 3) and symmetry is

7 LIMDEP 7 — the econometrics package used to estimate the system of equations — is only able to handle a two equation tobit system. Hence, only three types of labour could be modelled.

imposed in the estimation process, giving two possible systems of cost share equations, a youth-adult female system:

$$\begin{aligned} s_y &= a_y + a_{yy} \ln\left(\frac{w_y}{w_{am}}\right) + a_{yaf} \ln\left(\frac{w_{af}}{w_{am}}\right) + a_{yq} \ln q + \lambda_{yy} ed_y + e_y \\ s_{af} &= a_{af} + a_{yaf} \ln\left(\frac{w_y}{w_{am}}\right) + a_{afaf} \ln\left(\frac{w_{af}}{w_{am}}\right) + a_{afq} \ln q + \lambda_{afy} ed_y + e_{af} \end{aligned} \qquad (9a)$$

or a youth-adult male system:

$$\begin{aligned} s_y &= a_y + a_{yy} \ln\left(\frac{w_y}{w_{af}}\right) + a_{yam} \ln\left(\frac{w_{am}}{w_{af}}\right) + a_{yq} \ln q + \lambda_{yy} ed_y + e_y \\ s_{am} &= a_{am} + a_{yam} \ln\left(\frac{w_y}{w_{af}}\right) + a_{amam} \ln\left(\frac{w_{am}}{w_{af}}\right) + a_{amq} \ln q + \lambda_{amy} ed_y + e_{am} \end{aligned} \qquad (9b)$$

It is worth noting that by definition of the homogeneity restriction, the estimated coefficients on all of the relative wage variables in the transformed model (equation 9) are theoretically the same as the corresponding coefficients on the absolute wage variables in the unconstrained model (equation 8).

4.2 Australian Workplace Industrial Relations Survey 1995

The primary data sources for this study are the main and employee surveys from AWIRS 95.[8] The main survey covers 2 001 workplaces, with 20 or more employees, from all ANZSIC divisions, except Agricultural, forestry and fishing, and Defence. From the workplaces included in the main survey, a random sample of 19 155 employees from 1 828 workplaces was selected to form the basis of the employee survey. The employee survey contains unit record information on employee demographics, earnings, hours worked, education level and occupation. This information was matched with workplace characteristics, such as industry and workplace size, taken from the workplace characteristics and general management questionnaires in the main survey. The variables used in this study and their originating questionnaires are outlined in Table 4.1.

8 A general description ofthe AWIRS 95 dataset is given in Appendix B.

Table 4.1: AWIRS 95 survey information used in analysis

Variable description	*Question*	*Questionnaire*
Workplace identifier	WPID	Various
Age	E2	Employee
Usual number of hours worked per week	E11	Employee
Usual overtime worked per week	E12	Employee
Highest level of education completed	E43	Employee
Usual pre-tax earnings including overtime	E47	Employee
Number of employees at workplace[a]	A1 BB1	Workplace characteristic General management
Industry classification	BB6	General management

a When no answer was given in the workplace characteristics questionnaire (A1), responses from the general management questionnaire (BB1) were used.

In order to maximise in-sample variation in the factors of interest, namely hourly wages, minimal data cleaning was undertaken. This had the additional benefit of not biasing the estimated relationship by excluding some observations from the analysis on the basis that they appeared too 'high' or too 'low'.[9]

However, not all observations were useable. For example, employees that failed to respond to any of the survey questions used in this study were excluded from this analysis. In addition, employees that responded that their usual hours of work were zero were also excluded. This reduced the number of persons in the sample from 19 155 to 18 144 and the number of workplaces from 1 828 to 1 823.

Because of the large degree of censoring of the youth cost share (1 367 of the 1 823 observations were zero), the system of equations was not invariant to the equation dropped. As this study is primarily concerned with the determinants of youth employment, in particular the effect of an increase in youth wages on hours worked, the sample of workplaces was narrowed to reduce the proportion of youth limit observations, while maintaining a high degree of in-sample variation in youth wages.

This was achieved in two ways. First, the sample was limited to those workplaces in industries where youth are more likely to be employed — retail trade, accommodation, construction and manufacturing. This reduced the

9 Nevertheless, some of the outliers were checked to verify that they were plausible, rather than the result of mistakes or sampling error. For example, one workplace employing a very large number of youth hours was verified as being a genuinely very large workplace

sample to 668 workplaces, with 265 workplaces employing youth. Second, the sample was limited to industries where youth are employed more intensively (ie the youth to adult employee ratio is relatively high). This sample covered 410 workplaces from retail trade, accommodation, cultural and recreation, and personal services, with 203 workplaces employing youth.

Ideally, it would have been desirable to exclude from the sample employees who could have been expected to be 'off' the spot labour demand curve — in other words, not paid the value of their marginal product. A potentially important group of employees in this category are apprentices, those undertaking traineeships or those receiving a significant amount of general, as opposed to firm-specific, on-the-job training. Employers often pay such workers less than the value of their marginal product while they undertake the training, as a way of ensuring that the employee shares some of the cost of the training. Unfortunately, it has been impossible to identify and exclude apprentices and those undertaking traineeships from the AWIRS survey data.

A general description of the AWIRS 95 dataset and summary statistics are given in Appendix B.

Definitions and data transformations

Youth are defined as those employees between the age of 15 and 20 years — the age information provided in AWIRS 95 is grouped and cannot be disaggregated. Those employees aged 21 years and over are classified as adults.

As the unit of analysis in this study is the workplace, it is necessary to aggregate the employee information from the within-workplace sample (recall that only a subset of employees from each workplace were included in the employee survey) up to the workplace level to obtain a profile by workplace, for each labour type, of the:

- number of employees;
- number of hours worked;
- average hourly wage; and
- the cost share.

Using the employer information on the total number of people employed at each workplace, and calculating the total number of employees surveyed, it is possible to calculate what proportion of the total employees returned survey questionnaires. The survey number of youth, adult male and adult female employees were scaled using this estimate.

The same process was applied to the hours worked to obtain an estimate of the hours worked at each workplace by labour type.

There were a number of steps taken in deriving the average hourly wage paid to youth and adult employees by workplace. First, it was necessary to calculate the average weekly earnings of employees. AWIRS 95 collected information on average weekly earnings in income bands of $50.[10] The mid point from each income band was assumed to be representative of average weekly earnings. For example, an employee recording weekly earnings between $200 and $249 per week was assumed to have average weekly earnings of $225. This method was applied to all income bands except the final band, which had no upper bound. To obtain average weekly earnings for the upper income band, it was assumed the earnings distribution was skewed to the right and employees in this group were apportioned across hypothetical $50 wage bands at a declining rate. Based on this method, the average weekly earnings of the top income bracket were estimated to be $1 325. This method is more elaborate than used in most studies, but was motivated by the relatively high proportion of employees falling within top band (6.2 per cent). Full calculation details are given in Appendix B.

Second, to calculate the observed average hourly wage for workplaces which employed youth, adult male and adult female employees, the sum of average weekly earnings was divided by the sum of total hours worked (including overtime) for each employment type in each workplace.

Third, as there were some zero cost shares in the sample, it was necessary to impute a 'virtual' hourly wage a workplace would have had to pay a particular labour type, had they employed them.[11] An alternative option would have been to drop those workplaces from the study that employed none of a particular category of labour. However, it was felt that the observation of a zero cost share was itself an important piece of information. Thus, a 'virtual' hourly wage was imputed for these observations, making use of a wage dummy

[10] The exception to this rule is the first and last band. The first band grouped all employees earning less than $100 and the last band grouped all employees earning more than $1 150 per week. The relatively large size of the first band makes it difficult to get an accurate picture of the hourly wage costs of those who work only a few hours a week, a group likely to include a high proportion of young workers. The econometric results reported later are not unduly sensitive to dropping those workplaces with workers reporting less than $100 per week.

[11] As noted earlier, the proportion of workplaces reporting no youth workers is large. In addition, there are 84 and 53 workplaces with no survey information on adult males and adult females, respectively.

variable regression technique associated with hedonic analysis (eg Griliches 1961, Mincer 1974, Rosen 1974, Ashenfelter and Layard 1986).

The ‘virtual’ hourly wage was imputed using observed average hourly wages in similar workplaces. The wage dummy variable regression was used to establish similarity on the basis of characteristics that had the most impact on observed hourly wages. The factors considered as potentially important influences on the hourly wages included firm size, industry, and a State and regional indicator.[12] Adult male and adult female hourly wages were imputed using firm size, industry and region. Youth hourly wages were imputed using firm size and industry.[13]

To account for differences in the educational attainment of young workers across workplaces, the estimation included a variable measuring the average education of the young workers relative to the overall average education at that workplace. Where youth were not employed, a ‘virtual’ relative education variable was constructed using the same method as for hourly wages. Details of on the underlying educational data are given in Appendix B.

4.3 Youth wages and employment

The main focus of the econometric analysis is on the estimated youth own wage elasticity (equation 6), as this indicates the effect on youth employment of an increase in the youth hourly wage. The youth cross wage elasticities (equation 7) are also of interest, as these indicate the effects on employment levels of other types of labour as a result of increasing youth wages.

The equation system incorporates both youth and adult wages as potential determinants of their respective employment, along with a total employment variable (which acts as a scale variable to correct for differences in workplace size across the sample), and a variable measuring the relative educational attainment of youth.

One outstanding issue is whether there are systematic differences in youth employment decisions, based on technological or other industry differences, that need to be taken into account. This issue is addressed later in the chapter, where separate regressions are reported for individual industries.

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[12] The State and regional identifiers were obtained on special release from DWRSB. The regional identifier only distinguishes metropolitan from non metropolitan areas.

[13] Refer to Appendix B for the wage dummy regression results.

Based on the three databases described above and a using bivariate tobit estimator, estimation progressed in stages. First, the system was estimated in an unrestricted form, and then with the symmetry restrictions imposed (equation 8). Next, the model was transformed to account for homogeneity restrictions and estimated with both homogeneity and full system (symmetry and homogeneity) restrictions imposed (equation 9). Estimating both the restricted and unrestricted systems allows the significance of the restrictions to be tested.

As the focus of this study is on the relationship between youth wages and employment, only the wage coefficients and corresponding elasticities from the youth equation are reported (Tables 4.2 to 4.4). The remaining coefficients (ie the coefficients on total hours and relative education) are reported in Appendix B. Because of the complex nature of estimation, the econometric package used (LIMDEP) produces limited diagnostics (these being restricted to t-statistics on coefficients and the value of the log-likelihood function).

Table 4.2: Estimated youth own wage coefficients from youth equation[ab]

System	*Full sample*	*Youth employment industries*	*Youth intensive industries*
Unconstrained			
youth-adult female	-0.62***	-0.87***	-0.74***
youth-adult male	-0.68***	-0.88***	-0.77***
Symmetry			
youth-adult female	-0.63***	-0.89***	nh
youth-adult male	nh	nh	nh
No. of observations	1 823	668	410
Ave youth cost share	0.04	0.09	0.13

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a Estimated wage coefficients when homogeneity is imposed are not reported as the restrictions did not hold at the 1 per cent level of significance. Due to estimation problems, no estimates were obtained when both symmetry and homogeneity were imposed. The results for the full equation are reported in Appendix B.

b Coefficients rounded to two decimal places.

*** Significantly different from zero, at the 1 per cent level of significance. ** Significantly different from zero, at the 5 per cent level of significance. * Significantly different from zero, at the 10 per cent level of significance.

Source: Commission estimates.

For the full sample, and for sub-samples of *youth employment industries* (those employing a significant share of all youth) and *youth intensive industries* (those employing a significant share of youth relative to adults), there are a significant number of workplaces employing no youth. As noted earlier, this means that the coefficient estimates in the youth equation are not invariant to which adult equation is dropped. Thus, estimates from both sub-systems are shown in Tables 4.2 to 4.4, to give an indication of the extent of the invariance problem.

For the full sample, the estimated coefficients from the unconstrained system of equations show a negative and significant relationship between the youth labour cost share and youth wages, indicating that an increase in youth wages would lower youth employment (Table 4.2). Using equation (6), the youth own wage elasticity from the full sample is calculated to be around -16 per cent, implying that each one per cent increase in the youth wage would reduce youth employment by about 16 per cent (Table 4.3). Nevertheless, the small average cost share of youth in the full sample (less than 5 per cent) exaggerates the magnitude of this elasticity and makes it unreliable (Hamermesh 1982). From the sub-samples of youth employment and youth intensive industries, the calculated elasticities are approximately -11 per cent and -7 per cent, respectively (Table 4.3). These estimates are roughly the same as the highest estimates obtained in overseas studies (reported in Chapter 3).

Table 4.3: Estimated youth own wage elasticities from youth equation[ab]

System	*Full sample*	*Youth employment industries*	*Youth intensive industries*
Unconstrained			
youth-adult female	-15.50***	-10.91***	-6.65***
youth-adult male	-16.88***	-11.06**	-6.92***
Symmetry			
youth-adult female	-15.51***	-11.15***	nh
youth-adult male	nh	nh	nh

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a Estimated wage elasticities when homogeneity is imposed are not reported as the restrictions did not hold at the 1 per cent level of significance. Due to estimation problems, no estimates were obtained when both symmetry and homogeneity were imposed.

b Elasticities evaluated using unrounded coefficients and sample cost share means (see Appendix B, Table B.3).

*** Significantly different from zero, at the 1 per cent level of significance. ** Significantly different from zero, at the 5 per cent level of significance. * Significantly different from zero, at the 10 per cent level of significance.

Source: Commission estimates.

