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Quality-adjusted Labour Inputs

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Quality-adjusted Labour Inputs

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Analytical Services Branch

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1. INTRODUCTION

Since the late 1990s, the Australian Bureau of Statistics (ABS) has undertaken a series of projects to improve its estimates of labour and multifactor productivity and to develop an accounting system that reflects the accumulation of and changes in human capital. As part of this work, this paper reports improved labour inputs and labour productivity estimates by reflecting changes in the skill level of the workforce.

Productivity is recognised as an important factor that affects long term economic growth and welfare. As a result, it is of interest to policy makers, businesses, academics and the community in general.

Productivity is most simply defined as the ratio of output to one or more inputs. Thus, productivity increases if output grows faster than inputs. Productivity growth represents an increase in output not attributable to an increase in inputs.

Economic growth can be achieved through increases in the quantity of inputs. However, increases in labour, capital and material inputs impose opportunity costs on society such as less leisure time, lower current consumption (through investment) and lower reserves of natural resources. A better way to increase output is to improve the effectiveness in the use of inputs such as labour, capital or intermediate inputs.

The current ABS measure of labour inputs is based on the assumption of homogeneous labour. That is, for example, an hour's work from a brain surgeon is treated as equal to an hour's work from a cleaner. Total labour inputs are a simple sum of all hours worked. However, the effective quantity of labour input depends not only on the hours worked but also on the characteristics of those performing the work. This study recognises the fact that workers are heterogeneous. Accordingly, workers with differing traits are treated as separate and distinct inputs in the measurement of labour inputs. We focus on two important measures of labour quality (or skill) [1]: education and work experience (Jorgenson, Gollop and Fraumeni, 1987). [2]

We use human capital theory to quantify the contribution of different skills in the labour force to total labour inputs. A modified version of the labour composition model, developed by the U.S. Bureau of Labour Statistics (BLS, 1993), is used to

1 In what follows, 'quality of labour' and 'skills' are used interchangeably.

2 Other labour characteristics may also include class of work, occupation and sex.

compile new aggregate labour input and labour productivity measures that reflect the changes in the distribution (or composition) of skills in the labour force. The experimental measures cover the period from 1982 to 1999.

Note that the analysis reported in this paper was completed in 2001. The focus of this paper is on the methodology developed by the ABS and subsequently employed in the production of official statistics on labour inputs and productivity (i.e. the series based on quality-adjusted hours). The statistical results shown in the graphs and tables in this paper are derived from data available at the time of the initial study. They may differ slightly from more recent estimates published by the ABS, due to subsequent revisions and the incorporation of more up-to-date information. For official purposes, it is recommended that readers use the latest official estimates, published in the *Australian System of National Accounts* (ABS cat. no. 5204.0).

Since the completion of this study, the ABS has moved on to measure the stock of human capital and to construct an accumulation account for human capital. Some early results are reported in Wei (2004).[3]

The structure of this paper is as follows. Section 2 discusses the background of the paper including the scope of the study, human capital theory and its relationship to the labour inputs used in the production process. Section 3 describes the methodology used in this paper. A brief description of data sources is provided in Section 4 as well as an overview of important data items used and their construction. Estimates of quality-adjusted labour inputs and productivity are provided in Sections 5 and 6. Section 7 draws conclusions from the paper.

3 Readers who are interested in the estimation of human capital stock and accumulation accounts may contact Hui Wei through email (hui.wei@abs.gov.au) or telephone (02) 6252 5754.

2. BACKGROUND

This section begins with an outline of the scope of the paper and a description of the current ABS approach to calculating labour inputs and productivity. A discussion of human capital theory and its relationship to labour inputs follows.

2.1 Scope of the study

In the Australian National Accounts labour productivity is currently estimated by dividing total hours worked (labour input) into output. [4] Estimates are calculated for the market sector only. The industries covered by the market and non-market sectors are listed in the following table.

2.1 Market and non-market sectors of the Australian economy

Market sector	*Non-market sector*
• Agriculture	• Property and Business Services
• Mining	• Government Administration and Defence
• Manufacturing	• Education
• Electricity, Gas and Water	• Health and Community Services
• Construction	• Personal and Other Services
• Wholesale Trade	
• Retail Trade	
• Accommodation, Cafes and Restaurants	
• Transport and Storage	
• Communications	
• Finance and Insurance	
• Cultural and Recreational Services	

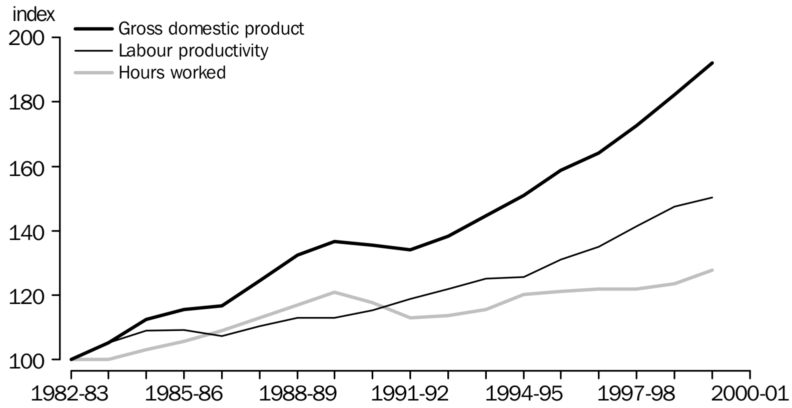
2.2 Current ABS practice

The ABS measure of labour input treats workers as homogenous units. Thus, an hour worked by the most unproductive worker is given the same weight as an hour worked by the most productive worker.

Figure 2.2 below displays the current ABS indexes of gross domestic product, labour input and labour productivity for the market sector. Between 1982–83 and 1999–2000, gross domestic product increased by 88%. Over the same period, labour input, as measured by hours worked, increased by 28%. Labour productivity increased by 47%.

4 The Australian National Accounts also include multifactor productivity measures. As far as labour inputs are concerned, both labour productivity and multifactor productivity measures have used exactly the same estimation method. In this study, we focus only on labour productivity for the purpose of demonstration.

2.2 Output, labour input and labour productivity – Market sector



Source: Australian System of National Accounts (ABS cat.no. 5204.0)

2.3 Human capital theory and labour inputs

In this paper, the human capital model is used to provide a theoretical foundation for measuring labour inputs. Human capital is a productive resource in which investments can be made. It comprises the skills and knowledge which enable a worker to contribute to a firm's output and to earn a wage. Education and training that improve the worker's skill, and hence productivity, are considered investments in human capital.

In a world of perfect competition, the forces of demand and supply ensure that market equilibrium prevails in the long run. At this point, firms have adjusted their output level such that the cost of producing one extra unit of output equals the price of that output. This implies that firms combine all inputs into the production process efficiently. This efficiency condition is satisfied if the change in output from hiring an extra person (marginal product of labour) multiplied by the price of output (value of the marginal product of labour) equals the price of labour (wage).

The human capital model suggests that differences between workers' productivity can be attributed to differences in skill levels. At the equilibrium, the worker with the higher productivity will receive higher compensation. Schooling and post-school training are a means of acquiring additional skills. These skill acquisitions are considered investments in human capital.[5] Individuals decide on the level of investment based on their expected lifetime earnings from the investment.[6]

As post-school training is difficult to measure, the literature suggests using years of work experience as a proxy measure. This relationship is depicted in figure 2.3, the 'age–earnings' profile.

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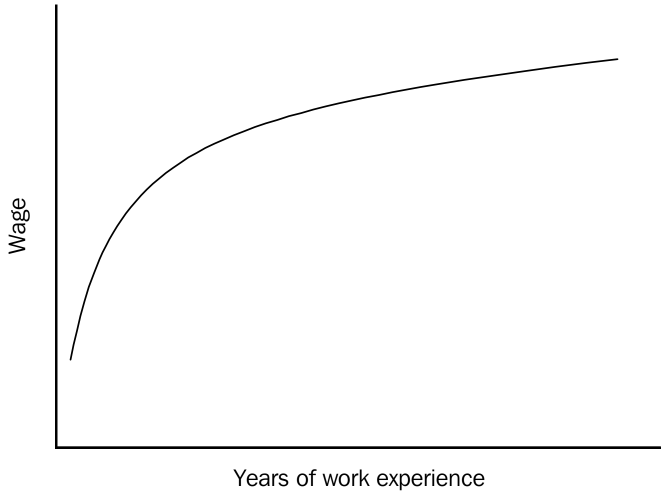
5 In this paper, schooling refers to basic schooling and tertiary institution studies.

6 Other reasons for investing in human capital include the expected non-pecuniary benefits, the ability to absorb information etc.. Those that can more readily absorb information are more likely to invest in education.

2.3 Age–Earnings Profile



According to human capital theory there is a positive relationship between wage levels and years of work experience. There is empirical evidence to suggest that this curve is concave from below, suggesting diminishing returns to work experience. The concavity of this function is determined by the worker calculating the costs and benefits of further investments in human capital. For example, a worker nearing retirement may decide to reduce investments because the marginal benefits of further education are beginning to be outweighed by the marginal costs.[7]

There are a number of theories competing with the human capital model to explain the relationship between wage rates and level of education. The Screening Model and the Multiperiod Implicit Contract Model (MICM) are two examples. In this section, we only give a brief discussion of the alternative models and their implications for our estimates of wage rates.

