Does Quality Matter in Labour Input? The Changing Pattern of Labour Composition in New Zealand

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Abstract

The composition of the New Zealand workforce has changed considerably over the past two decades. Qualification levels have risen, labour force participation has trended upwards for women, immigrants have increasingly been sourced from Asia, and the large baby-boom cohort has contributed to an ageing of the workforce. The question is whether such compositional changes have affected the quality of labour.

Our estimates show a large rise in labour quality since 1988 as a result of increasing qualification levels, particularly at university degree level. With age as a proxy for work experience, an ageing of the workforce also contributed to rising labour quality. The annual rise in labour quality averaged 0.6% from 1988 to 2005, which was comparable to the experience of Australia, the United States and the euro area.

Although labour quality rose in every year of our sample period, the rise was not constant over time. The increase was much stronger in the first half of the period (1988 to 1997) than in the second half (1997 to 2005). By drawing a large number of lower-skilled people into work, the strength of recent employment growth may have dampened growth in labour quality.

Accounting for changes in labour quality has implications for labour productivity. Almost half of labour productivity growth of 1.4% per annum since 1988 can be attributed to the rise in labour quality. Labour productivity measured as output per quality-adjusted working hour rose by 0.8% per annum on average from 1988 to 2005, with annual growth of 0.5% in the first half of the period and 1.1% in the second half.

JEL CLASSIFICATION

J21 - Labor Force and Employment, Size, and Structure

J24 - Human Capital; Skills; Occupational Choice; Labor Productivity

J31 - Wage Level and Structure; Wage Differentials

J61 - Geographic Labor Mobility; Immigrant Workers

KEYWORDS

Labour Quality; Human Capital; Wage Differentials; Labour Productivity

Table of Contents

List of Tables

List of Figures

Does Quality Matter in Labour Input? The Changing Pattern of Labour Composition in New Zealand

1 Introduction

This paper aims to improve the measurement of labour input by adjusting for changes in the composition, or quality, of the workforce.[1] Current measures of labour input assume an hour worked by one person is equal to an hour worked by anyone else, regardless of differences in education or experience. However, when trying to establish the productive capacity of an economy, it may not be appropriate to assume the marginal worker has the same productivity as the average worker.

One approach for considering the performance of an economy has been to use the growth accounting framework to examine the proximate sources of economic growth. Using this approach, economic growth can be sourced from growth in labour input and growth in labour productivity (output per labour input). Currently, labour input is measured as the total number of hours worked in the economy.

The growth accounting approach shows there has been a significant increase in labour input in New Zealand since the early 1990s, but a step up in labour productivity has been more difficult to identify. Indeed, there appears to have been a slowing of labour productivity growth in recent years at the economy-wide level and in the measured sector of the economy (ie, excluding industries in which productivity is hard to measure).

Previous estimates of labour productivity, however, use total hours worked as the measure of labour input. As a result, these estimates of labour productivity growth include the impact of changing workforce composition. Using the methodology developed by the Bureau of Labor Statistics (1993), this paper estimates changes in the quality of labour. By separating the growth of labour input into two components, hours worked and labour quality, we can develop a richer understanding of the underlying trend of labour productivity.

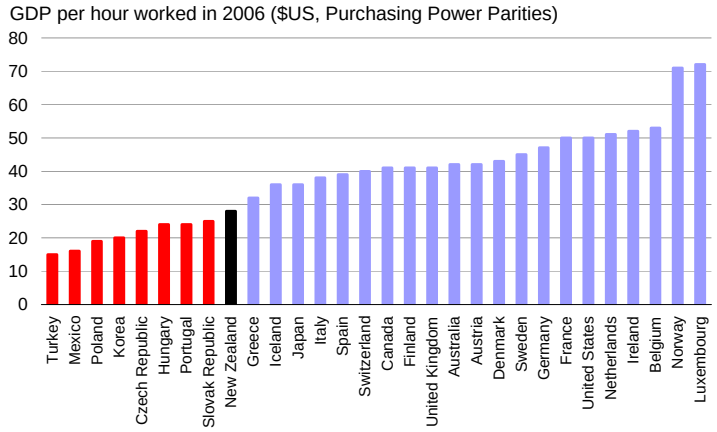
One hypothesis is that strong employment growth is correlated with relatively slow productivity growth as new entrants take time to learn skills on the job and tend to have lower skill levels than the average worker (IMF, 2005). The possibility that labour productivity growth can be dampened by employment growth due to changes in labour quality is also discussed by the Organisation for Economic Co-operation and Development (OECD):

[1] 'Labour quality' and 'labour composition' are used interchangeably in this paper. Other terms used overseas include 'skill' and 'human capital'.