The cross wage elasticity estimates from the unconstrained model are negative, indicating a complementary relationship between youth employment and both types of adult employment (Table 4.4). However, before any definite assessment of the youth-adult cross wage elasticities can be made, it is desirable that the symmetry and homogeneity restrictions hold, as these impose economically sensible conditions on the cross wage coefficients. However, the likelihood ratio (LR) tests show that homogeneity restrictions do not hold at the one per cent level and symmetry holds only in some cases (Appendix B, Table B.7 and Table B.8).

Table 4.4: Estimated cross wage elasticities from youth equation[ab]

System	*Full sample*	*Youth employment industries*	*Youth intensive industries*
Youth employment response to changes in adult male wages:			
Unconstrained			
youth-adult female	-9.80***	-4.39***	-4.34***
youth-adult male	-9.93***	-4.18**	-4.60**
Symmetry			
youth-adult female	-11.40***	-5.05***	nh
youth-adult male	nh	nh	nh
Youth employment response to changes in adult female wages:			
Unconstrained			
youth-adult female	-19.62***	-10.29***	-8.84***
youth-adult male	-17.81***	-7.60**	-7.81**
Symmetry			
youth-adult female	-12.76***	-5.77***	nh
youth-adult male	nh	nh	nh

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a Estimated wage elasticities when homogeneity is imposed are not report as the restrictions did not hold at the 1 per cent level of significance. Due to estimation problems, no estimates were obtained when both symmetry and homogeneity were imposed.

b Elasticities evaluated using unrounded coefficients and sample cost share means (see Appendix B, Table B.3).

*** Significantly different from zero, at the 1 per cent level of significance. ** Significantly different from zero, at the 5 per cent level of significance. * Significantly different from zero, at the 10 per cent level of significance.

Source: Commission estimates.

One reason homogeneity of input prices may not hold is that the system of cost share equations was derived from a cost function that did not include the cost of capital. That is, it was assumed that the decisions on the youth/adult composition of labour can be made independent of the price of capital. Imposing homogeneity then effectively forces at least one type of adult labour to be a substitute for youth labour. However, if the assumption of weak separability does not hold, some of the substitution could instead be with capital. The homogeneity restriction imposed here would be inappropriate, and would exaggerate the extent of youth-adult substitution, since one relevant input price has not been included.

As outlined in Appendix C, if the assumption of weak separability does not hold, the homogeneity condition imposed here would not be expected to hold. As noted earlier, AWIRS 95 does not collect information on the rental prices of capital, so it is not possible to include these in the specification, nor is it possible to test the hypothesis of weak separability. However, given the significance with which the homogeneity restrictions are rejected, it is reasonable to suppose that youth labour and capital may be substitutes. Additional evidence on this is discussed below.

In principle, it is possible to obtain alternative estimates of youth own and cross wage elasticities, and to test for weak separability, using the time series data by industry from Chapter 2, and estimates of the rental price of capital services by industry obtained using methods reported in Gretton and Fisher (1997). However, attempts to do yielded unreliable estimates.[14] A high degree of multicollinearity between youth and adult hourly earnings in that sample precluded any precise estimates of own and cross wage elasticities, while a high degree of multicollinearity between the rental price of capital and output precluded any reliable test of weak separability. However, those overseas studies that have tested for separability between labour and capital have strongly rejected it (Berndt and Christensen 1974, Denny and Fuss 1977, and Grant and Hamermesh 1981).

Symmetry restrictions are independent of whether or not weak separability is an appropriate assumption. One reason symmetry may not always hold in the

[14] This alternative system was estimated as a system of seemingly unrelated regression equations (SURE) using maximum likelihood estimation in version 7 of LIMDEP. The data set consisted of a time series (13 observations from 1984 to 1996) of cross sectional data (8 industries for each year, the industries being those in the market sector, for which independent estimates of output are available — see Appendix A). The model was estimated in levels and first differences, with and without constants and industry dummy variables (for the intercept only). The systems were estimated progressively, first in an unconstrained form, then imposing symmetry only, homogeneity only, and finally imposing both homogeneity and symmetry. The results of the various systems were highly unstable because of strong multicollinearity, particularly in the ABS wage data.

above estimations is because of a failure to take account of differences in behaviour across different industries.[15]

Industry results

As outlined above, youth employment is concentrated in a few industries — retail trade, accommodation, cafes and restaurants, construction, and manufacturing — which account for approximately 75 per cent of all youth employment. Of these industries, retail trade is the single largest employer of youth, accounting for approximately 50 per cent. Other industries, while not employing a large proportion of all youth, nevertheless have a high proportion of youth relative to adults. These include the cultural and recreation, and personal and other services industries.

In establishing the determinants of youth employment, it may be important to account for industry-specific behaviour, such as differences in technological base or managerial style, that may affect the relationship between youth wages and employment. One way would be to allow for industry-specific intercepts in the system. This would *shift* the position of the youth labour demand function up or down for particular industries, but leave the relationship between youth employment and wages *(slope)* equal across industries. Alternatively the system could be estimated industry by industry. The latter method is preferable, as it allows the wage coefficients (a_{ij}), as well as the intercept (a_i), to vary across industries.

An industry dataset was developed for the six industries of interest — drawn from the full sample of 1 823 workplaces. The estimated youth own wage coefficients and elasticities are reported in Tables 4.5 and 4.6, respectively.

[15] However, symmetry may not be *expected* to hold in the region of the vertical axis. Symmetry relies on the cost function being twice continuously differentiable (see Appendix C), a property which usually does not hold where a demand curve cuts the vertical axis.

Table 4.5: Estimated youth own wage coefficients from youth equation, selected industries[ab]

System	*Retail*	*Accomm*	*Manuf*	*Constr*	*Culture*	*Person*
Unconstrained						
youth-adult female	-0.28***	-0.66***	-0.52***	0.14	-0.08	ne
youth-adult male	-0.29***	-0.64***	-0.53***	0.10	-0.09	-0.24***
Symmetry						
youth-adult female	ne	-0.59***	-0.51***	ne	-0.01	ne
youth-adult male	nh	-0.61***	-0.51***	0.33***	-0.05	-0.12*
Homogeneity						
youth-adult female	nh	-0.58***	nh	0.67***	0.22**	-0.09
youth-adult male	nh	-0.48***	nh	0.64***	0.22*	-0.11
No. of observations	155	85	349	79	78	95
Ave youth cost share	0.22	0.16	0.03	0.02	0.05	0.01

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a The results for the full equation are reported in Appendix B.

b Coefficients rounded to two decimal places.

*** Significantly different from zero, at the 1 per cent level of significance. ** Significantly different from zero, at the 5 per cent level of significance. * Significantly different from zero, at the 10 per cent level of significance.

Source: Commission estimates.

Table 4.6: Estimated youth own wage elasticities from youth equation, selected industries[a]

	Retail	*Accomm*	*Manuf*	*Constr*	*Culture*	*Person*
Unconstrained						
youth-adult female	-2.08***	-5.06***	-20.03***	0.22	-2.47	ne
youth-adult male	-2.14***	-4.97***	-20.32***	-0.11	-2.59	-18.19***
Symmetry						
youth-adult female	ne	-4.62***	-19.36***	ne	-1.15	ne
youth-adult male	nh	-4.73**	-19.36***	1.74***	-1.96	-9.62**
Homogeneity						
youth-adult female	nh	-4.54***	nh	4.36***	3.23**	-7.55
youth-adult male	nh	-3.88***	nh	4.11***	3.07**	-8.92
No. of observations	155	85	349	79	78	95
Ave youth cost share	0.22	0.16	0.03	0.13	0.05	0.01

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a Elasticities evaluated using unrounded coefficients and sample cost share means (see Appendix B, Table B.3).

b When estimated coefficients are very small in magnitude, it is possible that the calculated elasticity can change sign, as in this case.

*** Significantly different from zero, at the 1 per cent level of significance. ** Significantly different from zero, at the 5 per cent level of significance. * Significantly different from zero, at the 10 per cent level of significance.

Source: Commission estimates.

The negative relationship between the youth cost share and youth wages remains robust for the youth intensive industries. In some individual industries, the strength of the relationship is smaller in magnitude than it was for the industry groups or the full sample. For example, in retail trade, the estimated youth own wage elasticity is approximately -2 per cent, while in accommodation, cafes, and restaurants, the youth own wage elasticity is around -5 per cent. The magnitude of the youth own wage elasticity for manufacturing, at -20, is similar to the estimate from the full sample. However, the average youth cost share in manufacturing is less than 5 per cent, making this elasticity estimate unreliable. The elasticity estimates for the construction and personal services industries are questionable for similar reasons.

Homogeneity and symmetry are rejected less frequently in the industry-specific estimations. This, together with the variation in coefficient estimates across industries, suggests that the full-sample and group estimates may suffer from aggregation bias.

Nevertheless, in no cases were both symmetry and homogeneity accepted in industry-specific estimations. Once again, the failure of homogeneity may be evidence that weak separability does not hold. If so, then even the own wage coefficients will be biased, because of the omission of a capital price variable from the estimated demand equations.

In general, it is not possible to predict the direction of this bias. However, Berndt (1981, pp. 134–136) suggests that, to the extent that studies of labour-labour substitution that omit capital are holding aggregate labour rather than output constant, it may be possible to place a bound on the magnitude, and sometimes infer the direction, of the output constant price elasticities from estimates of the aggregate labour constant price elasticities. Specifically, for a constant returns to scale production technology, the aggregate labour constant own price elasticities of demand will be smaller, in absolute value terms, than the corresponding output constant own price elasticities of demand. Thus, the results reported here may understate the true output constant own wage elasticities.

The failure of both symmetry and homogeneity to hold means that the magnitude of the cross wage elasticities reported in Table 4.7 should be treated with caution. In most cases, the estimates suggest a complementary relationship between youth and adult employees, except where the imposition of homogeneity alone forces some substitution. However, the magnitude of the underlying cross wage coefficients vary between industries. For example, in the retail industry adult females are highly complementary with youth, while in accommodation, cafes and restaurants the degree of complementarity is apparently much less.

The estimated cross wage elasticities reported here may also suffer from omitted variable bias. Berndt (1981) suggests that the aggregate labour constant cross price elasticities of demand will be larger, in strict (not absolute value) terms, than the corresponding output constant cross price elasticities of demand.

Nevertheless, the general finding of a complementary relationship between youth and adult workers should also be treated with caution. The studies referred to in Chapter 3 look at the own and cross wage elasticities of demand for youth labour within more appropriate systems that allow for capital-labour substitution. These studies find that, in aggregate, adult labour weakly substitutes for youth labour, as does capital.[16] Nevertheless, these studies are

[16] Hamermesh (1982) finds a complementary relationship between capital and youth (and adult) labour. However, owing to the positive own price elasticity of demand for capital and low t-statistics on some of the variables, this finding should be treated cautiously.

now quite old, being undertaken before the technological and regulatory changes in retailing and other service industries that were outlined in Chapter 2.

Table 4.7 Estimated youth cross wage elasticities from youth equation, selected industries[a]

System	*Retail*	*Accomm*	*Manuf*	*Constr*	*Culture*	*Person*
Youth employment response to changes in adult male wages:						
Unconstrained						
youth-adult female	-3.40***	2.36*	-10.22***	-16.45***	-20.12***	ne
youth-adult male	-3.43***	1.77	-8.39***	-15.78***	-20.43***	-21.02
Symmetry						
youth-adult female	ne	2.25	-10.93***	ne	-24.43***	ne
youth-adult male	nh	4.00***	-3.12**	-2.88***	-11.46	1.36
Homogeneity						
youth-adult female	nh	7.95[b]	nh	-10.30[b]	-0.72[b]	ne
youth-adult male	nh	0.00	nh	ne	-1.46	-13.69
Youth employment response to changes in adult female wages:						
Unconstrained						
youth-adult female	-5.55***	-2.57**	-8.39***	-1.19	-13.47***	ne
youth-adult male	-5.27***	-1.71	-5.95*	-1.58	-13.40***	-15.93
Symmetry						
youth-adult female	ne	-0.06	-3.56**	ne	1.28	ne
youth-adult male	nh	-1.72	-7.61**	-3.99***	-14.78***	-23.63
Homogeneity						
youth-adult female	nh	-3.40	nh	5.49	-2.50	ne
youth-adult male	nh	0.19[b]	nh	5.52[b]	-1.38[b]	22.61[b]

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a Elasticities evaluated using unrounded coefficients and sample cost share means (see Appendix B, Table B.3).

b Unable to ascertain statistical significance as the underlying coefficient was recovered (ie not estimated).

Source: Commission estimates.

Indirect evidence from studies looking at skilled-unskilled labour substitution within similar frameworks come to similar conclusions about the interactions between different types of labour and capital (eg Betts 1997, Draper and Manders 1997, Shadman-Mehta and Sneesens 1995 and a range of studies cited in Hamermesh 1993).[17] Capital is more likely to substitute for unskilled than skilled labour, with the latter sometimes found to be weakly complementary with capital. This suggests that youth may be more susceptible to being replaced by capital than adults, owing to their generally lower skill levels. This would weaken the need for youth-adult substitution, although as noted above, the evidence from these studies is not conclusive.

4.4 Summing up

This chapter has used Australian data on employment and wages for a cross section of workplaces, derived from the AWIRS 95, to establish a formal relationship between youth employment and its determinants.

The empirical results indicate a strong and robust negative relationship between youth employment and youth wages. This relationship suggests that a 1 per cent increase in youth wages would lead to a decrease in youth employment of between 2 and 5 per cent in industries employing a relatively high proportion of youth. There is some evidence that raising youth wages may also reduce adult employment. However, the data limitations make it difficult to have confidence in this result.