According to the Screening Model, productivity is determined by innate ability instead of education. Firms do not have perfect information about workers' abilities. Employers use the level of education as an easy way of screening the most able people into the more difficult and better paid jobs. This suggests that ability, rather than education or training, is the main determinant of wages. For the human capital model, it implies that returns to education should be reinterpreted as returns to ability.

MICM suggests that the 'age–earning' profile is not an accurate representation of the relationship between wages and productivity (or skills). Rather it partly reflects a deferred payment implicitly contained in the contract between the employer and the employee. The two parties negotiate a contract whereby the employee agrees to take a wage lower than their value of marginal product early in their career in order to

7 Other factors influencing the shape of the age earnings profile include depreciation or obsolescence of the original investments and changing utilities (i.e. preference for leisure hours over work hours).

receive a wage greater than their value of marginal product later. This hypothesis implies that the human capital model may overstate the returns to investment in post-school training.

Despite these competing models, the human capital model has been widely adopted for estimating labour inputs (BLS, 1993) and has been supported by empirical evidence in the literature. Therefore, human capital theory provides the basis for the analysis in this paper.

3. METHODOLOGY

The adjustment of labour inputs for changes in quality is conducted using the 'labour composition model' which is based on the human capital model. The model can be derived from a production function more general than the one currently used by the ABS in its measurement of productivity. Specifically, the adjustment involves two steps. A wage rate is derived to measure the average impact of skills on the wage level of workers in a particular 'educational attainment and experience' group. The wage rates derived from the first step are then used as weights to compile a new labour input index. The labour composition model also provides a growth accounting framework to measure the impact of changes in labour quality on aggregate labour inputs.

The 'labour composition model' and growth accounting framework are described in Sections 3.1 and 3.2. A brief description of the wage equation used in this paper is then provided in Section 3.3.

3.1 Labour Composition Model

The 'labour composition model' is based on a general production function.[8] In this section we present only a brief description of the model. Additional details are provided in Appendix A.

The production process can be described by a production function. In the current Australian National Accounts, the production function takes the form:

$$q = f\left(k_1,\ldots,k_n,H,t\right) \tag{1}$$

where output q is produced by n types of capital input k and a single type of labour input H. t represents the state of technology. In this production function, labour inputs are assumed to be homogeneous.

A more general production function that allows for treatment of labour inputs with different characteristics and their unique contribution to the output can be represented by:

$$q = g\left(k_1,\ldots,k_n,h_1,\ldots,h_m,t\right) \tag{2}$$

where h_1 , … , h_m represent distinct labour inputs.

8 Labour composition models have been described elsewhere in detail, such as the Bureau of Labour Statistics (BLS, 1993) and Aspden (1990). This presentation mainly follows that of BLS with minor modifications.

Under certain technical and market equilibrium conditions [9], the growth rate of productivity can be expressed as:

$$\frac{\dot{A}}{A} = \frac{\dot{q}}{q} - \sum_{i=1}^{n} s_{ki} \frac{\dot{k}_i}{k_i} - \sum_{j=1}^{m} s_{hj} \frac{\dot{h}_j}{h_j} \tag{3}$$

where s_{ki} denotes the value share of the *i*th capital input and s_{hj} denotes the value share of the *j*th labour input in the total costs.

$\dot{A}/A$, $\dot{q}/q$, $\dot{k}_i/k_i$ and $\dot{h}_j/h_j$ are growth rates of productivity, output, the *i*th capital input and the *j*th labour input respectively. [10]

In this paper we focus on the construction of an aggregate labour input series. The growth rates of aggregate labour inputs is represented by the following equation:

$$\frac{\dot{L}}{L} = \sum_{j=1}^{m} s_{hj} \frac{\dot{h}_j}{h_j} \tag{4}$$

In the calculation, continuous changes (i.e. $\dot{L}/L$ and $\dot{h}_j/h_j$ in Equation 4) have to be replaced by discrete data and indexation techniques can be applied to compile aggregate labour inputs.

Specifically, we choose the chained Tornqvist index formula to aggregate labour inputs. Other index number formulas such as fixed-weight Laspeyres and Paasche index formulas could also be used. The Tornqvist formula was chosen for the following reasons. First, it is consistent with the method used in the current Australian National Accounts where a chained Tornqvist formula is used to compile the measures of labour and multifactor productivity. Second, a fixed weighted index can result in an index number bias, especially during periods where prices or quantities experience rapid changes. Third, the Tornqvist index formula is consistent with the Translog production function. Translog functions are known to be flexible and impose fewer restrictions than many other forms such as the Cobb–Douglas and CES functions (Christensen, Jorgenson and Lau, 1973). Diewert (1976) showed that changes in output modelled by a translog production function can be “exactly” represented by Tornqvist indexes.

In our case, the Tornqvist index of labour inputs can be calculated based on the difference of labour inputs (expressed in natural logarithms) of successive periods, which are weighted by the average shares of labour compensation of the two periods:

$$\Delta \ln L = \sum_{j} \frac{1}{2} \Big(s_{lj}(t) + s_{lj}(t-1) \Big) \, \Delta \ln h_j \tag{5}$$

---

9 Interested readers may refer to Appendix A for details of the conditions.

10 $\dot{A}/A = \frac{\partial g}{\partial t} \times \frac{1}{g}$

where $\Delta \ln L$ represents the first order difference of logarithms of aggregate labour input, $\Delta \ln h_j$ is the first order difference of logarithms of the ith type of labour input, s_{lj}(t) and s_{lj}(t–1) are value shares of the jth labour inputs in the total labour costs in periods t and t–1 respectively.

If we apply (2) the Tornqvist index to multifactor productivity, Equation (3) becomes: [11]

$$\Delta \ln A = \Delta \ln Q - \frac{1}{2}\left(s_k(t) + s_k(t-1) \right) \Delta \ln K - \frac{1}{2}\left(s_l(t) + s_l(t-1) \right) \Delta \ln L \qquad (6)$$

where $\Delta \ln K$ is the difference of logarithms of aggregate capital.

3.2 Accounting for labour composition

Changes in the index of labour composition (LC) are defined as the difference between the change in the indexes of the new aggregate labour input and the sum of hours worked. This is expressed in equation (7).

$$\Delta \ln LC = \Delta \ln L - \Delta \ln H = \Delta \ln \frac{L}{H} \qquad (7)$$

where L is new measure of aggregate labour inputs which account for changes in quality. The variable H represents the simple summation of hours worked.

In the current National Accounts, multifactor productivity is measured by:

$$\Delta \ln B = \Delta \ln Q - \frac{1}{2}\left(s_k(t) + s_k(t-1) \right) \Delta \ln K - \frac{1}{2}\left(s_l(t) + s_l(t-1) \right) \Delta \ln H \qquad (8)$$

Substituting Equations (7) and (8) into Equation (6), we arrive at Equation (9):

$$\Delta \ln A = \Delta \ln B - \frac{1}{2}\left(s_l(t) + s_l(t-1) \right) \Delta \ln LC \qquad (9)$$

Equation (9) provides a straightforward interpretation of the new multifactor productivity. The changes in this new multifactor productivity measure can be decomposed into two components. The first component reflects changes in productivity resulting from changes in the *quantity* of labour inputs, and the second component reflects changes in the *quality* of labour caused by variation of its composition. From Equation (9) it is straightforward to infer the impact of quality on productivity. When the quality of labour improves ($\Delta \ln LC > 0$), it has an effect of reducing productivity with other factors held constant. A deterioration of labour quality ($\Delta \ln LC < 0$) has an effect of increasing productivity with other factors held constant.

11 In this section, we use Equation (3) for the growth of multifactor productivity. This was recommended for the Australian National Accounts in its calculation of multifactor productivity.

3.3 Estimation of average wage and wage model [12]

The calculation of aggregate labour inputs based on Tornqvist index formulae (in Equation (5)) depends upon the availability of data on the share of labour compensation for each type of worker (s_{lj}). This section describes the method used to estimate these shares.

Two techniques have been used to derive the weights for workers with different educational attainment and levels of work experience. The first method uses the average wage of each type of worker from the sample, after the data is appropriately cross-classified. This method is straightforward and easily calculated.

Alternatively, we can use econometric techniques to fit an earnings function or wage model, to derive a wage rate for each type of worker. The benefit of this method is that we can control for other factors, such as age, sex, and numbers of dependent children.

This section is mainly focused on the modelling of an earnings function based on human capital theory. According to human capital theory, skills are the most important sources of workers' productivity and they may be acquired through formal education and post-school training.

Economic theory suggests that, at the long-term competitive equilibrium, employers hire workers to the level where workers are paid at their marginal product. This market equilibrium condition and the human capital hypothesis establishes the relationship between workers' earnings (or wage), education attained and the level of training received by the workers. Although extensive research has been reported in the literature on other aspects of wage determination, the relationship between earnings and school education and post-school training has remained the core of all human capital models. [13]

In the literature, researchers have used work experience as a proxy measure for workers' training, because data on this form of training are scarce and often unavailable. In this paper, we also use the concept of work experience instead of training due to the lack of data. At competitive equilibrium, wages can be described as a function of education, work experience and other traits of workers. We use the functional form of the wage model which was applied by the BLS (1993) to U.S. data:

$$\ln\left(W_{ij}\right) = a + bS_i + cX_j - dX_j^2 + fZ \qquad (10)$$

12 The ABS distinguishes between the concepts of 'earning' and 'wage' for wage and salary earners in that earnings include wages as well as non-wage supplements such as severance, termination fee and compensations. In this paper, however, we use the words of 'earning' and 'wage' interchangeably, when referring to the wage rate.