> The negative relationship between employment growth and average measured labour productivity growth … arises, in part, because conventional measures of labour productivity do not adequately control for changes in the quality of labour. Aggregate employment growth is usually associated with faster employment growth for the low-educated than for the highly-educated, so reduces the average level of skills and productivity ... Thus, an increase in employment with no change in the average productivity per unit of skilled labour and/or individual productivity for those already in employment would lead to a reduction in average measured labour productivity.
>
> OECD, 2007:60

We are interested in productivity as it is a key determinant of living standards. The level of labour productivity, as measured by Gross Domestic Product (GDP) per hour worked, is relatively low in New Zealand at 22nd out of the 30 nations in the OECD (*Figure 1*). Among some of our usual comparator nations in 2006, Ireland was 4th, the United States was 6th, Australia was 12th, the United Kingdom was 13th, and Canada was 14th equal. Highlighting the importance of productivity, New Zealand's ranking on labour productivity matches its ranking in GDP per capita.

Figure 1: Labour productivity levels across the OECD, 2006



Source: OECD

The Australian Bureau of Statistics regularly produces a quality-adjusted labour input series, as do other countries' statistical agencies. Statistics New Zealand is also producing a quality-adjusted labour input series and plans to release an experimental series later in 2008. At this stage, we expect the method used here will be broadly similar to the approach adopted by Statistics New Zealand.

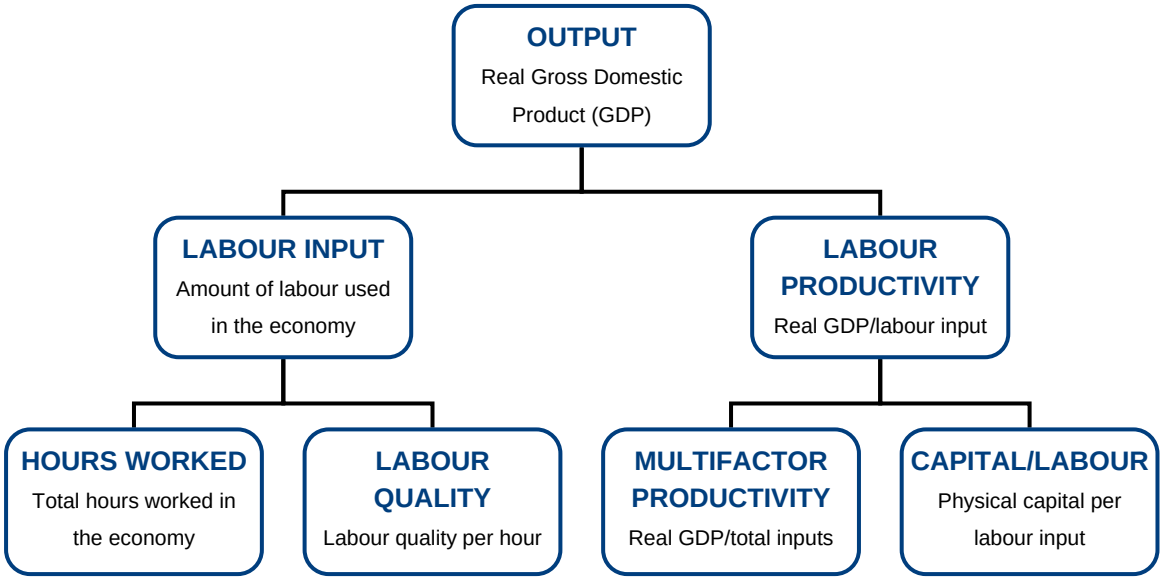
The remainder of the paper is structured as follows. Section 2 provides a summary of international and New Zealand studies on measuring labour quality. Section 3 describes the dataset and the methodology we use to measure labour quality in New Zealand from 1988 to 2005. Results are provided in Section 4, including estimates of quality-adjusted labour input and labour productivity growth. Section 5 discusses the implications from this study and areas of possible future research. A conclusion is provided in Section 6.