[17] These findings are also broadly consistent with those looking at educational attainment (see Hamermesh 1993, pp. 113–8).

5 CONCLUSION

This study has examined trends in youth employment over time. It has used both formal and informal methods to explain those trends.

One striking trend has been the decline in teenage employment. Between 1966 and 1997, the number of teenagers employed fell by 15 per cent.

Another striking trend has been the shift in the composition of teenage employment away from full-time and towards part-time employment. Indeed, the decline in total numbers is associated entirely with a fall in full-time employment. Teenage part-time employment has increased, but mainly in retail trade.

The available data indicate that, when measured on an hourly basis, teenage real wage costs have increased slightly. This could explain, at least in part, the decline in full-time employment. For teenage part-time workers, both real hourly earnings and total hours worked have risen. Increased demand for part-time workers resulting from extended trading hours in retail and other service industries could explain this trend.

While the teenage wage has not changed much relative to the adult wage over time, teenage employment has declined relative to adult employment. For teenage full-time workers, wage costs and employment have both fallen relative to adults. For teenage part-time workers, wage costs and employment have both increased relative to adults. Neither trend is consistent with a strong degree of substitution between teenage and adult workers. Indeed, the trends suggest the opposite.

It is remarkable that these casual observations, made by examining industry and economy-wide data over time, are born out by more formal econometric analysis of an entirely different dataset. The formal techniques are better able to isolate the influence of wages from the influence of other factors affecting youth employment. The advantage of the using AWIRS 95, a cross sectional dataset observed at a single point in time, is that there is less need to correct for non-wage factors, such as youth mobility and educational attainment, that vary predominantly over time.

The analysis using the AWIRS 95 dataset finds a significant and negative relationship between youth employment and youth wages. The best estimates suggest that a 1 per cent increase in youth wages would lead to a decrease in youth employment of between 2 and 5 per cent in industries employing a relatively high proportion of youth.

The cross sectional evidence on the relationship between youth and adult employment is much less robust. The reason is that the AWIRS 95 data does not contain information on capital used by workplace. Thus, the analysis cannot take account of the influence on youth employment of changes in the price of capital. Without the facility to allow for substitution between (relatively unskilled) youth and capital as the price of one rises relative to the other, some tightly constrained specifications force more apparent substitution between youth and adult employment than might occur in practice. Indeed, looser specifications suggest a complementary relationship between youth and at least some categories of adults. Nevertheless, the data limitations make it difficult to have confidence in this result.

Ideally, the relationship between youth and adult employment should be examined in a properly specified formulation that also includes capital. Attempts at such an estimation in a pooled time series cross section context gave unreliable results, because of a strong degree of covariation over time in youth and adult wages.

Other studies typically find substitution between unskilled labour and capital, confirming that capital is important in the analysis. This would leave more room for complementarity between different types of labour. Most other studies that have analysed the issue directly have found substitution between youth and adult labour. Nevertheless, these studies are dated, and subsequent technological and regulatory changes could have altered the relationship between youth and adult labour.

The purpose of the study was to examine the determinants of youth employment in order to shed light on the possible implications of abolishing junior rates of pay in State and Federal awards. To the extent that replacing such awards with non-discriminatory alternatives would lead to an increase in youth wages, the results of this analysis suggest quite strongly that there would be a more than proportionate reduction in youth employment. Data limitations make it difficult to make a reliable assessment of the effect on adult employment.

A TIME SERIES DATA SOURCES AND ISSUES

This appendix gives sources for the data used in Chapter 2, and explores associated conceptual issues. Appendix B discusses the corresponding issues relating to the AWIRS 95 dataset used in Chapter 4.

A.1 ABS labour market data

A suite of ABS surveys provides details on the labour market. The surveys are either employer-based or household-based (employee-based). This section compares the two main employer surveys — the *Average Weekly Earnings* (ABS Cat. No. 6302.0) and *Employee Earnings and Hours* (ABS Cat. No. 6306.0) — and the two main employee surveys — the *Labour Force Australia* (ABS Cat. No. 6203.0) and *Weekly Earnings of Employees (Distribution) Australia* (ABS Cat. No. 6310.0). As this study looks at labour demand, it only deals with people in the labour force. It does not cover those people not actively looking for or participating in work (eg those solely engaged in full-time education).

Average Weekly Earnings

This survey of *Average Weekly Earnings* (AWE) is a quarterly survey of approximately 5 000 employers. The modern AWE collection commenced 30 years ago and there are some series back to the Second World War. The survey covers all wage and salary earners who receive pay, except for a range of employees not easily captured in reasonably large scale workplaces — most notably employees of businesses in agriculture, forestry and fishing. The survey provides details on average weekly ordinary earnings and average weekly total earnings by industry, but not by age. It is, therefore, an inappropriate survey to use to look at youth employment.

Employee Earnings and Hours

The biennial survey of *Employee Earnings and Hours* (EEH) is another employer-based survey that commenced in 1975. Like the AWE, the EEH excludes agriculture, forestry and fishing businesses and does not have detailed demographic information (eg age and gender). It does present separate data for junior employees (aged under 21) who are not being paid the adult wage rate for their occupation, by industry. But since 1983, EEH classifies employees under 21 years of age who are paid the adult rates of pay, not as juniors, but as adults.

This study focuses on the role of wages (and other factors) in affecting youth employment. The variation in youth wages across junior and adult award rates is one important source of variation with which to establish the influence of youth wages on employment. The EEH now lacks this variation, although at the time the BLMR (1983) conducted its study using the EEH dataset, this was not the case. Prior to 1983, junior and adult workers were distinguished solely on the basis of age (DIR 1997, p. 5). Youth were then defined as all employees under 21 years of age, irrespective of whether they were paid adult wage rates or not.

Labour Force Survey

The *Labour Force Australia* (LFS) is a household survey that collects data on demographic and labour force characteristics of the Australian population. The survey is conducted monthly and provides data on the number of employed persons classified by age. It also provides data on the number of youth employed since the mid-1960s. The survey provides information on other characteristics of youth, including employment status, gender, occupation and industry classification.

As argued in Chapter 2, the number of employed persons is not an appropriate measure of labour demand. In addition, the LFS does not collect data on wages.

Weekly Earnings of Employees (Distribution) Australia

The *Weekly Earnings of Employees (Distribution) Australia* (WEEDA) is a supplementary survey accompanying the August LFS. It asks respondents additional questions on hours worked, hours paid, weekly earnings and other benefits that they receive. WEEDA excludes persons working for payment in kind, and since 1984 has had its sample size reduced to seven-eighths of the LFS.

The weekly earnings data in WEEDA refer to the amount of ‘last total pay’ workers received as wages and salaries. Weekly earnings are before taxation and other deductions, and also include any back payment of wage increases or prepayment of leave. For workers who receive monthly and fortnightly earnings, their earnings are converted into a weekly equivalent.

Based on advice from the ABS, the Commission chose WEEDA as the primary source of time series data for this study — primarily because of the compatibility of its persons, earnings, and hours data.

The unpublished data obtained from the ABS on employees, hours paid and earnings are for employment in the main job — the job in which most hours are worked. The data have been adjusted to exclude workers who are on workers compensation. The ABS also adjusted the data to match the standard labour force definition of full-time (those working more than 35 hours a week in all jobs) and part-time workers (those working less than 35 hours), rather than the classification used in WEEDA that is based on self-perception (since 1988). Apprentices, who may not be on their labour demand curves, are included in the analysis in this paper as WEEDA is incapable of identifying apprentices. (Another supplementary survey collects information on apprentices, but does not include data on their earnings.)

Although copies of the original publications exist, the ABS are unable to access the unpublished data from the WEEDA survey used in this paper for the years prior to 1984.[1] The ABS did not publish estimates of total earnings and hours worked from the WEEDA for 1996, although it did publish estimates of the number of persons employed. This study interpolated the missing observations for 1996 from the 1995 and 1997 observations.

A.2 Descriptive statistics

Hours paid and hourly earnings

The cost of employing labour depends not only on the level of wages paid, but also on the extent of non-cash benefits provided and the on-costs associated with employment (eg superannuation, workers compensation premiums, fringe benefits tax, and payroll tax). Some of these costs vary with the number of hours worked (eg wages and overtime), while others do not (eg salaries, search, administration and on-costs). The fixed costs influence an employers decision whether to employ additional labour, but are far less important than the variable costs in deciding whether to utilise existing employees more effectively as these costs have, for the most part, already been incurred. The distinction relevant for assessing the impacts of youth employment is the difference between the fixed costs associated with employing youth over adults. While there are some differences in the costs themselves (eg concessional payroll tax arrangements associated with employing apprentices), these differences do not generally differ significantly between youth and adult workers. In addition, the ABS does not collect reliable information outlining how these fixed costs vary with age. The econometric work, therefore, focuses on the variable costs of employment.

1 Although WEEDA has been conducted on an annual basis, the ABS regard it as a supplementary survey rather than a time series survey and, as such, did not convert the data over to its current computer system. The original magnetic tapes exist, but have deteriorated to such an extent that they are unreadable (ABS Personal communication).

In making their employment decisions, employers are concerned with the number of hours of productive work they receive and not the number of hours actually paid. The presence of regular unpaid overtime may influence their employment decisions by effectively reducing the hourly earnings of employees.[2]

The ABS advice was to use the WEEDA hours paid data in preference to hours worked data as the hours worked were only for the survey reference week (the week prior to the interview). However, hours paid and earnings data were for the last pay received, and could cover a period of a week, a fortnight or a month. Thus, hours paid and earnings are comparable, while hours worked and earnings are not.

The ABS provided unpublished estimates of the number of employees, the total number of hours paid and total fortnightly earnings from WEEDA cross-classified by:

- age (15 to 19 years, 20 to 24 years, and over 24 years);
- gender (males, females, persons);
- industry (1 digit ANZSIC); and
- employment status (full-time, part-time, total).

Estimates of hourly earnings were then derived by dividing total earnings by the total number of hours paid.

Educational attainment

Differences in employment patterns and levels over time may reflect changes in the quality of the labour employed (eg maturity, social skills, education, flexibility). However, these changes are often difficult to measure objectively.

The number of years spent in education may approximate the level of educational attainment actually achieved. Maturity too generally increases with age. It may also increase with the number of years spent in the labour force. To the extent that years spent in education are correlated with age, any measure of educational attainment may also be a crude measure of maturity.

The ABS collects information on the educational attainment of those in the labour force in its *Transition from Education to Work* survey (ABS Cat. No. 6227.0) conducted in May of each year. The ABS provided unpublished annual data on numbers of people from this survey from 1984 to 1997 cross-classified by:

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2 This is more likely to be an issue for salaried employees than those on wages

- age (15 to 19 years, 20 to 24 years, and over 24 years);
- gender (males, females, persons);
- level of educational attainment (Table A.1);
- industry (1 digit ANZSIC); and
- employment status (full-time, part-time, total).

Table A.1: ABS categories of educational attainment for those in the labour force

15 to 19 and *20 to 24 year olds*	*Over 24 years*
With post school qualifications	With post school qualifications
Completed Year 12	Completed highest level of secondary school
Completed Year 11 Completed Year 10 Completed other year	Did not complete highest level of secondary school
Never attended school	Never attended school
Still at school[a]	Still at school

a For 15 to 19 year olds, the ABS also provided their age.

The index of educational attainment was calculated as the weighted average number of years of schooling needed by each group to obtain its qualification (Table A.2), with the weights being numbers of people in the various age, gender, industry or employment status categories, as required. Thus, the index adjusts for population changes over time.

As the ABS were unable to break down post school qualifications into the various types of educational qualifications, the index does not explicitly incorporate differences in entry level requirements and average duration across different types of post school qualifications.

Table A.2: Weights used for index of educational attainment

Educational attainment	*Teenage (15 to 19 years)*	*Adults (20 to 24 years)*	*Adults (Over 24 years)*
Post school qualifications	15	17	17
Completed Year 12	13	13	13
Completed Year 11	12	13	na
Completed Year 10	11	13	na
Completed other year	10	13	13
Never attended school	10	13	13
Still at school — age not specified	na	13	13
Still at school — aged 19 years	13	na	na
Still at school — aged 18 years	13	na	na
Still at school — aged 17 years	12	na	na
Still at school — aged 16 years	11	na	na
Still at school — aged 15 years or less	10	na	na

All adults over the age of 20 were assumed to have reached at least the same level of educational attainment or maturity as someone having completed year 12. This was on the basis that their formal schooling, however, short, would have been supplemented by some post-school experience. Those adults possessing post school qualifications were assumed to have an additional educational advantage over those without post secondary qualifications. As 15 to 19 year olds are more likely than adults to have only recently completed their schooling or to have less work experience, youth workers were assigned a lower value of educational attainment that varied with the level of schooling completed. For those still at school, their level of educational attainment was based on their age (as a proxy for the number of years of schooling).

Labour mobility

In addition to the on-costs associated with employment (eg wages, superannuation, workers compensation, and payroll tax), there are a number of fixed costs associated with the turnover of staff (eg the cost of advertising, interviewing applicants, training and firing staff). Higher levels of staff turnover will translate into higher fixed costs. In many cases, these costs will not be insignificant. This may discourage employers from employing staff that are more likely to leave (eg young workers).

The labour mobility index employed in this study measures the weighted-average number of times workers have changed employers or commenced a new job in the last 12 months. The ABS assigned workers to industries based on their current job (if currently working) or industry of last job (if not currently working). The ABS provided unpublished data on the number of employees in each age group having 0, 1, 2 or 3 or more different employers, with the latter group assumed to have only 3 employers in order to calculate the index.[3] A yearly average was used for each category of labour to adjust for population changes over time.