13 Other factors that may determine wage at individual level include industry, occupation, sex, ethnic background, unionisation and innate ability.

The log of the wage (W_{ij}) is a function of *i* years of schooling (*S*), or the *i*th level of educational attainment, *j* years of working experience (*X*) and other traits (*Z*). The second order term in Equation (10) reflects diminishing returns to work experience in the earnings profile as discussed in Section 2.3.

In Equation (10), the intercept (*a*) can be interpreted as the starting wage. The remaining coefficients (*b*, *c* and *d*) represent returns to education and work experience in the human capital theory. [14]

Equation (10) includes a vector of other traits *Z* which represents a number of factors that may make a difference in the wage level. In this study, we include a variable to reflect wage differences arising from part-time and full-time arrangements, along with a variable which reflects the regional location of the worker (because of a belief that urban and rural labour markets are different and workers in urban areas may have a higher average wage than workers outside the major cities). Potential wage differences between male and female were also considered and subsequently estimated separately (using equation (10)).

We do not use industry or occupation as explanatory variables. Wage differences between industries can reflect allocative inefficiency rather than differences in marginal products. According to BLS (1993), this source of inefficiency remains in the current measure of multifactor productivity. Occupational differences in wages are believed to be highly correlated with education (BLS, 1993), because education is often a prerequisite for the entrance into certain occupations. Thus, education has a direct return through higher wages within an occupation and an indirect return through the ability of more educated workers to move between occupations. By treating occupation as a separate variable, our calculated returns to education might reflect only the 'direct' returns to education, and hence underestimate the total impact of education on wages.

Other variables that have been subject to scrutiny in the human capital literature include innate ability, unionisation, job tenure, availability of non-wage compensation and ethnicity. All these variables may potentially affect workers' wages. Other studies, such as the BLS (1993), investigated the effects that some of these other variables have on the wage level.

First, BLS (1993) investigations on job tenure found that the estimated wage equation could be improved if job tenure was included in the model. They referred to job tenure as firm-specific training where the costs of the training are shared between the

14 The coefficients may be interpreted differently under different models. For example, the coefficient (*b*) should be interpreted as returns to 'ability' under the 'screening' (Spence, 1974) model because education, according to this model, is correlated with ability and employers pay for workers' ability to perform a job. Under the multiperiod implicit contract model (Lazear, 1979 and 1981 and Medoff and Abraham, 1980), coefficients (*c* and *d*) may overestimate the returns to experience and it partly reflects a kind of implicit contract between employers and workers as explained in Section 3.

employer and the worker. An employer laying off a worker would suffer a capital loss to the firm in relation to its share of the cost of training. Alternatively, a worker quitting would create a capital loss to the worker for his or her share of the cost of training. The BLS expected there to be a different relationship between job tenure and earnings than total experience and earnings. This is because total experience includes general training where the costs are generally borne entirely by the worker. Although the BLS found that job tenure could improve the model, we did not include it as there is no consistent set of data available for Australia.

Second, greater innate ability allows an individual to gain more education and a higher return from that education. This correlation between ability and education means that omitting 'ability' from the model could lead to overestimation of the education and experience coefficients. However, investigations carried out by the BLS indicated that higher earnings paid to employees with more schooling partly reflects payments for ability. The main reason we have not examined innate ability for this paper is a lack of data.

Third, the BLS found that the omission of the unionisation variable had a small effect on the return to education and experience for most workers, however the results were not consistent when tested on a range of cohorts. It is thought that unions could cause workers' marginal products to diverge from earnings if they, or the firms, exercised market power. They could also distort the earnings–experience profile or affect the returns to schooling. Given that the BLS found unionisation to have only a minimal effect, and there is a lack of relevant data, we have not included the variable in our examination of the wage model.

Last, the BLS investigated the effect of omitting non-wage compensation. The dependent variable should conceptually include all forms of labour compensation. However the BLS found that omitting this component would not significantly change the labour input measures. Once again, a lack of data has prompted us to exclude non-wage compensation from the wage model. This is discussed further in Section 4 under construction of the hourly-wage variable.

4. AN OVERVIEW OF IMPORTANT VARIABLES

This section provides information about data sources. Specifically, we describe how the data have been adjusted for the purpose of this study and summarise the resulting data items.

4.1 Data sources

The data which provide the basis for this investigation were sourced from the Income and Distribution Survey (IDS), the Survey of Income and Housing Costs (SIHC), the Labour Force Survey (LFS) and the Australian National Accounts.

The SIHC [15] was run by the ABS between 1994 and 2003 [16] and data were collected in conjunction with the Monthly Population Survey of which the LFS is the main component. The survey is conducted on a monthly basis with annual data obtained by aggregating monthly data.

The SIHC replaced the IDS which was run every three to four years prior to 1994–95. Although the first IDS was conducted in 1969, the only readily available IDS data are for the years after 1982–83. As the data were not collected annually before 1994–95, we have had to interpolate the gaps between the survey years to construct a time series of our new labour inputs measure. Interpolation issues will be discussed in detail in Section 6. At June 2003, the survey data were available only up to 1999–2000. Throughout the paper reference to the IDS is used synonymously for IDS and SIHC.

In this study, we use IDS data to construct estimates of hours worked, wages, potential experience and educational attainment and other model variables.

4.2 Hourly wages

Following BLS experience (BLS, 1993), hourly wages are used as the dependent variable in the wage equation. The IDS unit record data used in this paper are limited to those people aged 15 to 65, who are active in the labour market and are wage and/or salary earners. Thus, self-employed people are excluded. Also excluded from the investigation are people who earn less than $1 per hour, and those who have never received any formal schooling (we assume these people are not reporting properly).

The hourly wage rate refers to the current hourly income earned from wages or salaries from the person's main job. Wages and salaries may differ sligtly from earnings. In addition to wage and salary payments, earnings may include income

15 See the *Survey of Income and Housing Costs: User Guide* (ABS cat. no. 6553.0) for a detailed description of the SIHC.

16 The Survey of Income and Housing Costs was renamed in 2003 and is now called Survey of Income and Housing (SIH).

earned from a person's own business, as well as some severance payments, termination fees, compensation payments, fringe benefits and other entitlements. Ideally we should include all labour income, including wages and non-wage entitlements. However, the IDS does not include any information on these entitlements, and so we have used wages for the estimation.

We sometimes find it necessary to adjust workers' full-time and/or part-time status. The labour force is restricted to wage and/or salary earners employed in either full-time or part-time work. Sometimes a person's own opinion on whether they work full-time or part-time differs from our assessment of their labour force status. For consistency, rather than classifying each worker according to their reported status, we classify them on the basis of their stated average weekly hours of work. Workers are classified as 'full-time' if they work 35 or more hours per week, and 'part-time' if they work fewer than 35 hours per week.

Following the practice of the BLS (1993), we use hourly wage rates as the dependent variable in the wage equation. However, the IDS files do not record estimates of hourly wage rates for workers. Instead these are derived by dividing each worker's average weekly income from their main job by the average hours worked per week in that job.

The average hourly wage rates for men, women and all people are presented in table 4.1. There has been a steady increase in the average hourly wage rate for both men and women. In all years, the average hourly wage rate for men is higher than for women.

4.1 Average hourly wage rate ($/hour)*

Year	*Males*	*Females*	*Total*
1982–1983	7.70	6.30	7.20
1986–1987	9.80	8.00	9.20
1990–1991	12.70	10.70	12.10
1994–1995	14.00	12.50	13.50
1995–1996	14.30	12.40	13.60
1996–1997	14.90	12.50	14.00
1997–1998	15.40	13.20	14.60
1999–2000	17.00	14.20	16.00

Note: *Full-time and part-time wage and salary earners in the market sector
Source: *Income and Distribution Survey* and *Survey of Income and Housing Costs*

4.3 Hours worked

Estimates of hours worked are also constructed from IDS data. Adjustments similar to those we made for hourly wages are also applied to this variable. For example, the observations are limited to those wage and salary earners aged between 15 and 65 years and definitions of full-time and part-time are based on the actual hours worked per week.

Initial investigation of the IDS data showed that with these restrictions the hours worked data did not line up with the Labour Force estimates of total hours worked. This is due to the restrictions imposed on the dataset, where workers who are self-employed, earn less than $1 per hour, or have never received any formal schooling are excluded. Although these were only minor differences, for consistency, we benchmarked IDS data on hours worked to the Labour Force Survey totals for the corresponding years.

Table 4.2 displays the average weekly hours worked by labour force status by sex, based on SIHC and the IDS. It shows that average weekly hours worked by male full-time employees has risen consistently since 1982–83 from 42.4 to 45.2. Part-time weekly hours, however, fell significantly for men. The working hours for women were fairly static over the period.

4.2 Average weekly hours worked per person*

	Males		*Females*		*Total*	
Year	*Full-time*	*Part-time*	*Full-time*	*Part-time*	*Full-time*	*Part-time*
1982–1983	42.4	19.6	41.8	17.9	42.2	18.1
1986–1987	43.2	15.3	39.8	16.1	42.3	15.9
1990–1991	44.1	19.6	40.5	18.0	43.2	18.3
1994–1995	44.6	16.2	41.0	17.7	43.7	17.2
1995–1996	45.0	15.6	41.6	17.4	44.1	16.9
1996–1997	45.1	16.9	41.4	17.3	44.1	17.2
1997–1998	45.4	16.0	41.3	16.9	44.4	16.5
1999–2000	45.2	17.1	41.6	17.1	44.2	17.1

Note: *Full-time and part-time wage and salary earners in the market sector

Source: *Income and Distribution Survey* and *Survey of Income and Housing Costs*

4.4 Years of potential experience

In the literature on human capital and labour composition, working experience is often used as proxy for post-school training. For example, the BLS (1993) used actual experience in the estimation of a wage equation.[17] In Australia, however, we have found no data that could enable us to compile estimates of actual working experience. As a result, we use 'potential experience'.