A.3 Pooled time series cross sectional econometric data

In addition to providing the descriptive statistics in Chapter 2, the WEEDA survey data also provided the basis for an alternative, pooled time series cross sectional regression exercise reported briefly in Chapter 4. Reported below are the additional data used in that exercise.

Industry coverage

An output measure that is independent of the inputs used does not exist for many industries, primarily service industries. The ABS measures the output of these non-market industries as the value of labour used in providing the services. Therefore, there will be a high degree of correlation (or multicollinearity) between the wages paid to labour and the value of output in those industries. The alternative econometric analysis was therefore restricted to the market sector that had independent measures of output (Table A.3).

Although mining and electricity, gas & water industries are part of the market sector with independent measures of output, they were excluded from the time series analysis as both industries employed insufficient youth and adult females to yield reliable estimates (ANZSIC divisions B and D respectively).[4] The larger employing industries of transport & storage and communication services were aggregated for the time series econometrics for similar reasons (ANZSIC divisions I and J, respectively).

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3 The ABS were unable to provide data on the number of different employers for 1984 and 1985.

4 The mining and electricity, gas & water industries employed 2 180 and 1 099 youth in 1996 (0.4 and 0.2 per cent respectively of the 223 742 youth employed in all industries). These industries likewise employed 12 467 and 10 446 adult females (both 0.4 per cent).

Table A.3: One digit ANZSIC industries

	ANZSIC industry	*Sector*	*Reason for exclusion*
A	Agriculture, forestry & fishing	Market	Included
B	Mining	Market	Too few youth
C	Manufacturing	Market	Included
D	Electricity, gas & water	Market	Too few youth
E	Construction	Market	Included
F	Wholesale trade	Market	Included
G	Retail trade	Market	Included
H	Accommodation, cafes & restaurants	Market	Included
I,J	Transport, storage & communication services	Market	Included
K	Finance & insurance	Non-market	Non-market sector
L	Property & business services	Non-market	Non-market sector
M	Government administration & defence	Non-market	Non-market sector
N	Education	Non-market	Non-market sector
O	Health & community services	Non-market	Non-market sector
P	Cultural & recreational services	Market	Included
Q	Personal & other services	Non-market	Non-market sector

The ABS changed its system for classifying industry data from ASIC to ANZSIC in 1993. The ABS converted the original ASIC data it provided for the period 1985 to 1993 into ANZSIC. This study converted the 1984 data from 2 digit ASIC to ANZSIC using the concordance provided in Gretton & Fisher (1997) and ABS Cat. No. 1292.0.

Output

Output by industry was measured as GDP(I) expressed in constant prices sourced from the dX database (ABS Cat. No. 5206.0).

Rental price of capital

Unlike a production function that expresses output as a function of the quantities of inputs used, a cost function is expressed as a function of input prices. Appendix C outlines the reasoning why a cost function approach was adopted in this paper. In a long-run cost function, a price of capital is required (unless weak separability is assumed). Most empirical studies that estimate long-term cost functions use an index of the rental price as a proxy for the price of capital.

The rental price of capital was estimated using the methodology employed by the ABS (Aspen 1990 and Gretton & Fisher 1997, pp. C14–C15).

All data used in these calculations came from the dX database (ABS Cat. No. 5206.0 and 5221.0). The consumption of fixed capital (expressed in current prices) was used as the measure of depreciation. The net capital stock used measures the constant price value of *non-dwelling construction* and *plant and equipment* by *private enterprises* and *public trading enterprises*. The value of capital income was measured by the Gross Operating Surplus (GOS) — the excess of gross output over the costs incurred in producing that output before allowing for the consumption of fixed capital (ABS Cat. No. 5216.0). This measure, however, overestimates the true return to capital as the ABS does not separate the wages and salaries of the self employed from the return on capital. The rental prices of capital for each industry were then calculated as an index with a base in 1984 of 50.0.

Cost shares

Total weekly production costs for each industry were estimated as the sum of labour and capital costs.[5] Weekly labour costs were estimated as the total number of hours paid in the survey week multiplied by the average hourly earnings. The weekly cost of capital was estimated by dividing the annual cost of capital — the current capital stock multiplied by the rental price — by 52.

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5 Land and other input were excluded from the cost function as it was not possible to get reliable annual estimates of cost.

B AWIRS 95 DATASET AND RELATED ISSUES

This appendix provides a general discussion of the AWIRS 95 dataset. It also provides details of the data transformations needed to undertake the analysis and a more detailed presentation of the econometric results presented in Chapter 4.

B.1 AWIRS 95

AWIRS 95 is the second comprehensive workplace survey conducted by DWRSB. The main objective of AWIRS 95 was to continue the development of a comprehensive and statistically reliable data base on Australian workplace industrial relations. AWIRS 95 comprises 4 surveys, each with one or more questionnaires. Table B.1 outlines the structure of AWIRS 95.

Table B.1: Structure of AWIRS 95

Survey	*Questionnaire*
Main	Employee Relations Management
	General Management
	Union Delegate
	Workplace Characteristics
Employee	Employee
Small Workplace	Small Workplace
Panel	Employee Relations Management
	General Management
	Union Delegate
	Workplace Characteristics

The main survey comprises four different questionnaires on workplace characteristics, major products or services, organisational change, management and employee relations, awards, employment, and occupational categories. The main survey covers 2 001 workplaces with 20 or more employees from all ANZSIC divisions except Agricultural, forestry and fishing, and Defence. From the workplaces included in the main survey, a random sample of 19 155 employees were selected to form the basis of the employee survey. The employee survey covers 1 828 workplaces out of a possible 2 001 workplaces and collects information on employee demographic details, training experience, attitudes to changes of work environment, hours worked, earnings and occupation. The small workplace survey includes workplaces with between 5 and 19 employees. It covers a similar but reduced number of topics from the main survey. The panel survey is a sample of 698 workplaces from the first AWIRS conducted in 1990 that were still operation in 1995 (with 10 or more employees). It includes the same questions as the main survey.

The primary data source used for the cross sectional analysis (Chapter 4) is the employee survey, with information about workplace characteristics taken from various questionnaires in the main survey. The dataset comprised 1 823 workplaces (out of 1 828) which had survey information on youth employment.

The industries covered in the dataset AWIRS 95 survey generally reflect their relative importance in the economy (Table B.2).

Table B.2: A comparison of persons employed by industry (per cent)

Industry	*AWIRS 95 (1 828 workplaces)*	*ABS*[a]
Mining	3.5	1.1
Manufacturing	20.4	12.1
Electricity, gas & water	4.1	1.0
Construction	2.8	8.0
Wholesale trade	4.0	6.4
Retail trade	7.6	15.8
Accommodation, cafes & restaurants	3.0	4.9
Transport & storage	4.2	4.9
Communication services	3.0	1.9
Finance & insurance	5.3	4.1
Property & business services	5.8	10.3
Government[a]	9.2	5.6
Education	8.4	7.6
Health & community services	10.9	9.8
Cultural & recreational services	3.4	2.4
Personal & other services	4.5	4.1
Total	*100.0*	*100.0*

a Non-farm employment, including Defence.

Sources: AWIRS 95, ABS Cat. No. 5204.0.

The main survey covers workplaces with 20 or more employees, and its distribution of workplaces is skewed heavily towards those with smaller numbers of employees (Figure B.1). However, the distribution of employees across workplace size is skewed toward medium to larger workplaces (Figure B.2). Therefore, factors affecting smaller workplaces will affect a large proportion of all workplaces, but only a small proportion of employees. Conversely, any event that affects large workplaces only affects a small proportion of workplaces, but has an impact on a larger proportion of employees (Morehead et al 1997).

Figure B.1: Distribution of workplaces by workplace size

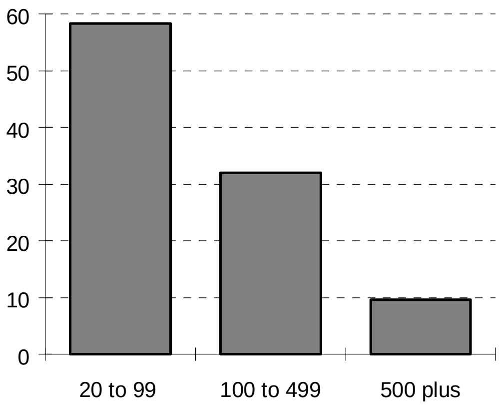
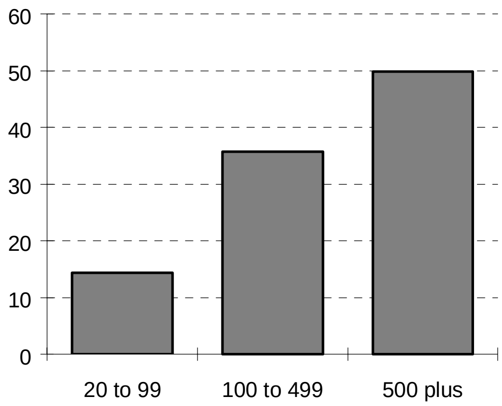


Figure B.2: Distribution of employees by workplace size



Source: Commission estimates based on AWIRS 95.

The organisational structure and ownership of workplaces can have significant effects on the operation of workplaces (Morehead et al 1997). Workplaces can be classified into two groups — those that are controlled by a wider organisation, and those that act on their own behalf. Small workplaces that are part of large organisations may be expected to follow company policies and behave in similar way to larger workplaces. This is particularly relevant for the retail trade industry, which is characterised by chain and franchise firms. From the AWIRS 95 main survey (general management questionnaire), approximately 80 per cent of workplaces indicated that they were part of a larger organisation (Morehead et al 1997).

Finally, general summary statistics for the economy and selected industries are given in Table B.3. Some variables exhibit considerable in-sample variation. The greatest variation in hourly wages is for adults in the accommodation, cafes, and restaurants industry. This variation is primarily driven by one extremely large observation. Sensitivity analysis was undertaken for accommodation, cafes and restaurants by removing this observation from the sample and re-estimating the labour demand equations. There was no effect on the signs or magnitudes of the explanatory variables.

B.2 Deriving the average hourly wage

As outlined in Chapter 4, a number of steps were taken to derive the average hourly wage paid to youth and adult employees, by workplace. One step was to calculate the average weekly earnings of employees using the grouped income bands. Another step was to impute an average 'virtual' hourly wage for workplaces not employing a particular category of labour, this being the wage a workplace would have had to pay that type of labour, had they employed them.

This section outlines the method used to calculate the average weekly earnings of employees in the income band of $1 150 and more, and the wage dummy regression used to impute virtual hourly wages.

Estimating an upper income bound

Income distributions are generally skewed to the right — with a small proportion of the people earning high incomes relative to the mean income. However, the proportion of employees in AWIRS 95 earning more than $1 150 per week represents a substantial proportion of the total sample (6.2 per cent) DWRSB (1997).

To obtain an estimate of average weekly earnings for this group is necessary to determine an upper income bound for this group. This is achieved by distributing the 6.2 per cent employees across hypothetical wage bands at a declining rate to impute a skewed income distribution (Table B.4). From these calculations, average weekly earnings for the top income bracket are estimated to be $1 325.

Table B.3: AWIRS 95 summary statistics

Variable	*Median*	*Mean*	*Std dev.*
Average youth hourly wage (dollars per hour):			
Full sample	9.42	9.53	3.15
Youth employment industries	9.42	8.98	2.43
Youth intensive industries	9.28	10.18	4.25
Retail trade	7.75	7.75	2.16
Accommodation	9.28	9.30	3.37
Construction	9.19	9.19	1.25
Manufacturing	9.42	9.42	2.29
Personal services	14.93	14.93	4.69
Cultural	10.21	10.21	2.66
Average adult male hourly wages (dollars per hour):			
Full sample	15.06	15.75	4.41
Youth employment industries	13.26	14.06	4.00
Youth intensive industries	13.13	13.99	4.23
Retail trade	12.07	12.87	4.24
Accommodation	12.09	13.31	3.23
Construction	14.84	15.29	3.09
Manufacturing	13.95	14.74	3.98
Personal services	16.62	16.40	3.69
Cultural	14.76	14.97	4.24
Average adult female hourly wage (dollars per hour):			
Full economy	13.68	13.95	4.16
Youth employment industries	12.11	12.57	4.58
Youth intensive industries	11.93	12.64	5.47
Retail trade	11.01	11.02	1.41
Accommodation	12.08	13.27	10.65
Construction	14.02	13.38	2.06
Manufacturing	12.91	12.91	3.10
Personal services	13.74	14.15	2.66
Cultural	13.39	13.33	3.65

(Cont...)

Table B.3: AWIRS 95 summary statistics (continued)

Variable	*Median*	*Mean*	*Std dev.*
Youth cost share (proportion):			
Full sample	0.00	0.04	0.12
Youth employment industries	0.00	0.09	0.17
Youth intensive industries	0.00	0.13	0.21
Retail trade	0.15	0.22	0.22
Accommodation	0.25	0.16	0.25
Construction	0.00	0.02	0.05
Manufacturing	0.00	0.03	0.08
Personal services	0.00	0.01	0.06
Cultural	0.00	0.05	0.14
Adult male cost share (proportion):			
Full sample	0.62	0.57	0.33
Youth employment industries	0.68	0.59	0.35
Youth intensive industries	0.39	0.42	0.34
Retail trade	0.23	0.03	0.31
Accommodation	0.27	0.33	0.31
Construction	0.96	0.88	0.19
Manufacturing	0.76	0.71	0.27
Personal services	0.77	0.69	0.27
Cultural	0.40	0.44	0.30
Adult female cost share (proportion):			
Full sample	0.33	0.38	0.31
Youth employment industries	0.26	0.33	0.30
Youth intensive industries	0.43	0.45	0.30
Retail trade	0.50	0.48	0.29
Accommodation	0.51	0.52	0.31
Construction	0.00	0.10	0.19
Manufacturing	0.19	0.26	0.26
Personal services	0.23	0.29	0.25
Cultural	0.52	0.51	0.29

(Cont...)