Potential experience refers to the likely number of years a person may have had in the workforce based on their education and age. In the case of women, the number of children are also taken into account. In this study, potential experience is estimated as the age of the worker minus 5 minus our estimate of the number of years of education. This assumption is based on a person starting school at 5 years of age and, upon completion of schooling, immediately finding employment. For women we also subtract an estimate of the time spent out of the labour force rearing each child. We allocate a period of one year for each child, up to a total of three. For four or more children we simply allocate a total of five years out of the workforce.

$$\text{Potential experience} = \text{Age} - 5 - \text{Education years} \; (- \text{No. of children}) \tag{11}$$

In many circumstances our treatment of the time women spend on raising children may not be an accurate representation of reality. For example, the survey responses in all IDSs capture only the number of dependants aged 18 or younger. The potential experience of women with children aged 18 years and over would be overestimated, because they were not identified as having spent time out of the labour force to raise those children. To overcome this problem, the BLS (1993) substituted data from the 1970 decennial census on the mean number of children ever born to women with 26 years or greater potential experience.

In order to calculate the years of potential experience based on Equation (11), it is necessary to obtain the years of education for each individual worker. In the IDS unit record file, there are no data on years of education, so this variable needs to be deduced from the information on educational attainment.

The IDS categorises educational attainment into nine separate educational groupings (ABS, 1997b). These are: not applicable; still at school; basic or skilled vocational qualifications; an associate, undergraduate or postgraduate diploma; and a bachelor or higher degree. For the purposes of this study we have grouped the educational attainment levels into like categories – 'still at school and not applicable', representing

17 In many cases, we have attempted to use a similar method to that used in the BLS (1993) study. One significant departure has been the use of an estimated potential experience variable. The BLS estimated an actual experience variable partly based on their Social Security Administration continuous work history files, the Inland Revenue Services and the 1973 Current Population Survey (Exact Match File).

those people who have no qualifications; 'vocational qualifications'; 'diplomas (excluding postgraduate)'; and 'degree or higher (including postgraduate diplomas)'.

We have restricted ourselves to four educational attainment variables for two reasons. First, the cell counts, or observations, for each year based on the full complement of education attainment variables are very low. The second reason for the restriction is to increase the consistency between qualification levels from 1982–83 through to 1990–91. These surveys did not possess the detailed education groupings that have existed since 1994–95. For example, postgraduate diplomas, bachelor degrees and higher degrees were not separately identifiable; instead they were grouped as one under the heading 'bachelor degree or higher'.

Using descriptions published by the ABS on education levels (ABS, 1994), we allocate years of education to each qualification level. Those still at school or with no qualifications are assumed to have 10 years of education. People with a vocational qualification are assumed to have 12 years of education (basic year 10 schooling plus two years of additional education). People who have diplomas are thought to have finished secondary school and then completed a further two years of education and are therefore assumed to have 14 years of education. Those people who hold a bachelor degree or higher are assumed to have completed 16 years of education – comprising of secondary school and approximately 4 years of university education. These classifications are summarised in table 4.3.

4.3 Qualification level and years of education

Qualification level	*Years of education*
Still at school or no qualification	10
Basic or skilled vocational qualification	12
Associate diploma, Undergraduate diploma	14
Bachelor degree, Postgraduate diploma, Higher degree	16

While we have used these groupings to derive potential experience, it should be noted that the method of allocating education attainment to four major categories poses a number of limitations. First, allocating a certain number of years to a given qualification may not be an accurate reflection of actual years of schooling. For example, allocating 16 years of education to a person with a higher degree may underestimate the actual years of education. A higher degree generally represents a doctorate or similar. This would generally take at least 17 years of schooling – 12 years regular schooling, plus three years for a bachelor degree and a further two years at least for the higher degree.

Second, it is widely believed that the quality of education varies from school to school, as well as between different universities and other tertiary institutions. This study assumes a similar level in the quality of education across the board.

Finally, the IDS records only the highest educational qualifications gained. Therefore if an individual initially gains a trade certificate then goes on to complete a degree or similar, this person will, according to the IDS, only be recognised as having completed the degree. This may lead to an underestimate of the actual number of years of schooling which will then cause the potential work experience of that individual to be overestimated.

The average number of years of potential work experience are displayed in table 4.4. Since 1982–83 the average number of years of potential experience for men has increased slightly. In contrast the average years of potential experience for women increased from 12.5 in 1982–83 to 16.6 in 1999–2000. While still not equalling the average potential experience of men, the increase in average female years of experience raised the total average from 16.7 years in 1982–83 to 18.4 years in 1999–2000.

4.4 Average number of years of potential experience*

Year	*Males*	*Females*	*Total*
1982–1983	19.2	12.5	16.7
1986–1987	18.0	14.6	17.0
1990–1991	18.7	15.8	17.7
1994–1995	19.0	16.1	18.0
1995–1996	19.3	16.2	18.1
1996–1997	19.4	16.6	18.3
1997–1998	19.9	16.9	18.8
1999–2000	19.6	16.6	18.4

Note: *Full-time and part-time wage and salary earners in the market sector
Source: *Income and Distribution Survey* and *Survey of Income and Housing Costs*

Given the definition of the years of working experience, there is an obvious relationship between this variable and the age of the workforce. As the labour force becomes older, the potential experience of the labour force must increase. But increases in the retention rates in schools and universities, where many young people are delaying entering the workforce by increasing their education levels, also play a part.

Table 4.5 shows that between 1982–83 and 1999–2000 the percentage distribution of the labour force aged 15 to 24, and 25 to 34 has decreased. On the other hand the percentage distribution of the labour force aged 35 years and over has increased from around 42% in 1982–83 to over 49% in 1999–2000.

4.5 Percentage distribution of labour force aged 15 to 65*

	Age				
Year	*15–24 years*	*25–34 years*	*35–44 years*	*45–54 years*	*55–65 years*
1982–1983	29.8	28.5	18.6	14.0	9.1
1986–1987	30.7	26.4	23.4	12.9	6.7
1990–1991	25.6	28.8	24.6	14.5	6.5
1994–1995	25.8	27.3	23.5	17.6	5.7
1995–1996	25.3	27.8	23.0	17.1	6.7
1996–1997	25.2	26.5	23.6	18.0	6.7
1997–1998	23.7	25.0	25.5	19.0	6.8
1999–2000	25.4	25.4	24.2	17.7	7.4

Note: *Full-time and part-time wage and salary earners in the market sector
Source: *Income and Distribution Survey* and *Survey of Income and Housing Costs*

Table 4.6 shows that there has been a decrease in the share of hours worked contributed by workers at the lower end of potential experience since 1982–83. Conversely, potential experience of between 20 and 39 years has recorded the largest increase in the proportion of hours worked over the period.

4.6 Percentage distribution of hours worked by potential experience*

	Potential Experience (10 year groupings)				
Year	*0–9 years*	*10–19 years*	*20–29 years*	*30–39 years*	*40–50 years*
1982–1983	37.5	27.3	15.2	12.4	7.5
1986–1987	35.3	27.0	20.1	12.1	5.7
1990–1991	31.2	29.0	21.7	12.8	5.4
1994–1995	29.8	28.1	22.3	15.4	4.5
1995–1996	30.1	27.9	21.3	15.4	5.4
1996–1997	29.8	27.1	21.6	16.1	5.4
1997–1998	28.5	25.6	23.6	16.9	5.5
1999–2000	29.9	26.5	22.0	15.7	5.9

Note: *Full-time and part-time wage and salary earners in the market sector
Source: *Income and Distribution Survey* and *Survey of Income and Housing Costs*

Combining the tables above, it is obvious that since 1982–83 the age distribution of the work force has increased, as has their educational attainment and potential experience. The changes in the distribution of potential experience may have a direct impact on the quality-adjusted labour inputs. For example, a given amount of hours worked in 1982–83 could represent a smaller amount of labour inputs than the same amount worked in 1999–2000 because the distribution is more skewed towards unskilled labour.

4.5 Educational attainment

Table 4.7 below, shows the distribution of hours worked by educational attainment by sex for a number of years since 1982–83.

Over the period the distribution of hours worked by men and women with a diploma has fallen. Conversely the distribution of hours worked by people who possess a degree or higher has increased.

Human capital theory, introduced in Section 2.3, suggests that people invest in education in order to receive higher lifetime earnings. This occurs because the more education a person holds the higher their marginal product. The table below tends to suggest that educational attainment at the higher end of the spectrum has risen since 1982–83, and the human capital model would suggest that this implies an increase in the average marginal product of the workforce.

4.7 Percentage distribution of hours worked by educational attainment*

	No qualification		*Vocational qualification*		*Diploma*		*Degree or higher*	
Year	*Males*	*Females*	*Males*	*Females*	*Males*	*Females*	*Males*	*Females*
1982–1983	34.3	24.3	19.2	2.2	7.2	8.9	2.6	1.3
1986–1987	37.3	25.3	20.3	1.9	5.6	5.4	3.2	1.1
1990–1991	32.7	24.1	18.9	1.8	7.5	8.5	4.8	1.9
1994–1995	34.6	26.3	18.8	5.8	5.6	2.1	4.7	2.2
1995–1996	32.7	27.0	19.1	6.3	5.4	1.9	5.2	2.7
1996–1997	31.6	26.6	19.1	6.0	6.6	2.7	5.1	2.5
1997–1998	34.4	24.3	19.7	6.0	5.6	2.3	5.1	2.7
1999–2000	34.9	26.0	19.2	6.3	4.2	3.0	5.7	2.7

Note: *Full-time and part-time wage and salary earners in the market sector
Source: *Income and Distribution Survey* and *Survey of Income and Housing Costs*

5. ESTIMATION OF WEIGHTS

This section of the paper examines two methods of deriving average wages for workers, grouped by varying levels of educational attainment and years of potential experience. The first method is based upon regression analysis, while the second uses simple averages to calculate average wages.

5.1 Estimated wage equation method

Equation (10) is used to estimate wages of men and women separately. Based on the discussion in Section 3.3, we include only two additional traits in our definition of Z – job status (i.e. whether employed full-time or part-time) and geographical location (i.e. urban or regional). Specifically, we estimate the following equation.

$$\ln\left(W\right) = a + c_1 PE + c_2 PE^2 + b_1 S_1 + b_2 S_2 + b_3 S_3 + f_1 PT + f_2 RG \qquad (12)$$

where W is the hourly wage rate, PE is potential experience, S_1 to S_2 and S_3 are dummy variables which refer to the educational attainment of a vocational qualification, a diploma, and bachelor or higher degree, respectively. Potential experience is grouped into five-year brackets.[18] The coefficients of c_1 and c_2 represent the return to experience and the coefficients of b_1, b_2 and b_3 are returns to the corresponding education categories. PT and RG are two dummy variables which refer to job status and location.

In this study, we use the hourly wage rate as the dependent variable. As explained in Section 4, wages are different from earnings and do not include non-wage entitlements which also represent income from labour. Failure to include these entitlements may have implications for the estimates of returns to experience (c_1 and c_2). In particular, if the proportion of non-wage entitlements in total earnings has a positive relationship with potential experience – which is very likely in reality – failure to include this component in the dependent variable will cause a downward bias in the return to potential experience. An example of this is the introduction of the fringe benefits tax (FBT) in 1985. Fringe benefits have traditionally been more of an issue for higher paid workers, increasing the share of non-monetary payments in total compensation for these workers. The introduction of the FBT, however, is likely to have the opposite effect for these workers – decreasing the share of non-monetary payments as these are rolled into normal wages and salary to avoid payment of additional tax.

Male and female wage equations are estimated separately for several reasons. First, by separately estimating male and female equations it is possible to identify and remove

18 Potential experience could have been treated as continuous variable and on a yearly incremental basis. The main reason for us to group them into 5 year brackets is that data are not available in some brackets.

any possible effects of discrimination on the female wage rate. Second, women are more likely than men to spend time out of the labour force raising children. This may lead to a different pattern of potential experience than their male counterparts. For example a man with 20 years potential experience who has not spent any time out of the labour force may have a higher level of actual experience than a woman who has 20 years of potential experience (because during those 20 years she has had a number of spells out of the labour force raising children). Third, a higher proportion of females are employed part-time with, possibly, a different distribution pattern to men across different education/experience groups.

Since there are very few, and sometimes no observations in many of the cells, especially at the high end of the scale, we aggregate potential experience into 5–year groupings instead of individual years. We then use ordinary least squares regression techniques to estimate the coefficients in Equation (12). These results are reported in Section 6.

5.2 Averaged wage method

The averaged wage method is similar to the estimated wage equation method except for the technique by which the weights are derived. Under this approach the wage rate is derived using a simple sample average.

Using the IDS unit record file, each unit is classified by education and potential experience, similar to table 5.1 below. The cell sizes are the same as those used in the estimated wages method. Using the hourly wage recorded for each labour unit, a simple average of hourly wages is derived for each cell in the matrix (i.e. all the relevant worker traits) for each of the IDS years.

5.1 Example of average hourly wage matrix

Education attainment	*Potential experience (years)*				
	0–4	*5–9*	*...*	*40–44*	*45–50*
No qualifications	..	..	..	..	..
Vocational qualifications	..	Average hourly wages			..
Diploma	..				..
Bachelor or higher degree	..	..	..	..	..

Once the average hourly wage matrix is calculated we combine it with the matrix of total number of hours worked per week (which are of the same dimensions). Thus, providing us with a matrix of weighted weekly employment hours. By summing this matrix across all cells we arrive at an estimate of total weighted hours. This total is then used to produce the chain Tornqvist index for labour input.

The averaged wage method is simple and the calculation is straightforward. There are, however, a couple of major disadvantages compared with the regression method. First, the number of observations in each trait group decreases geometrically as we further disaggregate the data. For example, if we were to add an industry dimension into the analysis, the number of observations would reduce considerably on average and there may be a lot of empty cells as a result. For cells with a small number of observations, the estimates may be influenced by a few unusual observations. Second, it is difficult to calculate estimates when traits are represented by a continuous variable.

6. RESULTS

This section presents the results of the two methods used to produce the experimental quality-adjusted labour input and then compares them to the current estimates of labour input. The parameter estimates of the wage equation are presented by sex, followed by the experimental estimates of quality-adjusted labour input, labour composition and labour productivity indexes.

6.1 Wage equations

Tables 6.1 and 6.2 present the parameter estimates for the estimated wage equations, as well as the *t-statistics* for each parameter estimate.

For male workers (table 6.1), *t-statistics* suggest that all the coefficients are statistically significant at the 95% confidence level. Additionally, in all cases, as education rises so too do the parameter estimates. These results are consistent with theory. That is, as education rises, income also increases to compensate workers for their investment.

Our findings are consistent with results from other empirical studies on the returns to education and training (Preston, 1997; Borland and Suen, 1990). These studies also conclude that earnings have a positive and significant relationship with both education and working experience.

6.1 Estimates for male workers

Parameter	*1982*	*1986*	*1990*	*1994*	*1995*	*1996*	*1997*	*1999*
Intercept (a)	1.46 (93.08)	1.67 (73.1)	1.94 (127.5)	2.01 (71.2)	2.02 (69.4)	2.10 (70.2)	2.09 (64.5)	2.15 (66.6)
PE (c_1)	0.041 (27.0)	0.045 (20.3)	0.040 (28.3)	0.040 (15.6)	0.042 (15.7)	0.039 (14.8)	0.037 (13.1)	0.40 (13.7)
PE^2 (c_2)	–0.00075 (–22.6)	–0.00081 (–16.3)	–0.00072 (–23.3)	–0.00070 (–12.2)	–0.00072 (–12.3)	–0.00070 (–12.1)	–0.00065 (–10.7)	–0.00067 (–10.5)
Vocational qualification (b_1)	0.123 (10.3)	0.144 (8.3)	0.138 (12.5)	0.120 (6.3)	0.118 (6.0)	0.143 (7.2)	0.124 (6.0)	0.085 (4.0)
Diploma (b_2)	0.283 (16.4)	0.254 (8.7)	0.209 (13.6)	0.236 (7.9)	0.221 (7.1)	0.236 (8.2)	0.260 (7.8)	0.270 (7.1)
Bachelor or higher degree (b_3)	0.518 (19.3)	0.515 (14.2)	0.449 (23.9)	0.394 (12.2)	0.475 (15.0)	0.444 (13.8)	0.457 (13.1)	0.434 (12.9)
Adjusted R^2	0.24	0.23	0.25	0.21	0.23	0.21	0.19	0.20
No of Observations	5,254	3,542	5,590	2,757	2,626	2,793	2,646	2,532

Notes:

1) *t-statistics* reported in parentheses.

2) Part-time and regional variables were included in the wage equation but are not reported in the above table due to insignificant *t-statistics*.

6.2 Estimates for female workers

Parameter	*1982*	*1986*	*1990*	*1994*	*1995*	*1996*	*1997*	*1999*
Intercept (a)	1.44 (75.6)	1.67 (56.9)	1.96 (101.0)	1.94 (62.9)	2.04 (61.3)	2.07 (71.4)	2.09 (56.4)	2.15 (63.8)
PE (c_1)	0.027 (12.6)	0.030 (10.3)	0.026 (15.2)	0.039 (13.1)	0.036 (12.1)	0.038 (14.5)	0.032 (9.5)	0.33 (11.0)
PE^2 (c_2)	–0.00054 (–10.7)	–0.00056 (–7.8)	–0.00054 (–12.9)	–0.00075 (–10.2)	–0.00074 (–10.1)	–0.00078 (–12.1)	–0.00057 (–6.9)	–0.00058 (–8.18)
Vocational qualification (b_1)	0.075 (2.4)	0.011 (0.2)	0.005 (0.2)	0.114 (4.2)	0.087 (3.1)	0.098 (4.0)	0.071 (2.3)	0.094 (3.3)
Diploma (b_2)	0.220 (12.7)	0.101 (3.5)	0.135 (9.4)	0.191 (4.5)	0.169 (3.6)	0.192 (5.5	0.187 (4.0)	0.143 (73.6)
Bachelor or higher degree (b_3)	0.435 (10.9)	0.356 (6.1)	0.332 (12.3)	0.426 (9.9)	0.351 (8.6)	0.400 (11.0)	0.281 (6.3)	0.341 (8.1)
Adjusted R^2	0.16	0.10	0.14	0.18	0.14	0.19	0.12	0.15
No of Observations	3,056	1,798	3,169	1,572	1,598	1,694	1,434	1,552

Notes:

1) *t-statistics* reported in parentheses.