Table B.3: AWIRS 95 summary statistics (continued)

Variable	*Median*	*Mean*	*Std dev.*
Total hours worked (hours per firm):			
Full sample	2 964.50	7 693.31	13 652.49
Youth employment industries	2 940.61	6 512.96	9 775.43
Youth intensive industries	2 067.80	4 416.52	7 538.74
Retail trade	2 678.00	4 224.03	4 891.97
Accommodation	1 316.00	3 385.48	5 058.96
Construction	1 959.57	2 999.84	3 979.56
Manufacturing	4 130.00	9 086.47	12 193.06
Personal services	1 971.13	5 090.86	9 529.15
Cultural	1 593.43	5 048.96	10 647.84
Youth relative education (years): [a]			
Full sample	-0.84	-0.90	1.67
Youth employment industries	-0.42	-0.47	1.51
Youth intensive industries	-0.31	-0.46	1.46
Retail trade	-0.16	-0.26	1.30
Accommodation	0.00	-0.07	1.55
Construction	-0.91	-0.79	1.80
Manufacturing	-0.75	-0.59	1.48
Personal services	-1.13	-1.20	1.26
Cultural	-0.31	-0.37	1.55

a Relative youth education is defined as the difference between the average number of years of education for youth and the average number of years of education for all employees, at each workplace.

Source: Commission estimates based on AWIRS 95.

Table B.4: Imputing an average wage for income band $1 150 and higher

Mid-point wage	*Percentage*	*No. of employees*	*Total earnings*
1 175	1.0	190	223 629.03
1 225	1.0	190	233 145.16
1 275	1.0	190	242 661.29
1 325	0.8	152	201 741.93
1 375	0.7	133	183 185.48
1 425	0.7	133	189 846.77
1 475	0.4	76	112 290.32
1 525	0.3	57	87 072.58
1 575	0.2	38	59 951.61
1 625	0.1	19	30 927.41
Total	*6.2*	*1 180*	*Average 1 325.81*

Source: Commission estimates.

Imputing 'virtual' hourly wages

It was necessary to impute a 'virtual' hourly wage for workplaces not employing a particular category of labour, this being the wage a workplace would have had to pay that type of labour, had they employed them.[1] The 'virtual' hourly wage was imputed using observed average hourly wages in similar workplaces. Using a wage dummy variable regression, similarity was determined on the basis of characteristics that had the most impact on observed hourly wages. The factors considered as potentially important influences on the hourly wages included firm size, industry, and a State and regional indicator. Adult male and adult female hourly wages were imputed using firm size, industry and region. Youth hourly wages were imputed using firm size and industry (Table B.5).

[1] As noted earlier, the proportion of workplaces reporting no youth workers is large. In addition, there are 84 and 53 workplaces with no survey information on adult males and adult females, respectively.

Table B.5: Determinants of average hourly wage[a]

Variables	*Youth*	*Adult male*	*Adult female*
Constant[b]	14.54 (6.50)	17.70 (18.61)	14.62 (15.06)
Workplace size:			
20 - 99 employees	-1.18 (-1.33)	-2.17 (-5.80)	-1.21 (-3.22)
100 - 499 employees	0.11 (0.13)	-1.37 (-3.67)	-0.99 (-2.54)
State:			
New South Wales	0.13 (0.09)	0.48 (0.62)	0.68 (0.91)
Victoria	1.18 (0.75)	-0.13 (-0.16)	0.09 (0.12)
Queensland	0.58 (0.36)	-0.58 (-0.72)	0.40 (0.51)
South Australia	1.18 (0.68)	-0.04 (-0.05)	-0.58 (-0.71)
Western Australia	1.76 (1.05)	-0.79 (-0.96)	0.04 (0.04)
Tasmania	0.10 (0.05)	0.30 (0.30)	0.21 (0.21)
Northern Territory	-6.89 (-1.33)	0.28 (0.17)	4.99 (7.07)
Region:			
Metropolitan	0.43 (0.82)	0.80 (3.27)	0.74 (2.81)

(Cont...)

Table B.5: Determinants of average hourly wage (continued)[a]

Variable	*Youth*	*Adult male*	*Adult female*
Industry:			
Mining	-2.04	3.58	1.50
	(-1.06)	(5.19)	(1.77)
Manufacturing	-5.62	-1.92	-1.53
	(-3.86)	(-3.91)	(-2.76)
Electricity, gas & water	-3.92	0.47	-0.02
	(-1.77)	(0.70)	(-0.02)
Construction	-5.38	-0.95	-0.89
	(-2.95)	(-1.47)	(-1.00)
Wholesale trade	-5.51	-0.73	-0.25
	(-2.98)	(-1.13)	(-0.34)
Retail trade	-7.44	-3.64	-2.72
	(-3.32)	(-6.06)	(-4.46)
Accommodation, cafes & restaurants	-5.13	-4.11	-2.70
	(-3.32)	(-6.00)	(-3.85)
Transport & storage	-6.05	-1.66	-1.11
	(-3.16)	(-2.67)	(-1.51)
Communication services	-2.97	-0.18	-0.29
	(-1.15)	(-0.26)	(-0.37)
Finance & insurance	-6.29	1.29	0.05
	(-3.76)	(2.04)	(0.07)
Property & business services	-4.95	1.22	0.27
	(-2.98)	(2.01)	(0.42)
Government	-5.59	0.85	1.17
	(-2.96)	(1.48)	(1.84)
Education	-8.21	1.32	1.56
	(-4.24)	(2.30)	(2.55)
Health & community services	-5.13	-1.94	-0.46
	(-2.96)	(-3.28)	(-0.77)
Cultural & recreational services	-4.44	-1.45	-1.14
	(-2.65)	(-2.17)	(-1.67)
Adjusted R^2	7.70	17.14	11.74

t-statistics reported in brackets.

a Dependent variable is hourly wage.

b Constant represents workplaces employing greater than 500, in the ACT, non-metropolitan, in personal and other services.

B.3 Econometric Results

This section provides a complete set of results of the econometrics undertaken in Chapter 4. Table B.6 outlines the structure of the tables that follow.

Table B.6 Summary of economic results, youth equation

Table number	*Dataset*	*System*
B.7	Full sample Youth employment industries Youth intensive industries	youth adult female
B.8	Full sample Youth employment industries Youth intensive industries	youth adult male
B.9	Retail trade Accommodation Manufacturing	youth adult female
B.10	Retail trade Accommodation Manufacturing	youth adult male
B.11	Construction Cultural & recreational Personal services	youth adult female
B.12	Construction Cultural & recreational Personal services	youth adult male

Table B.7: Regression results for the (youth, adult female) system, youth equation

Explanators[a]	*Full sample*		*Youth employment industries*		*Youth intensive industries*	
	coefficient	*t-statistic*	*coefficient*	*t-statistic*	*coefficient*	*t-statistic*
Unconstrained						
constant	4.19	35.45	5.81	26.03	6.82	23.91
youth wage	-0.62	-24.71	-0.87	-19.02	-0.74	-15.61
adult male wage	-0.44	-13.42	-0.43	-7.95	-0.61	-9.13
adult female wage	-0.85	-21.98	-0.92	-11.17	-1.18	-14.88
total hours	-0.01	-1.16	-0.10	-7.00	-0.09	-5.33
relative education	0.07	10.15	0.07	5.61	0.12	6.64
Symmetry						
constant	3.68	34.71	5.05	27.39	nh	nh
youth wage	-0.63	-26.00	-0.89	-20.10	nh	nh
adult male wage	-0.51	-16.35	-0.49	-9.27	nh	nh
adult female wage	-0.56	-25.19	-0.53	-11.92	nh	nh
total hours	-0.01	-1.69	-0.10	-6.96	nh	nh
relative education	0.08	11.17	0.08	6.28	nh	nh
Homogeneity						
constant	nh	nh	nh	nh	nh	nh
youth wage	nh	nh	nh	nh	nh	nh
female wage	nh	nh	nh	nh	nh	nh
total hours	nh	nh	nh	nh	nh	nh
relative education	nh	nh	nh	nh	nh	nh
LR tests[b]	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*
Symmetry	5.05	6.63	3.14	6.63	10.45	6.63
Homogeneity	133.92	9.21	92.50	9.21	73.20	9.21

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a All variables enter the regression in natural logarithms except relative youth education.

b The alternative hypothesis is the unrestricted model. The test statistic is calculated from the likelihood values for the restricted (L_R) and unrestricted (L_U) models according to the formula: $t = -2(\ln L_R - \ln L_U)$. Critical values (CV) are reported at the 1 per cent level of significance. No estimates were obtained for the model imposing both symmetry and homogeneity because of estimation problems.

Source: Commission estimates.

Table B.8: Regression results for the (youth, adult male) system, youth equation

Explanators[a]	*Full sample*		*Youth employment industries*		*Youth intensive industries*	
	coefficient	*t-statistic*	*coefficient*	*t-statistic*	*coefficient*	*t-statistic*
Unconstrained						
constant	4.01	34.74	5.13	23.11	6.50	24.99
youth wage	-0.68	-29.78	-0.88	-21.29	-0.77	-18.16
adult male wage	-0.45	-14.32	-0.41	-7.77	-0.64	-11.65
adult female wage	-0.77	-19.38	-0.69	-8.94	-1.05	-12.83
total hours	0.01	0.77	-0.08	-6.19	-0.07	-4.05
relative education	0.06	9.50	0.06	5.54	0.12	7.31
Symmetry						
constant	nh	nh	nh	nh	nh	nh
youth wage	nh	nh	nh	nh	nh	nh
adult male wage	nh	nh	nh	nh	nh	nh
adult female wage	nh	nh	nh	nh	nh	nh
total hours	nh	nh	nh	nh	nh	nh
relative education	nh	nh	nh	nh	nh	nh
Homogeneity						
constant	nh	nh	nh	nh	nh	nh
youth wage	nh	nh	nh	nh	nh	nh
male wage	nh	nh	nh	nh	nh	nh
total hours	nh	nh	nh	nh	nh	nh
relative education	nh	nh	nh	nh	nh	nh
LR tests[b]	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*
Symmetry	59.31	6.63	30.62	6.63	25.85	6.63
Homogeneity	140.94	9.21	90.28	9.21	65.24	9.21

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a All variables enter the regression in natural logarithms except relative youth education.

b The alternative hypothesis is the unrestricted model. The test statistic is calculated from the likelihood values for the restricted (L_R) and unrestricted (L_U) models according to the formula: $t = -2(\ln L_R - \ln L_U)$. Critical values (CV) are reported at the 1 per cent level of significance. No estimates were obtained for the model imposing both symmetry and homogeneity because of estimation problems.

Source: Commission estimates.

Table B.9: Regression results for the (youth, adult female) system, youth equation, selected industries

Explanators[a]	*Retail trade*		*Accommodation*		*Manufacturing*	
	coefficient	*t-statistic*	*coefficient*	*t-statistic*	*coefficient*	*t-statistic*
Unconstrained						
constant	7.16	11.74	5.23	6.70	1.51	6.40
youth	-0.28	-2.96	-0.66	-4.59	-0.52	-10.76
adult male	-0.80	-5.13	0.32	1.69	-0.30	-5.44
adult female	-1.30	-7.15	-0.48	-2.38	-0.24	-2.78
total hours	-0.09	-3.96	-0.44	-11.00	0.04	2.35
relative education	0.21	8.80	0.02	0.51	0.02	1.77
Symmetry						
constant	ne	ne	4.09	6.61	1.23	5.57
youth	ne	ne	-0.59	-4.16	-0.51	-10.39
adult male	ne	ne	0.30	1.64	-0.32	-5.73
adult female	ne	ne	-0.09	-0.95	-0.11	-1.55
total hours	ne	ne	-0.44	-11.56	-0.03	2.17
relative education	ne	ne	0.03	1.05	-0.02	2.03
Homogeneity						
constant	nh	nh	3.19	10.18	nh	nh
youth	nh	nh	-0.58	-4.39	nh	nh
adult female	nh	nh	-0.06	-0.36	nh	nh
total hours	nh	nh	-0.44	-10.83	nh	nh
relative education	nh	nh	0.04	1.29	nh	nh
LR tests[b]	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*
Symmetry	ne	6.63	0.85	6.63	0.22	6.63
Homogeneity	14.77	9.21	7.44	9.21	9.49	9.21

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a All variables enter the regression in natural logarithms except relative youth education.

b The alternative hypothesis is the unrestricted model. The test statistic is calculated from the likelihood values for the restricted (L_R) and unrestricted (L_U) models according to the formula: $t = -2(\ln L_R - \ln L_U)$. Critical values (CV) are reported at the 1 per cent level of significance. No estimates were obtained for the model imposing both symmetry and homogeneity because of estimation problems.

Source: Commission estimates.

Table B.10: Regression results for the (youth, adult male) system, youth equation, selected industries

Explanators[a]	*Retail trade*		*Accommodation*		*Manufacturing*	
	coefficient	*t-statistic*	*coefficient*	*t-statistic*	*coefficient*	*t-statistic*
Unconstrained						
constant	7.10	11.50	4.93	6.62	1.30	5.08
youth	-0.29	-3.31	-0.64	-5.07	-0.53	-9.90
adult male	-0.81	-5.49	0.22	1.28	-0.25	-4.32
adult female	-1.24	-6.66	-0.35	-1.62	-0.17	-1.93
total hours	-0.09	-4.16	-0.42	-10.60	0.03	1.83
relative education	0.22	10.62	0.02	0.79	0.03	2.93
Symmetry						
constant	nh	nh	4.02	5.75	1.06	4.64
youth	nh	nh	-0.61	-4.94	-0.51	-10.53
adult male	nh	nh	0.57	4.47	-0.11	-2.29
adult female	nh	nh	-0.35	-1.63	-0.22	-2.45
total hours	nh	nh	-0.43	-10.86	0.02	1.33
relative education	nh	nh	0.03	1.07	0.04	3.91
Homogeneity						
constant	nh	nh	3.10	10.30	nh	nh
youth	nh	nh	-0.48	-3.92	nh	nh
adult male	nh	nh	0.53	3.35	nh	nh
total hours	nh	nh	-0.42	-10.85	nh	nh
relative education	nh	nh	0.05	1.57	nh	nh
LR tests[b]	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*
Symmetry	8.60	6.63	0.83	6.63	0.78	6.63
Homogeneity	11.75	9.21	6.92	9.21	10.29	9.21

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a All variables enter the regression in natural logarithms except relative youth education.

b The alternative hypothesis is the unrestricted model. The test statistic is calculated from the likelihood values for the restricted (L_R) and unrestricted (L_U) models according to the formula: $t = -2(\ln L_R - \ln L_U)$. Critical values (CV) are reported at the 1 per cent level of significance. No estimates were obtained for the model imposing both symmetry and homogeneity because of estimation problems.

Source: Commission estimates.

Table B.11: Regression results for the (youth, adult female) system, youth equation, selected industries

Explanators[a]	*Construction*		*Cultural & recreational*		*Personal services*	
	coefficient	*t-statistic*	*coefficient*	*t-statistic*	*coefficient*	*t-statistic*
Unconstrained						
constant	3.52	4.86	5.24	6.76	ne	ne
youth	0.14	1.40	-0.08	-0.60	ne	ne
adult male	-2.15	-8.86	-1.11	-4.73	ne	ne
adult female	-0.21	-1.21	-0.75	-4.82	ne	ne
total hours	0.20	4.09	-0.10	-2.92	ne	ne
relative education	-0.13	-4.22	0.02	0.47	ne	ne
Symmetry						
constant	ne	ne	3.81	3.58	ne	ne
youth	ne	ne	-0.01	-0.05	ne	ne
adult male	ne	ne	-1.34	-4.89	ne	ne
adult female	ne	ne	0.04	0.53	ne	ne
total hours	ne	ne	-0.12	-3.42	ne	ne
relative education	ne	ne	-0.04	0.65	ne	ne
Homogeneity						
constant	-2.08	-4.93	0.85	3.45	-1.01	-1.59
youth	0.67	7.29	0.22	2.31	-0.09	-1.10
adult female	0.70	4.78	-0.16	-1.06	0.24	1.08
total hours	0.21	4.11	-0.17	-5.27	0.01	0.10
relative education	-0.10	-3.43	0.10	2.01	0.17	4.50
LR tests[b]	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*
Symmetry	ne	6.63	3.61	6.63	ne	6.63
Homogeneity	2.66	9.21	6.31	9.21	na	9.21

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a All variables enter the regression in natural logarithms except relative youth education.

b The alternative hypothesis is the unrestricted model. The test statistic is calculated from the likelihood values for the restricted (L_R) and unrestricted (L_U) models according to the formula: $t = -2(\ln L_R - \ln L_U)$. Critical values (CV) are reported at the 1 per cent level of significance. No estimates were obtained for the model imposing both symmetry and homogeneity because of estimation problems.

Source: Commission estimates.

Table B.12: Regression results for the (youth, adult male) system, youth equation, selected industries

Explanators[a]	*Construction*		*Cultural & recreational*		*Personal services*	
	coefficient	*t-statistic*	*coefficient*	*t-statistic*	*coefficien t*	*t-statistic*
Unconstrained						
constant	3.57	5.72	5.30	7.06	0.53	0.71
youth	0.10	0.89	-0.09	-0.63	-0.24	-3.10
adult male	-2.07	-9.86	-1.12	-4.80	-0.30	-1.42
adult female	-0.26	-1.42	-0.75	-4.48	-0.23	-0.63
total hours	0.19	3.10	-0.10	-3.11	0.06	0.75
relative education	-0.14	-5.71	-0.00	-0.03	0.09	2.22
Symmetry						
constant	-0.33	-0.50	4.29	7.54	-0.28	-0.53
youth	0.33	3.35	-0.05	-0.45	-0.12	-1.88
adult male	-0.42	-2.97	-0.64	-4.70	0.01	0.12
adult female	-0.57	-2.83	-0.82	-5.21	-0.34	-1.15
total hours	0.17	3.13	-0.12	-3.84	0.05	0.75
relative education	-0.09	-3.70	0.02	0.42	0.11	3.06
Homogeneity						
constant	-2.07	-4.31	0.86	3.69	-1.24	-2.34
youth	0.64	6.94	0.22	1.94	-0.11	-1.58
adult male	-1.28	-8.86	-0.11	-0.62	-0.20	-1.22
total hours	0.20	3.40	-0.17	-5.69	0.03	0.54
relative education	-0.11	-4.08	0.08	1.83	0.14	4.19
LR tests[b]	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*	*Test statistic*	*Critical value*
Symmetry	5.38	6.63	0.79	6.63	0.73	6.63
Homogeneity	2.77	9.21	7.32	9.21	1.07	9.21

ne: estimates not obtained because of estimation problems; nh: restrictions not holding at the 1 per cent level.

a All variables enter the regression in natural logarithms except relative youth education.

b The alternative hypothesis is the unrestricted model. The test statistic is calculated from the likelihood values for the restricted (L_R) and unrestricted (L_U) models according to the formula: $t = -2(\ln L_R - \ln L_U)$. Critical values (CV) are reported at the 1 per cent level of significance. No estimates were obtained for the model imposing both symmetry and homogeneity because of estimation problems.

Source: Commission estimates.

C MATHEMATICAL DERIVATIONS

This appendix outlines in more detail the theoretical model of labour demand underlying this study. It explains the reasons for the selection of functional forms in the econometric studies of the cross section and time series data. It also discusses the various statistical procedures that were used.

C.1 An economic model of labour demand

The model of labour demand used in this study is based on the derivation of factor demand equations in the neoclassical theory of the firm. In this theory, price taking firms facing some production technology choose their input demands and output supplies so as to maximise their profits. However, as the interest here is only on the input demand equations, and the AWIRS 95 database at least does not have data on output prices, the focus was placed on the narrower question of determining the least cost means of producing a given output.

A firm's problem is to:

$$\underset{\underline{x}\in\Re_{+}^{n}}{Min}\, C(\underline{x}) = \sum_{i=1}^{n} w_i x_i \quad \text{subject to } q \geq f(\underline{x},\underline{z}),$$

where $\underline{x}$ is an ($n \times 1$) vector of factor demands, $\underline{w}' = (w_1, w_2, ---, w_n)$ is a vector of factor prices, q is the firm's (non-negative) output, $\underline{z}$ is an ($m \times 1$) vector of environmental variables and $f:\Re_{+}^{n+m} \rightarrow \Re_{+}$ is the firms production technology. The solution to this problem will be a set of factor demands of the form:

$$x_i = x_i(\underline{w}, q, \underline{z}) \quad \forall i \in \{1,2,---,n\}.$$

If these factor demands are substituted back into the factor cost function, $C(\underline{x})$, a minimum value function is obtained:

$$C(\underline{w}, q, \underline{z}) = \sum_{i=1}^{n} w_i x_i(\underline{w}, q, \underline{z})$$

This is known as the minimum total cost function, or cost function for short, in the economics literature.

Cost functions can be shown to have the following properties (Varian 1992, pp. 72–74).

Nondecreasing in input prices

If $w_j^1 \geq w_j^0$ for all $j \in \{1,2,---,n\}$, then $C(\underline{w}^1, q^0, \underline{z}^0) \geq C(\underline{w}^0, q^0, \underline{z}^0)$.

This says that if the price of one input is increased while all other input prices are held constant, then the total cost of producing a given level of output cannot decline.

Homogeneity of degree one in input prices

$C(t\underline{w}, q, \underline{z}) = tC(\underline{w}, q, \underline{z}) \quad for \quad t > 0$.

This says that if all input prices are doubled, the cost of producing any given level of output doubles.

Concavity in input prices

$C(t\underline{w}^o + (1-t)\underline{w}^1, q, \underline{z}) \geq tC(\underline{w}^0, q, \underline{z}) + (1-t)C(\underline{w}^1, q, \underline{z}) \quad for \quad t \in [0,1]$.

An implication of this is that, if the cost function is twice continuously differentiable, the matrix of second derivatives of the cost function will be negative semidefinite.

Continuity in input prices

$C(\underline{w}, q, \underline{z})$ is a continuous function of $\underline{w}$, whenever $w_i > 0 \quad \forall i \in \{1,2,---,n\}$.

Shepherd's lemma

If the cost function is differentiable at $(\underline{w}, q, \underline{z})$ and $w_i > 0$ for all $i \in \{1,2,---,n\}$, then:

$$\frac{\partial C(\underline{w}, q, \underline{z})}{\partial w_i} = x_i(\underline{w}, q, \underline{z})$$

where $x_i(\underline{w}, q, \underline{z})$ is the output conditional demand for input factor i. By describing a link between the cost function and the output conditional input demand functions, Shepherds lemma allows the properties of cost functions to be used to infer the comparative static effects on input demand of changes in wages or output. In particular, the following results relating to output conditional factor demands follow directly from the cost function properties outlined above:

- $x_i(\underline{w},q,\underline{z}) = \dfrac{\partial C(\underline{w},q,\underline{z})}{\partial w_i} \geq 0$ since the cost function is non-decreasing in input prices.
- The factor demand equations, $x_i(\underline{w},q,\underline{z})$, are homogeneous of degree zero in input prices, as the cost function is homogeneous of degree one in input prices. (Refer to Varian 1992, p. 486 for a proof of this proposition.)
- The cross-price effects are symmetric and the own price effects are non-positive; that is:

  $$\frac{\partial^2 C(\underline{w},q,\underline{z})}{\partial w_j \partial w_i} = \frac{\partial x_i(\underline{w},q,\underline{z})}{\partial w_j} = \frac{\partial x_j(\underline{w},q,\underline{z})}{\partial w_i} = \frac{\partial^2 C(\underline{w},q,\underline{z})}{\partial w_i \partial w_j} \quad \forall i \neq j \text{ and}$$

  $\dfrac{\partial x_i(\underline{w},q,\underline{z})}{\partial w_i} = \dfrac{\partial^2 C(\underline{w},q,\underline{z})}{\partial w_i^2} \leq 0$. These results follow from the concavity of the cost function with respect to input prices.[1]

C.2 Flexible functional forms

While economic theory provides a set of properties about cost functions that rule out many potential functional forms, it provides no assistance in selecting one of the many forms that remain for use in an empirical investigation. Unfortunately, the results of an empirical study will not generally be robust to the choice of functional form. Indeed, since most of the commonly used statistical hypotheses tests are nested within the confines of the unrestricted model that is selected by the researcher, the choice of functional form limits the validity of any resulting inferences that arise from these tests. With this in mind, subject to degrees of freedom restrictions, it is advisable to choose a functional form that places as few prior restrictions on the technological structure of production as is possible.

There are two senses in which a functional form may be flexible. A particular functional form may be able to provide a second order differential approximation of any arbitrary function. Alternatively, it may provide a second order numerical (Taylor series) approximation of any arbitrary function. For more detail on the implications of flexible functional forms, refer to Chambers

1 The symmetry of the cross price terms also follows from a combination of Young's theorem and Shepherd's lemma when the cost function is twice continuously differentiable over the relevant range. For concavity to hold, the matrix of second derivatives of the cost function must be negative semi-definite. This in turn requires that the diagonal terms, that is, the own price effects, be non-positive.

(1988, pp. 158–202). The traditional functional forms for production technologies employed in economics, such as the Cobb-Douglas and Constant Elasticity of Substitution forms, are not flexible in either of these senses. They, at best, constitute only a first order approximation to an arbitrary technology.

Researchers are increasingly moving away from using the traditional, inflexible functional forms towards more flexible forms, such as the Translog, the Generalised McFadden, the Generalised Leontief, the Generalised Barnett and the Normalised Quadratic. While each of these forms may be flexible, they are not all equally suitable on all occasions. For example, if curvature conditions, consistent with the concavity property of cost functions discussed earlier, are imposed, the Translog and Generalised Leontief forms lose their flexibility. This has led a number of authors to advocate forms such as the Generalised McFadden and the Generalised Barnett (Diewert and Wales 1987). A further problem with the generalised quadratic forms, which include the Translog and the Generalised Leontief forms, is that they are very inflexible when it comes to representing separable production technologies (Chambers 1988, p. 174). However, taking these problems as given, the translog remains the most frequently used flexible functional form in empirical work (Greene 1993, p. 504).