2) Part-time and regional variables were included in the wage equation but are not reported in the above table due to insignificant *t-statistics*.

For female workers, table 6.2 shows that all *t-statistics* are significant for female coefficients except for the vocational qualifications variable in 1986 and 1990. Like the male employment estimates, the female parameter estimates all increase as the level of education increases.

Comparing the male and female parameter estimates we observe some differences in compensation. Differences are not as evident at the unskilled level where the intercept coefficients for men (representing no qualifications) are similar to those for women. However, as the level of educational attainment increases, the male coefficients are almost all higher than the female coefficients.

The coefficients in tables 6.1 and 6.2 look reasonable and seem consistent with human capital theory. The *t*-values are statistically significant suggesting that all the selected variables have an influence on the wage differences.

R-squared values for the equations representing male workers were in the neighbourhood of 0.22 and these values for the female workers' equations vary from 0.10 to 0.19, with an average of 0.15. Given that cross-sectional data has been used in the estimation, these R-squared values indicate that the models fit the data for both men and women reasonably well. The values of these statistics are of a similar order to those obtained by the BLS (1993), using U.S. data, which were approximately 0.25 for male workers and 0.14 for female workers.

The R-squared values would be disappointing if one were, say, trying to develop an explanatory model for wages using time series data. We believe, however, that they are acceptable for this kind of application. First, we have used cross-sectional data, not time series data. Second, we would have liked, but did not need, an exhaustive explanation of differences between the wages received by individuals. We want to capture those influences on wage differences that can be characterised as differences between the quality of labour, and those that are likely to vary over time (and hence lead to a quality change in the labour input and productivity time series). The wage equations appear to have served our purposes reasonably well.

To explore the possibility of further improving our model we examined the residuals. Specifically, we tested for the presence of heteroscedasticity and tested the stability of our estimated coefficients over time.

To detect the possibility of heteroscedasticity, we conducted White's general heteroscedasticity test. The results suggest that the hypothesis of heteroscedasticity can be accepted for eleven out of the fourteen regressions at the 5% significance level. However, after correcting for heteroscedasticity we found that the coefficients remained unchanged. This indicates that the coefficients are unaffected by the heteroscedasticity and can be used for the construction of the labour inputs index.

Coefficient stability tests were conducted to determine whether there were any changes in the relationship between the dependent and independent variables over the periods under consideration. If it were found that the relationship remained unchanged then we could produce statistically more efficient estimates by pooling the data from all the periods and estimating our coefficients, from this combined data, rather than estimating the coefficients period by period.

To test this proposition, we employed the Chow Test (for structural stability) where the null hypothesis was that the regression coefficients were stable between years. These tests were conducted for every pair of neighbouring periods.

The results of our tests suggest that we cannot reject the null hypothesis for most neighbouring years, except two periods (namely 1995–96 for men and 1996–97 for women). Given this variability (or instability) we do not pool the data. Thus, estimates are produced for all IDS years. Details of the test and results are provided in Appendix D.

6.2 Labour input indexes

After obtaining the matrices of hourly wages and hours worked, an index of quality-adjusted labour inputs is calculated. In this study we use the Tornqvist formula (Equation 13) to produce an index number for each period:

$$\ln T_t = \frac{1}{2}\sum_i (v_{i0} + v_{it}) \times \ln \frac{H_{it}}{H_{i0}} \qquad (13)$$

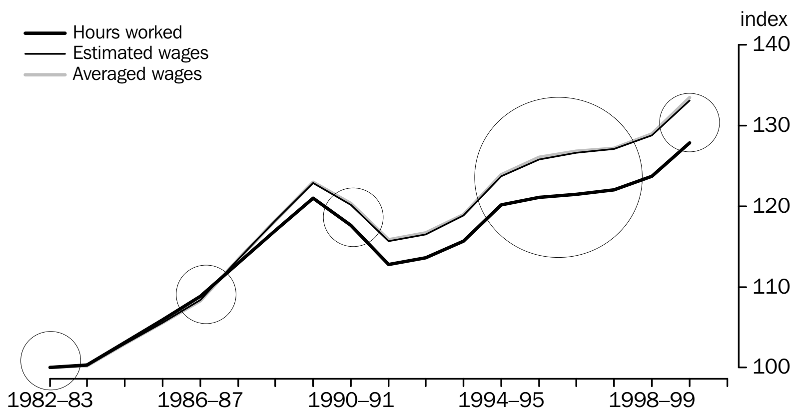
where the v_{i0} and v_{it} represent the weights for base period (0) and current period (t) defined as:

$$v_{i0} = \frac{W_{i0}H_{i0}}{\sum_j W_{j0}H_{j0}} \quad \text{and} \quad v_{it} = \frac{W_{it}H_{it}}{\sum_j W_{jt}H_{jt}}$$

and where W_{i0} and W_{it} refer to the wage of the ith labour force trait in the base and current periods. Similarly, H_{i0} and H_{it} refer to hours worked. The index uses weights from both the current and previous (base) periods. As time increases by one period, so too do the current and previous period's weights. Thus, the resulting index is linked through successive base periods. This type of index is known as a Chained Tornqvist index. This index formula is also used in the Australian National Accounts to construct productivity estimates.

Given that the IDS was not run every year, we must interpolate gaps in the index . The weighted hours data is interpolated using the index of hours worked from the Labour Force Survey. [19]

6.3 Comparison of labour input indexes – Current vs experimental



Note: 1982-83 is the base period

Figure 6.3 shows the current labour input index used by Australian National Accounts as well as the two experimental quality-adjusted labour input indexes. The circled

19 The interpolation technique used here did not affect the growth rate between index data points for actual survey years.

points represent those years for which a direct comparison can be made between the current and the quality-adjusted labour inputs.[20]

Over the period 1982–83 to 1999–2000 the quality-adjusted labour input indexes increased to 133.1 and 133.5 using the estimated wages equation and average wages methods, respectively. This compares to the current National Accounts input index of 127.9. This implies that the quality or skills of the labour force increased over this period. This is fully consistent with the trends in working experience and education attainment shown in Section 4 (tables 4.6 and 4.7).

The growth between the circled data points from figure 6.3 are presented below in table 6.4. The table shows that the experimental estimates of labour input are below the current labour input estimates in only one period 1982–83 to 1986–87. During that period the hours worked index has an annual average increase of 2.1% compared to the equivalent increase in the experimental labour input of 2.0%, using both the estimated and averaged wage method.

6.4 Comparison of labour input movements – Percentage change

		Experimental quality-adjusted labour inputs	
Years	*Current labour inputs*	*Estimated wage method*	*Averaged wage method*
1982–83 to 1986–87*	2.13	2.04	2.02
1986–87 to 1990–91*	2.00	2.66	2.72
1990–91 to 1994–95*	0.59	0.76	0.76
1994–95 to 1995–96	0.75	1.70	1.78
1995–96 to 1996–97	0.33	0.64	0.56
1996–97 to 1997–98	0.41	0.39	0.32
1997–98 to 1999–00*	2.42	2.36	2.48

*Note: These estimates are average annual increases between the specified years.
Source: *IDS* and *Australian National Accounts*

The reason the index for the current labour input is higher than the quality-adjusted indexes between 1982–83 and 1986–87 can be explained with the aid of table 4.7. This table shows the distribution of hours worked by educational attainment. Over this period the proportion of hours worked by people with no qualifications increased from around 58% of all hours worked to approximately 63% of hours worked. These workers are generally paid at the lower end of the wage and salary range so the increase in hours worked by them will attract a smaller weight. Conversely, the proportional decrease in hours worked by those with diplomas will attract a higher

20 Movements in the labour input index between the circled points are interpolated using the Hours Worked Index from the Labour Force Survey.

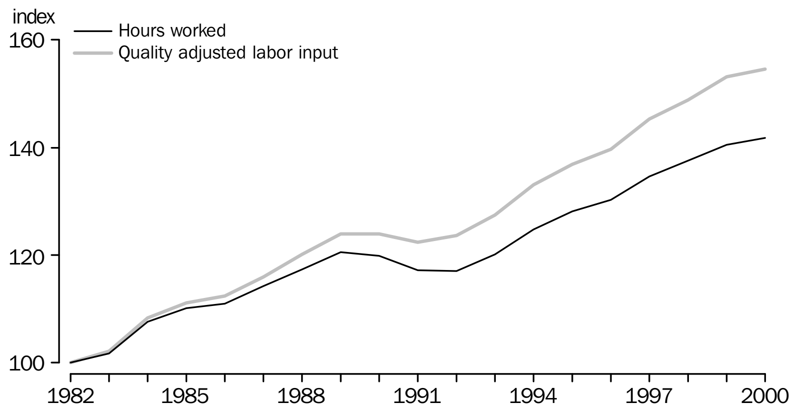
weight, as they are likely to be paid at the high end of the income range, and thus exaggerate the fall in hours. These two factors combined lead to a labour input index which is lower than the rise in hours worked index for the same period. Although not as pronounced, a similar shift in the distribution of hours worked occurs after 1990–91 (and to a lesser degree after 1997–98). In these later periods the quality-adjusted labour inputs have almost identical growth rates to the hours worked series.

Apart from 1982–83 to 1986–87 (and for the estimated wage method for 1997–98 to 1999–2000), the quality-adjusted labour inputs are all higher than the current labour input index. After 1986–87 there was a slight shift in the distribution of hours worked towards workers with higher educational qualifications.

Similarly, increases in the proportion of hours worked at the higher end of the potential experience scale (see table 4.6) contribute to the higher quality-adjusted labour input index. Workers with higher potential experience generally receive a greater wage or salary than workers with low potential experience.

The experimental quality-adjusted labour input indexes reported above reflect the distributional changes in educational attainment and potential experience reported in Section 4. Both the educational attainment and potential experience of the workforce on average increased over the entire period. The rise in the quality-adjusted labour input indexes over the hours worked index reflects rising skill levels in the workforce.

6.5 BLS estimates of labor input – Private business sector



Note: 1982 is the base period

Figure 6.5 shows a comparison of the original hours worked index and the subsequent quality-adjusted labour input for the U.S. economy, as published by the BLS. Since 1982 the new labour input index has risen at a higher rate than the original hours worked index. By 1999 the quality-adjusted labour input index was 153 versus the old labour input index of 141. This indicates that there has been an increase in the average skill level of the U.S. workforce over that period.

Although the BLS data do not show the quality-adjusted labour input falling below the hours worked index around 1986 and 1987, the overall growth in the two series to 1999 are similar to those experienced in Australia. The BLS hours worked index has an average annual growth rate of 2.0 percent while the quality-adjusted index increases by 2.5 percent annually. In comparison Australia's hours worked index and quality-adjusted labour input index (using the estimated equation) have average annual growth rates of 1.5 percent and 1.7 percent respectively.

6.3 Labour composition

Labour composition change shows the growth in labour input that is not attributable to the growth in hours worked. That is, the growth in labour input as a result of an increase in the education or experience of the workforce. The growth in labour composition is derived as the growth in labour input minus the growth in hours worked (defined by Equation 10) and it represents the gap between the existing labour inputs and the quality-adjusted labour inputs.

Table 6.6 shows the changes in labour composition. The quality-adjusted labour input displayed below is derived using the estimated wage equation method. During the entire period hours worked increased by 28% while labour input increased by 33%. This translates into an increase in labour composition of 5% for the entire period.

6.6 Changes in labour composition – Estimated wages method

	Growth rate of experimental labour input	Contribution of changes in	
Years		*Labour composition*	*Hours worked*
1982–83 to 1986–87	8.4	–0.4	8.8
1986–87 to 1990–91	10.9	2.8	8.1
1990–91 to 1994–95	2.9	0.7	2.2
1994–95 to 1995–96	1.7	0.9	0.7
1995–96 to 1996–97	0.6	0.3	0.3
1996–97 to 1997–98	0.4	0.0	0.4
1997–98 to 1999–00	4.7	–0.1	4.8
1982–83 to 1999–00	33.1	5.2	27.9

Note: The change in labour composition may not exactly equal the difference between the change in labour input and the change in hours worked due to rounding.
Source: IDS and Australian National Accounts

Table 6.6 shows an interesting relationship between the increase in economic activity (i.e. demand for labour) and labour composition. Between 1986–87 and 1990–91 labour input increased by 10.9% and hours worked 8.1%, leading to a labour composition increase of 2.8%. Australia experienced a recession in 1990–91. This helps to explain the large increase in labour composition. As demand for products falls in economic decline, firms tend to lay off their least productive workers. Generally these workers are the ones with the least experience. Therefore the average skill of the remaining labour force increases, leading to an increase in labour composition.

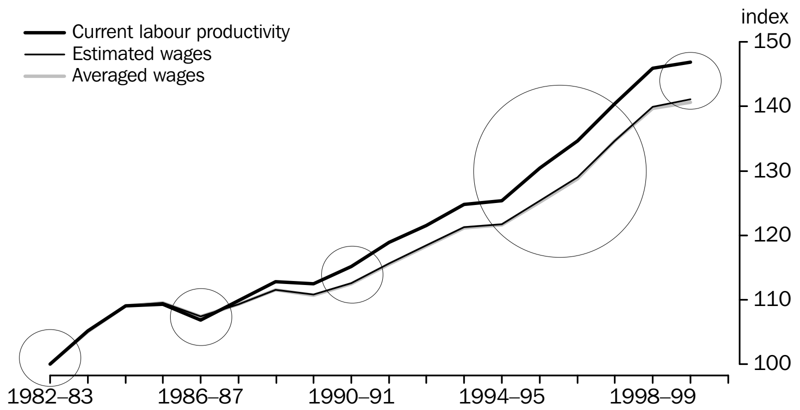
On the other hand, as the economy expands more and more people (including the young and inexperienced in the labour force) are employed. As this happens the average experience of the workforce falls, and so too does labour composition. Table 6.6 confirms the fall in labour composition as the economy expands after the 1982–83 recession.

6.4 Labour productivity indexes

In this section we look at the effect of the new quality-adjusted labour inputs on labour productivity. Figure 6.7 uses the indexes for labour input (from table B.1 in Appendix B) and gross domestic product for the market sector to compare the current and experimental quality-adjusted labour productivity series. Again, the circled points represent those years when an IDS was conducted.

This comparison shows that the quality-adjusted indexes increase at a slower rate than the current labour productivity index. From 1982–83 to 1999–2000, labour productivity derived from quality-adjusted labour inputs increased from 100 to 141.1 based on regression estimation or 140.6 based on the simple average method. For the same period, labour productivity, not adjusted for quality, increased to 146.9.

6.7 Comparison of labour productivity indexes – Current vs experimental



Note: 1982-83 is the base period

The movements between the circled data points from figure 6.7 are presented below in table 6.8. Since 1995–96 the growth in labour productivity, as measured by the current methodology and using the quality-adjusted labour inputs, has increased at a similar rate.

6.8 Comparison of labour productivity movements – Percentage change

Years	*Current labour productivity*	*Experimental quality-adjusted labour productivity*	
		Estimated wage method	*Averaged wage method*
1982–83 to 1986–87*	1.72	1.84	1.86
1986–87 to 1990–91*	1.89	1.19	1.15
1990–91 to 1994–95*	2.15	1.99	1.97
1994–95 to 1995–96	3.99	2.96	2.96
1995–96 to 1996–97	3.30	2.87	2.88
1996–97 to 1997–98	4.23	4.42	4.50
1997–98 to 1999–00*	2.30	2.36	2.22

*Note: These estimates are average annual increases between the specified years.
Source: *IDS* and *Australian National Accounts*

7. CONCLUSIONS

This paper demonstrates an experimental method which allows for the adjustment of labour inputs to take account of changes in the skill level of the workforce.

The experimental quality-adjusted labour input index is a theoretically better measure than the current labour input index: the experimental index takes account not only of changes in the number of hours worked, but also changes in the distribution of the education and experience levels of the workforce.

The current labour input – hours worked – is adjusted by weighting hours with the wage rate of each type of worker. Two methods were examined to produce the wage rate – an estimated wage equation and a simple averaging technique whereby the average wage by worker trait is derived from the unit record file.

The method with the most solid basis for adjusting labour inputs for changes in skills uses the estimated equation to derive the wage rate weights. This method is preferred to the averaging technique because it produces a more robust estimate of the different worker types wage rates. Estimates from this method produce a slightly higher labour input index than the average wage technique, translating to a marginally lower labour productivity series.

Experimental quality-adjusted labour inputs, derived using the estimated wage equation, have increased by 33.1% since 1982–83. Over the same period the current method of measuring labour inputs, the hours worked index, increased by 27.9%. Therefore the growth in the labour input attributable to changing levels in the education and experience of the workforce is 5.2%. This rise in the quality input of labour means that on average the labour force is now higher skilled than it was in 1982–83. Once we take into account of higher quality of labour, the labour productivity estimated using the experimental labour input index becomes lower than the estimates produced using the hours worked index.

The results obtained in this paper are similar to the labour inputs index that the BLS (1993) produced. The growth rates in the BLS's estimates and relationship between the labour input index and the hours worked index are similar to those derived in this paper for Australian data.

APPENDIXES

A. MEASUREMENT OF PRODUCTIVITY[21]

The production process can be described by a production function. The production function takes the form

$$q = f\left(k_1, \ldots, k_n, H, t\right) \tag{A1}$$

where output q is produced by n types of capital input k and a single type of labour input H. The t represents state of technology at time t. In this production function, labour is treated as a homogenous input and it ignores different characteristics of workers and their distinct contribution to the output.

A more general production function that allows for treatment of different labour inputs and accounts for a unique effect of different labour inputs on output can be represented by:

$$q = g\left(k_1, \ldots, k_n, h_1, \ldots, h_m, t\right) \tag{A2}$$

where h_1 , … , h_m represent distinct labour inputs.

The production function (A2) can be expressed in terms of growth rates by taking the logarithm and then the derivative with respect to time. This provides a framework where the growth rates of the output and inputs can be examined.

$$\frac{\dot{q}}{q} = \sum_{i=1}^{n} \alpha_i \frac{\dot{k}_i}{k_i} + \sum_{j=1}^{m} \beta_j \frac{\dot{h}_j}{h_j} + \frac{\dot{A}}{A} \tag{A3}$$

For any input k_i or h_j, the dot notations $\dot{k}_i / k_i$ and $\dot{h}_j / h_j$ denote the growth rate of ith capital and jth labour. The terms α_i and β_j are defined as:

$$\alpha_i = \frac{\partial g}{\partial k_i} \Bigg/ \frac{g}{k_i} \qquad i = 1, 2, \ldots, n$$

$$\beta_j = \frac{\partial g}{\partial h_j} \Bigg/ \frac{g}{h_j} \qquad j = 1, 2, \ldots, m$$

where g is the production function, and α_i and β_j are known as the output elasticities which measure the percentage change in output for a 1 percent change in an input.