Translog cost function

Suppose that the minimum cost function may be expressed in translog form as:

$$ln\,C(\underline{w},q,\underline{z}) = a_0 + \sum_{i=1}^{n} a_i\, ln\,w_i + a_q\, ln\,q + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}\, ln\,w_i\, ln\,w_j + \sum_{i=1}^{n} a_{iq}\, ln\,w_i\, ln\,q + \frac{1}{2} a_{qq} (ln\,q)^2 + \phi(\underline{w},q,\underline{z})$$

where

$$\phi(\underline{w},q,\underline{z}) = \sum_{j=1}^{m} \delta_j z_j^* + \sum_{j=1}^{m}\sum_{i=1}^{n} \lambda_{ij} \ln(w_i) z_j^* + \sum_{j=1}^{m} \xi_j \ln(q) z_j^* + \frac{1}{2}\sum_{j=1}^{m} \gamma_j (z_j^*)^2 \ ,$$

$\underline{w}$ is a vector of input prices, q is output and $\underline{z}^*$ is a vector of, possibly transformed, environmental variables.[2]

For this to satisfy the linear homogeneity property of cost functions, the following parameter restrictions must hold:

---

2 Depending on the nature of the underlying environmental variables, z_j, the z_j^* terms may either be the underlying variable itself, or the log of the underlying variable.

$$\sum_{i=1}^{n} a_i = 1$$

$$\sum_{j=1}^{n} a_{ij} = 0$$

$$\sum_{i=1}^{n} a_{iq} = 0$$

If the cost function is twice continuously differentiable, a combination of Young's theorem and Shepherd's lemma requires that the cross price effects in the set of input demand functions be symmetric. However, rather than apply Young's theorem to the actual cost function to obtain a set of restrictions, it can instead be applied to the translog approximation, so long as the translog approximation is twice continuously differentiable over the relevant range. This yields the following set of parameter restrictions:

$$\frac{\partial^2 \ln C(\underline{w},q,\underline{z})}{\partial \ln w_j \partial \ln w_i} = a_{ij} = a_{ji} = \frac{\partial^2 \ln C(\underline{w},q,\underline{z})}{\partial \ln w_i \partial \ln w_j} \quad \forall i \neq j.$$

According to the chain rule of differentiation:

$$\frac{\partial C}{\partial w_k} = \frac{\partial C}{\partial \ln C}\frac{\partial \ln C}{\partial \ln w_k}\frac{\partial \ln w_k}{\partial w_k} = \frac{C}{w_k}\frac{\partial \ln C}{\partial \ln w_k},$$

so that

$$\frac{\partial \ln C}{\partial \ln w_k} = \frac{w_k}{C}\frac{\partial C}{\partial w_k}.$$

Thus, upon applying Shepherds lemma and partially imposing the symmetry restrictions:[3]

$$s_k = \frac{w_k x_k}{C} = a_k + \sum_{i=1}^{n} a_{ki} \ln w_i + a_{kq} \ln q + \sum_{j=1}^{m} \lambda_{kj} z_j^* \quad for \quad k \in \{1,2,---,n\}.$$

This system of cost share equations forms the basis of the empirical analysis in this study. It was estimated subject to the linear homogeneity restrictions outlined above and the cross equation symmetry restrictions.[4]

3 The symmetry restrictions have two impacts in this model. These impacts can be characterised as within equation effects and cross equation effects. The partial imposition of symmetry at this point involves imposing symmetry within each equation only. No cross equation restrictions have been imposed.

Price and substitution elasticities

Suppose that a production technology can be represented by the cost function $C(\underline{w},q,\underline{z})$. Then the Hicks-Allen elasticities of factor substitution for this technology are given by $\sigma_{ij} = \frac{C * C_{ij}}{C_i * C_j}$, where $C_i = \frac{\partial C(\underline{w},q,\underline{z})}{\partial w_i}$ and $C_{ij} = \frac{\partial C_i}{\partial w_j} = \frac{\partial^2 C(\underline{w},q,\underline{z})}{\partial w_j \partial w_i}$. The own and cross price elasticities of output conditional input demand may be obtained from these Hicks-Allen factor substitution elasticities by the transformation $\varepsilon_{ij} = s_j \sigma_{ij}$, where $s_j = \frac{w_j x_j}{C}$ is the share of the jth input in total production costs (Berndt 1991, pp. 463–75; Greene 1993, p. 504).

Cross-price elasticities of demand

For the translog representation of the cost function outlined above:

$$C_i = \frac{\partial C}{\partial w_i} = \frac{\partial C}{\partial \ln C}\frac{\partial \ln C}{\partial \ln w_i}\frac{\partial \ln w_i}{\partial w_i} = \frac{\partial \ln w_i / \partial w_i}{\partial \ln C / \partial C}\frac{\partial \ln C}{\partial \ln w_i} = \frac{C * s_i}{w_i}, \text{ and}$$

$$\begin{aligned}
C_{ij} &= \frac{\partial C_i}{\partial w_j} \\
&= \frac{1}{w_i}\frac{\partial C s_i}{\partial w_j} \qquad (i \neq j) \\
&= \frac{1}{w_i}[\frac{\partial s_i}{\partial w_j}C + \frac{\partial C}{\partial w_j}s_i] \\
&= \frac{1}{w_i}[C\frac{\partial s_i}{\partial \ln w_j}\frac{\partial \ln w_j}{\partial w_j} + (\frac{C s_j}{w_j})s_i] \\
&= \frac{1}{w_i}[\frac{C a_{ij}}{w_j} + \frac{C s_i s_j}{w_j}]
\end{aligned}$$

---

4 As is explained later in this appendix, it is not possible to directly estimate the entire system of n cost share equations, as the covariance matrix is singular. Instead, one equation is dropped and the system consisting of the remaining $(n-1)$ cost share equations is estimated. As some of the restrictions detailed above are necessary to recover the parameter estimates in the dropped equation, only a subset of these restrictions are directly imposed at the estimation stage.

$$= \quad \frac{C}{w_i w_j}[a_{ij} + s_i s_j].$$

Thus the Hicks-Allen elasticities of factor substitution are:

$$\sigma_{ij} \quad = \quad \frac{C * C_{ij}}{C_i * C_j}$$

$$= \quad \frac{C[\frac{C}{w_i w_j}(a_{ij} + s_i s_j)]}{(\frac{Cs_i}{w_i})(\frac{Cs_j}{w_j})}$$

$$= \quad \frac{(\frac{C^2}{w_i w_j})[a_{ij} + s_i s_j]}{(\frac{C^2}{w_i w_j})s_i s_j}$$

$$= \quad \frac{a_{ij} + s_i s_j}{s_i s_j} \qquad (i \neq j).$$

Hence the cross price elasticities of output conditional input demands for a production technology represented by the translog cost function are:

$$\varepsilon_{ij} \quad = \quad s_j * \sigma_{ij}$$

$$= \quad \frac{s_j[a_{ij} + s_i s_j]}{s_i s_j}$$

$$= \quad \frac{a_{ij} + s_i s_j}{s_i} \qquad (i \neq j)$$

Own-price elasticities of demand

As before, for the translog cost function, $C_i = \frac{Cs_i}{w_i}$. However, the second derivative differs from the cross price case. Now:

$$C_{ii} \quad = \quad \frac{\partial C_i}{\partial w_i}$$

$$= \frac{\partial(\frac{Cs_i}{w_i})}{\partial w_i}$$

$$= \frac{1}{w_i^2}[\frac{\partial C}{\partial w_i}(s_i)w_i - 1Cs_i]$$

$$= \frac{1}{w_i^2}[w_i(\frac{\partial C}{\partial w_i}s_i + \frac{\partial s_i}{\partial w_i}C) - Cs_i]$$

$$= \frac{1}{w_i^2}[w_i(\frac{Cs_i}{w_i}s_i + C\frac{\partial s_i}{\partial \ln w_i}\frac{\partial \ln w_i}{\partial w_i}) - Cs_i]$$

$$= \frac{1}{w_i^2}[w_i(\frac{Cs_i^2}{w_i} + \frac{C}{w_i}a_{ii}) - Cs_i]$$

$$= \frac{1}{w_i^2}[\frac{w_i C}{w_i}(s_i^2 + a_{ii}) - Cs_i]$$

$$= \frac{1}{w_i^2}[C(s_i^2 + a_{ii}) - Cs_i]$$

$$= \frac{C}{w_i^2}(s_i^2 + a_{ii} - s_i)$$

$$= \frac{C}{w_i^2}[a_{ii} + s_i(s_i - 1)].$$

Thus:

$$\sigma_{ii} = \frac{C * C_{ii}}{C_i * C_i}$$

$$= \frac{C(\frac{C}{w_i^2})[a_{ii} + s_i(s_i - 1)]}{(\frac{Cs_i}{w_i})(\frac{Cs_i}{w_i})}$$

$$= \frac{(\frac{C}{w_i})^2[a_{ii} + s_i(s_i - 1)]}{(\frac{C}{w_i})^2 s_i^2}$$

$$= \frac{a_{ii} + s_i(s_i - 1)}{s_i^2}.$$

Hence the constant output own price elasticities of demand for a production technology that can be represented by a translog cost function are:

$$\begin{aligned}\varepsilon_{ii} &= s_i * \sigma_{ii} \\ &= \frac{s_i[a_{ii} + s_i(s_i - 1)]}{s_i^2} \\ &= \frac{a_{ii} + s_i(s_i - 1)}{s_i}.\end{aligned}$$

C.3 Weak separability and input aggregation

Often, disaggregated data will not be available on all inputs. The necessity of working with aggregated data has led researchers to examine the circumstances under which aggregation over a subset of inputs is justifiable. A potential justification was provided by Hicks' composite commodity theorem. This said that, if relative prices did not change within a subset of commodities in response to a policy alteration, they could be treated as a composite, or aggregate, commodity since there would be no substitution effects between these commodities.

Unfortunately, it is rarely the case that relative prices of the subset of inputs that make up a statistical aggregate such as labour will remain constant. Hence an alternative justification for such aggregation, focusing on the structure of the production technology rather than economic factors, was sought. A production technology that is weakly separable between subsets of inputs provides a justification for treating those subsets as a single aggregate input. This has the added advantage in relatively small data sets that it reduces the number of parameters that need to be directly estimated.

In terms of cost functions, a production technology with N labour inputs and a single capital input, in which labour and capital are weakly separable, may be represented as follows:

$$C(\underline{w}, r, q) = C(c^N(\underline{w}, q), r, q) = C(W, r, q)$$

where $W = c^N(\underline{w}, q)$ is a scalar. In essence, W may be interpreted as the minimum total cost of producing the labour aggregate and hence may be treated as its 'price'. Furthermore, if the production technology is weakly separable, the nested 'labour cost' function, $c^N(\underline{w}, q)$, will itself satisfy all of the standard cost function properties outlined above. On the other hand, if weak separability does not hold, $c^N(\underline{w}, q)$ will not in general satisfy all of the standard cost function properties. In particular, it should fail to satisfy the linear homogeneity property. However, if the aggregator function is twice continuously differentiable over the relevant range, the symmetry restrictions will still apply, as Young's theorem will apply regardless of whether or not weak separability is an appropriate assumption.

Clearly, a number of functional forms will be able to incorporate weak separability. As this study has used a translog representation of the cost function for both cross section data, in which no capital price was available, and time series data, in which a capital price was available, the implications of weak separability for this specific case will be outlined in more detail.

Consider the following translog cost function, which excludes environmental terms for simplicity:

$$\ln C(\underline{w},r,q) = \ln a_0 + \sum_{i=1}^{n} a_i \ln w_i + a_q \ln q + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij} \ln w_i \ln w_j + \sum_{i=1}^{n} a_{iq} \ln w_i \ln q$$
$$+ \frac{a_{qq}}{2}(\ln q)^2 + a_r \ln r + \frac{1}{2}\sum_{i=1}^{n}(a_{ir} + a_{ri})\ln r \ln w_i + \frac{a_{rr}}{2}(\ln r)^2 + a_{rq} \ln r \ln q$$

Note that the underlying cost function can be obtained from a translog representation by applying the exponential transformation to both sides of the translog equation. This yields:

$$C(\underline{w},r,q) = a_0 (\prod_{i=1}^{n} w_i^{a_i}) q^{a_q} (\prod_{j=1}^{n}\prod_{i=1}^{n} e^{\frac{a_{ij}}{2}\ln w_i \ln w_j})(\prod_{i=1}^{n} e^{a_{iq}\ln w_i \ln q}) e^{\frac{a_{qq}}{2}(\ln q)^2} r^{a_r}$$
$$*(\prod_{i=1}^{n} e^{\frac{(a_{ir}+a_{ri})}{2}\ln r \ln w_i}) e^{\frac{a_{rr}}{2}(\ln r)^2} e^{a_{rq}\ln r \ln q}$$

$$= a_0 (\prod_{i=1}^{n} w_i^{a_i}) q^{a_q} (\prod_{j=1}^{n}\prod_{i=1}^{n} w_i^{\frac{a_{ij}}{2}\ln w_j})(\prod_{i=1}^{n} w_i^{a_{iq}\ln q}) q^{\frac{a_{qq}}{2}\ln q} r^{a_r}$$
$$*(\prod_{i=1}^{n} w_i^{\frac{(a_{ir}+a_{ri})}{2}\ln r}) r^{\frac{a_{rr}}{2}\ln r} r^{a_{rq}\ln q}$$

$$= a_0 (\prod_{i=1}^{n} w_i^{a_i})(\prod_{j=1}^{n}\prod_{i=1}^{n} w_i^{\frac{a_{ij}}{2}\ln w_j})(\prod_{i=1}^{n} w_i^{a_{iq}\ln q})(\prod_{i=1}^{n} w_i^{\frac{(a_{ir}+a_{ri})}{2}\ln r})$$
$$*r^{a_r + \frac{a_{rr}}{2}\ln r + a_{rq}\ln q} q^{a_q + \frac{a_{qq}}{2}\ln q}$$

$$= \quad C(c^N(\underline{w},q),\underline{w},r,q)$$

Unfortunately, because the (w_i, r) interaction interaction terms take an exponential form, it is not possible to separate these terms. Thus, if the translog cost function is to be weakly separable, the coefficients on the $(\ln r * \ln w_i)$ terms must be zero.