21 Labour Composition Model has been described in details elsewhere such as BLS (1993) and Aspden (1990). The presentation mainly follows that of BLS with minor modifications.

Multifactor productivity, or the effect of change in technology on the output is measured by $\dot{A}/A$, which is defined as:

$$\dot{A}/A = \frac{\partial g}{\partial t} \times \frac{1}{g}$$

By rearranging Equation (A3), we can derive an expression for the growth rate of multifactor productivity in Equation (A4):

$$\frac{\dot{A}}{A} = \frac{\dot{q}}{q} - \sum_{i=1}^{n} \alpha_i \frac{\dot{k}_i}{k_i} - \sum_{j=1}^{m} \beta_j \frac{\dot{h}_j}{h_j} \qquad \text{(A4)}$$

However, as the output elasticities cannot be directly observed, they need to be derived from market equilibrium conditions. If we assume that producers minimise costs, the production function exhibits constant returns to scale, and factor input markets are in competitive equilibrium, then it can be demonstrated that each factor's output elasticity is equal its share of total costs.

Let s_{ki} denote the share of *i*th capital input and s_{kj} denote the share of *j*th labour input in the total costs. Replacing the output elasticities from Equation (A4) with the shares of input factors in total cost for capital and labour input, we arrive at Equation (A5):

$$\frac{\dot{A}}{A} = \frac{\dot{q}}{q} - \sum_{i=1}^{n} s_{ki} \frac{\dot{k}_i}{k_i} - \sum_{j=1}^{m} s_{hj} \frac{\dot{h}_j}{h_j} \qquad \text{(A5)}$$

where s_{ki} and s_{hj} are defined as:

$$s_{ki} = P_{ki}k_i \Big/ \sum_{ij} \left(P_{ki}k_i + P_{hj}h_j \right)$$

$$s_{hj} = P_{hj}h_j \Big/ \sum_{ij} \left(P_{ki}k_i + P_{hj}h_j \right)$$

with P_{ki} and P_{hj} being the prices of the *i*th capital and *j*th labour services, previously defined.

Meaningful and unambiguous aggregates of capital and labour inputs exist, if the inputs are separable [22] and the impact of technology on output is Hicks-neutral. Under these assumptions, capital and labour aggregates can be expressed by equations (A6) and (A7):

$$\frac{\dot{K}}{K} = \sum_{i=1}^{n} s_{ki} \frac{\dot{k}_i}{k_i} \qquad \text{(A6)}$$

$$\frac{\dot{L}}{L} = \sum_{j=1}^{m} s_{hj} \frac{\dot{h}_j}{h_j} \qquad \text{(A7)}$$

---

22 The notion of separability of inputs in a production function is developed by Berndt and Christensen (1973)

where s_{ki} and s_{bj} represent the share of labour compensation (or cost shares of each type of input to its aggregate). For example s_{bj} is the share of compensation paid to each *j*th of labour input in the total cost of labour.

We can substitute Equations (A6) and (A7) into (A4) and express growth of multifactor productivity in terms of the growth rates of output, aggregate capital and labour inputs:

$$\frac{\dot{A}}{A} = \frac{\dot{q}}{q} - s_k \frac{\dot{K}}{K} - s_l \frac{\dot{L}}{L}$$

where s_l and s_k are the shares of labour and capital in the total costs and L and K are aggregate inputs of labour and capital.

B. LABOUR INPUT AND LABOUR PRODUCTIVITY INDEXES

B.1 Labour input indexes (1982–83 = 100)

		Quality-adjusted labour input	
Year	Current labour input (Hours worked)	Estimated wages method	Averaged wages method
1982–83	100.0	100.0	100.0
1983–84	100.3	100.2	100.2
1984–85	103.1	102.9	102.9
1985–86	105.9	105.6	105.6
1986–87	108.8	108.4	108.3
1987–88	113.0	113.4	113.4
1988–89	117.0	118.2	118.2
1989–90	121.0	122.9	123.0
1990–91	117.6	120.2	120.4
1991–92	112.8	115.7	115.9
1992–93	113.6	116.5	116.7
1993–94	115.7	118.9	119.0
1994–95	120.2	123.7	123.9
1995–96	121.1	125.8	126.1
1996–97	121.5	126.6	126.8
1997–98	122.0	127.1	127.2
1998–99	123.7	128.8	129.0
1999–00	127.9	133.1	133.5

B.2 Labour productivity indexes (1982–83 = 100)

		Quality-adjusted labour productivity	
Year	Current labour productivity	Estimated wages method	Averaged wages method
1982–83	100.0	100.0	100.0
1983–84	105.2	105.1	105.1
1984–85	109.1	109.1	109.1
1985–86	109.3	109.5	109.5
1986–87	106.9	107.4	107.5
1987–88	109.9	109.3	109.3
1988–89	112.8	111.5	111.5
1989–90	112.5	110.8	110.7
1990–91	115.2	112.6	112.5
1991–92	118.9	115.7	115.5
1992–93	121.5	118.5	118.3
1993–94	124.8	121.3	121.2
1994–95	125.4	121.8	121.6
1995–96	130.4	125.4	125.2
1996–97	134.7	129.0	128.8
1997–98	140.4	134.7	134.6
1998–99	145.9	139.9	139.7
1999–00	146.9	141.1	140.6

C. DESCRIPTIVE STATISTICS ON SELECTED VARIABLES

C.1 Descriptive statistics on selected variables

		1982–83	*1986–87*	*1990–91*	*1994–95*	*1995–96*	*1996–97*	*1997–98*	*1999–00*
Age	Mean	33.9	33.2	34.3	34.4	34.6	34.9	35.4	35.0
	Std Dev.	12.7	12.3	11.8	11.9	12.2	12.2	12.2	12.4
	Min.	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
	Max.	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
Education years	Mean	11.3	11.1	11.5	11.2	11.3	11.3	11.3	11.3
	Std Dev.	1.8	1.7	1.9	1.8	1.8	1.9	1.8	1.9
	Min.	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Max.	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Potential experience	Mean	16.7	16.9	17.7	18.0	18.1	18.3	18.8	18.4
	Std Dev.	12.9	12.2	11.9	11.9	12.1	12.2	12.2	12.3
	Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Max.	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Hourly income	Mean	7.2	9.2	11.9	13.4	13.6	14.0	14.6	15.8
	Std Dev.	3.3	3.7	4.7	6.7	6.5	6.4	7.1	10.0
	Min.	0.0	0.0	0.4	0.5	0.1	0.0	0.2	0.8
	Max.	29.4	27.8	38.5	67.2	56.3	57.1	65.7	250.0
Hours worked	Mean	38.8	37.3	38.5	37.4	37.7	37.4	37.2	36.5
	Std Dev.	9.3	13.0	13.2	14.3	14.9	14.9	15.5	15.3
	Min.	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Max.	70.0	99.0	99.0	98.0	98.0	98.0	98.0	98.0

D. CHOW TEST FOR STRUCTURAL STABILITY

The Chow test follows an F distribution with df (k, n_1+n_2–$2k$):

$$F = \frac{\left(RRSS - URSS \right) / k}{URSS \left(n_1 + n_2 - 2k \right)}$$

where *RRSS* is the restricted residual sum of squares (i.e. restricting the parameters to be equal between the two periods); *URSS* the unrestricted residual sum of squares; k the number of estimated coefficients and n_1 and n_2 represent the respective numbers of observations in each data set.

If the test statistic is greater than the critical value, we reject the hypothesis that coefficients remained unchanged. The results of the Chow test are presented in table D.1.

D.1 F-Test results

Sex / Year	*Test Statistic*	*Number of Restrictions / Degrees of Freedom*
Male		
1982–83 to 1986–87	45.44*	8 / 8798
1986–87 to 1990–91	88.77*	8 / 9118
1990–91 to 1994–95	11.53*	8 / 8333
1994–95 to 1995–96	1.91	8 / 5369
1995–96 to 1996–97	5.24*	8 / 5405
1996–97 to 1997–98	4.47*	8 / 5425
1997–98 to 1999–00	8.30*	8 / 5164
Female		
1982–83 to 1986–87	31.13*	8 / 4840
1986–87 to 1990–91	149.43*	8 / 4953
1990–91 to 1994–95	39.32*	8 / 4727
1994–95 to 1995–96	5.25*	8 / 3156
1995–96 to 1996–97	1.06	8 / 3278
1996–97 to 1997–98	8.91*	8 / 3114
1997–98 to 1999–00	6.47*	8 / 2972

Note: The 5% F test with 8 restrictions and infinite degrees of freedom = 1.94

The first column shows the years for which the data was pooled. The second gives the result of the F test statistic, and the third the degrees of freedom, where the first figure is the number of estimated coefficients and the second is the number of observations in the pooled data.[23] The critical values are given at the foot of the table.

From the second column in table D.1 the test statistics marked with an asterisk indicate that pooling of data is not recommended for those matched years. This indicates that there has been a structural change between those years which will be neglected if data were to be pooled. This reinforces the decision to estimate the earnings functions separately for each year.

23 Note, in F tables any number greater than 120 observations is referred to as infinite.

LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
BLS	Bureau of Labour Statistics
FBT	Fringe Benefits Tax
IDS	Income and Distribution Survey
LC	Labour Composition
LFS	Labour Force Survey
MICM	Multiperiod Implicit Contract Model
SIHC	Survey of Income and Housing Costs

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