This insight can form the basis of a statistical hypotheses test of the validity of the weak separability assumption. Specifically, to test the hypotheses of weak separability, estimate the model with and without the $(\ln r * \ln w_i)$ terms, noting the log-likelihood value in each case. Using these log-likelihood values, construct a standard likelihood ratio test of the weak separability hypotheses.

Note that imposing weak separability on the translog functional form limits flexibility by disallowing interaction between the individual prices of labour and the price of capital. This underscores the point that the generalised quadratic class of functional forms, which includes the translog and generalised Leontief forms, are 'very inflexible in representing separable technologies' (Chambers 1988, p. 174).[5]

C.4 A system of regression equations

The demand for youth employment was estimated as part of a system of demand equations in this paper. Given that analysing the determinants of youth employment was the focus of the paper, it is relevant to ask why the youth labour demand equation was not estimated as a single equation regression. Certainly, least squares or maximum likelihood estimates would yield unbiased parameter estimates in a single equation regression. However, the model from which the demand for youth was derived in this study generates a system of demand equations, one equation for each factor. Given that the demand equations are derived from the same problem, one would expect the disturbances on each of the factor demand equations to be correlated. Under these circumstances, estimation of the entire system will improve the efficiency of the parameter estimates (Judge et al 1982, pp. 315–25). Furthermore, as discussed above, the underlying model gives rise to cross equation parameter restrictions which cannot be imposed on a single equation regression.

5 For a more detailed, technical discussion of weak separability, in the context of short-run variable cost functions and short-run variable profit functions, in which a quantity of capital variable rather than a price of capital variable enters the functions (as the capital stock is fixed in the short run), refer to Woodland (1978) and Diewert and Wales (1995).

Singular covariance matrix

Economic theory and the assumption of a translog cost function has provided the following system of seemingly unrelated regression equations (SURE) that, along with the symmetry and homogeneity restrictions, can form the basis of an estimable model:

$$S_k = \frac{w_k x_k}{C} = a_k + \sum_{i=1}^{n} a_{ki} \ln w_i + a_{kq} \ln q + \sum_{j=1}^{m} \lambda_{kj} z_j^* + \varepsilon_k \quad for \quad k \in \{1,2,---,n\}.$$

However, in this form, the model is not yet operational. The dependent variables in this model are cost shares (S_k). Hence they are linearly dependent, because they must sum to one — that is, only $(n-1)$ of the n cost share equations, where the disturbance terms are included, are linearly independent.[6] An implication of this is that for each observation, the sum of the disturbance terms will be zero, so that both the matrix of residual cross products and the covariance matrix for this system of equations will be singular (Berndt 1991, pp. 471–2). This poses problems for maximum likelihood estimation.

The solution to the singularity of the covariance matrix problem is to drop one of the cost share equations. Assuming that the covariance matrix for the full system of equations had a rank of $(n-1)$, the covariance matrix for the sub-system of $(n-1)$ cost share equations will be non-singular. Of course, this raises the question of which equation should be dropped. It turns out that in the standard SURE models, where the vector of error terms follows a multivariate normal distribution, if maximum likelihood estimation is employed, the parameter estimates will be invariant to the choice of equation that is dropped (Barten 1969, Greene 1993, Berndt 1991). It is worth noting that not all of the parameters in the dropped equation are lost forever. Given estimates of the parameters in the remaining sub-system of $(n-1)$ equations, the homogeneity and symmetry restrictions can be used to recover estimates of at least some of the parameters in the dropped equation. Details of how this is accomplished for the translog cost function case are described below.

Imposing homogeneity prior to estimation

It is often simpler to impose conditions directly, rather than estimate subject to parameter restraints. While this cannot be done for the cross equation symmetry restrictions in the demand system, it can be done for the within equation homogeneity restrictions. Specifically, these restrictions can be used

6 More accurately, at most $(n-1)$ of the n share equations are linearly independent. In the event that any individual factor's cost share systematically takes a zero value, even fewer equations will be linearly independent.

to transform each of the cost share equations from being functions of n individual price variables to being functions of $(n-1)$ relative price variables. A natural choice for the numeraire price in this set up is the price of the input whose share equation has been dropped. Suppose that this is input n. Then for each of the remaining cost share equations, the within equation homogeneity restrictions imply that $a_{kn} = -(\sum_{i=1}^{n-1} a_{ki})$. Thus each of the demand equations can be written as:

$$
\begin{aligned}
s_k &= a_k + \sum_{i=1}^{n} a_{ki} \ln w_i + a_{kq} \ln q + \sum_{j=1}^{m} \lambda_{kj} z_j^* + \varepsilon_k \\
&= a_k + \sum_{i=1}^{n-1} a_{ki} \ln w_i + a_{kn} \ln w_n + a_{kq} \ln q + \sum_{j=1}^{m} \lambda_{kj} z_j^* + \varepsilon_k \\
&= a_k + \sum_{i=1}^{n-1} a_{ki} \ln w_i - (\sum_{i=1}^{n-1} a_{ki}) \ln w_n + a_{kq} \ln q + \sum_{j=1}^{m} \lambda_{kj} z_j^* + \varepsilon_k \\
&= a_k + \sum_{i=1}^{n-1} a_{ki} \ln w_i - (\sum_{i=1}^{n-1} a_{ki} \ln w_n) + a_{kq} \ln q + \sum_{j=1}^{m} \lambda_{kj} z_j^* + \varepsilon_k \\
&= a_k + \sum_{i=1}^{n-1} a_{ki} (\ln w_i - \ln w_n) + a_{kq} \ln q + \sum_{j=1}^{m} \lambda_{kj} z_j^* + \varepsilon_k \\
&= a_k + \sum_{i=1}^{n-1} a_{ki} \ln(\frac{w_i}{w_n}) + a_{kq} \ln q + \sum_{j=1}^{m} \lambda_{kj} z_j^* + \varepsilon_k .
\end{aligned}
$$

Note that the coefficients on the relative price terms are identical to the coefficients on the individual prices in the numerator of the relative price terms from the original specification. The remaining homogeneity restrictions, along with the cross equation symmetry restrictions relating to the price of the nth input, will be used to recover some of the coefficient estimates for the dropped equation. Hence, in estimating the subsystem of $(n-1)$ cost share equations, the procedure is to use the relative price specification above, employ maximum likelihood estimation to ensure invariance and estimate subject to the cross equation symmetry restrictions that relate to the $(n-1)$ equations in the directly estimated sub-system.

Recovery of lost parameters

Thus, the process of obtaining an estimable sub-system of demand equations involves:

- deriving the complete demand system;

- imposing within equation symmetry conditions;
- dropping an equation; and
- reparameterising the remaining equations to impose within equation homogeneity conditions.

In the process, a number of parameters have been lost — the estimated system will not generate direct estimates of these parameters. In some cases, this is of little or no consequence. For example, the constant term in the translog cost function is of no interest in this study. Similarly, given that the underlying economic theory requires symmetric cross price effects, it is of little consequence that this has been imposed within equations — the missing effect equals the estimated one.

However, a number of the missing parameters are of interest. These include the missing price parameters in the estimated equations and the parameters of the dropped equation. The procedures for recovering these are outlined below.

First, consider the price coefficients in the estimated equation. The estimated coefficients on the relative price terms, $\ln(\frac{w_i}{w_n}),\ \ for\ \ i \neq n,$ are available, but what is required is the coefficient estimates on the individual price terms, $\ln w_i$, for all i. As was shown when deriving the estimable equations, however, the coefficient on the i th relative price term is identical to the coefficient on the i th individual price term. Thus, estimates for $(n-1)$ of the individual price terms in each equation can easily be recovered. Furthermore, these estimates can then be used with the within equation homogeneity restrictions to recover estimates of the coefficients on the $\ln w_n$ terms. Specifically, $\hat{a}_{kn} = -(\sum_{i=1}^{n-1} \hat{a}_{ki})$.

Now consider the coefficients on the variables in the dropped equation (the cost share of the n th input). There are three types of coefficients that may need to be recovered — those for the constant (intercept) term, the price terms and the output term.

One of the cross equation homogeneity restrictions related to the constant terms in the factor cost share equations. Using this restriction, along with the estimates of the constant coefficients from the other $(n-1)$ equations, an estimate of the constant term in the dropped equation is given by $\hat{a}_n = 1-(\sum_{i=1}^{n-1} \hat{a}_i)$.

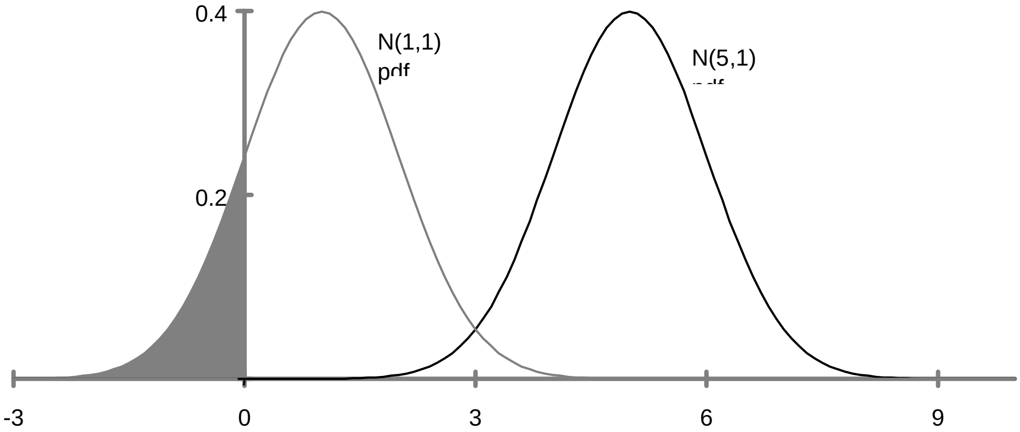
The other cross equation homogeneity restriction relates to the output coefficients. In a similar fashion, this restriction can be combined with the estimates of the output coefficients from the $(n-1)$ estimated equations to recover an estimate of the output coefficient in the dropped equation. Specifically, $\hat{a}_{nq} = -(\sum_{i=1}^{n-1} \hat{a}_{iq})$.

The only coefficient estimates that have yet to be recovered are those for the price terms in the dropped equation. All of the cross price terms can be directly recovered from the cross equation symmetry restrictions — that is, $\hat{a}_{ni} = \hat{a}_{in}$ for all $i \neq n$. Finally, an estimate of the own-price coefficient in the dropped equation can be recovered by using the within equation homogeneity restriction and the recovered estimates of the other price coefficients for that equation. This resulting estimate of the own price coefficient for the dropped equation is $\hat{a}_{nn} = -(\sum_{i=1}^{n} \hat{a}_{ni})$.

C.5 Censored regression techniques

The statistical procedures employed in this study varied with the nature of the data. While in the alternative time series study described briefly in Chapter 4, the data were judged to be sufficiently aggregated to allow the use of a standard seemingly unrelated regression equations model, this was not the case for the cross section study, which used unit record data. The complete data set contained a relatively large proportion of zero observations, at least for youth employment, and no negative observations for the dependent variables. As such, the mean of the dependent variable was closer to zero than is normally the case with more aggregated data. In this situation, the problem for the common models of demand systems (such as SURE techniques) that censored data poses is more severe. The reason for this is that a greater portion of the distribution is being censored (as indicated by the shaded area in Figure C.1).

Figure C.1: The potential significance of censored data[a]



For this reason, censored regression techniques were necessary. If censored regression techniques had not been used, the predicted cost shares for each of the $(n-1)$ inputs directly estimated would certainly have been biased downwards and some may even have become negative. For example, if the conditional distribution of the cost shares, given the values taken by the explanatory variables, was modelled as being multivariate normal, then there is a non-zero probability that a negative cost share would have been predicted.

While techniques for estimating single equation censored regression models, such as tobit models, have been available in a number of popular statistics and econometrics software packages for quite some time, estimation of multi-equation censored regression models has required researchers to either write their own code or to employ some ingenious techniques to obtain the desired results (Amemiya 1974, Wales and Woodland 1983). Fortunately, a popular microeconometric software package, Limdep, recently incorporated a component which allows for the maximum likelihood estimation of a system of two tobit equations (BTOBIT) (Greene 1998). The model specification for BTOBIT employs the usual tobit specification for each equation in the two equation system being estimated.

Thus the model in which the adult male labour cost share equation has been dropped is specified in the form:

$$s_k \quad = \quad Max(s_k^*, 0), \quad k \in \{adult\ female, youth\}$$

where

$$s_k^* \quad = \quad a_k + a_{ky} \ln(\frac{w_y}{w_{am}}) + a_{kaf} \ln(\frac{w_{af}}{w_{am}}) + a_{qk} \ln q + \sum_{j=1}^{m} \lambda_{kj} z_j^* + \varepsilon_k$$

and

$$(\varepsilon_{af}, \varepsilon_y) \quad \sim \quad N_2(0,0,\sigma_{af}^2, \sigma_y^2, \rho).$$

Unfortunately, in analysing the cross section data, the coefficient estimates were not always invariant to the choice of dropped equation. For example, the invariance property did not hold when the full sample of observations from the AWIRS 95 database was used. However, this full sample contained a large number of zero cost shares. As the number of zero observations was reduced, the coefficient estimates from the two systems — (youth, adult female) and (youth, adult male) — approached each other. This suggested that invariance may break down in a system of censored regressions when significant weight is placed on the limit observations.

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