2 Previous studies

2.1 International studies

Our study seeks to replicate, with some modifications, international studies that adjust labour input for changes in labour quality. These studies generally use the growth accounting framework to decompose economic growth into the contribution from labour input and the contribution from the residual, labour productivity (*Figure 2*).[2]

Figure 2: Growth accounting framework, including labour quality



Using total hours worked as the measure of labour input means any change in the quality of the workforce will be measured as a change in labour productivity. Therefore, the extent to which changes in labour quality have contributed to labour productivity growth can be estimated. There are two widely-used approaches for estimating labour quality: the "estimated wage model" from the Bureau of Labor Statistics (1993) and the "average wage model" from Jorgensen, Gallop and Fraumeni (1987). These studies acknowledge the difficulties in measuring labour quality, especially the use of wages as a proxy for the productivity of workers, and the use of formal educational qualifications and work experience as a proxy for skill. Our study primarily uses the estimated wage model, but also uses the average wage model as a cross-check on the main results.

The Bureau of Labor Statistics (1993) estimates labour quality in the private business sector of the United States. Firstly, they cross-classify hours worked by educational attainment, work experience, and gender. Secondly, regression analysis is used to identify the impact of these sources of change on labour composition by estimating a wage equation to calculate average wages for cross-categorised groups using unit-record data. Lastly, once wage measures have been estimated, Tornqvist indexes of labour

[2] The growth accounting framework has some limitations. For example, it shows the proximate sources of economic growth, rather than the causes of economic growth, and cannot capture the interactions between the components. Furthermore, labour productivity is a partial productivity measure so can be influenced by changes in the mix of inputs used in production.

input are created, weighting the hours worked of each group by the wage of the group (using the wage from the wage equation). Their results show a rise in labour quality in the United States over the long term (1948 to 1990) in the order of 0.3% per annum, with a small rise of 0.1% per annum from 1973 to 1979 and a large rise of 0.5% per annum from 1979 to 1990.

The other method for estimating labour quality is outlined in Jorgensen *et al* (1987) and updated in Ho and Jorgensen (1999). Ho and Jorgensen (1999) estimate labour quality in the private sector of the United States by dividing the workforce up into small groups by common characteristics such as age, gender, qualifications, industry and employment status. The authors weight the hours worked of each group by that group's share of the total wage bill and add the weighted hours to arrive at an estimate of quality-adjusted hours worked. Their results show a rise in labour quality in the United States over the long term (1948 to 1995) in the order of 0.7% per annum, driven by increasing qualification levels. They find that labour quality in the United States grew by 1.1% from 1948 to 1968, by only 0.1% from 1968 to 1973, and by 0.4% from 1973 to 1995.

Gregg and Wadsworth (2000) show that time in and out of work matters for labour quality. Wages are estimated as a function of age, gender and education, and a dummy variable for whether a worker is a new entrant. They find the average entry wage is around 30-40% lower than the overall average wage in the United Kingdom.

Belorgey, Lecat and Maury (2004) found that the long-term output per worker elasticity with respect to the employment rate is -0.5 across a range of countries. This result implies the productivity of people currently out of work, but who would be the first to be affected by a rise in employment, is on average half that of persons currently in work.

For the euro area, Schwerdt and Turunen (2006) use the Bureau of Labor Statistics approach to find an average rise in labour quality of 0.6% per annum from 1984 to 2004, which accounts for around a third of the rise in labour productivity. They found strong growth in labour quality in the early 1990s (due to increased participation in tertiary education and an ageing population) had moderated towards the end of the decade, possibly due to strong growth in employment of workers with lower human capital.

The Australian Bureau of Statistics (2005) also bases its work on the Bureau of Labor Statistics approach. Their results suggest a far lower *level* of labour productivity over the entire estimation period using a quality-adjusted labour measure, and lower labour productivity *growth* over the period from 1986 to 1997 (with only minor differences for other time periods). From 1982/83 until 1999/2000, quality-adjusted labour input in the market sector rose 33.1%, driven by a 27.9% rise in hours worked and a 5.2% rise in labour quality. Although our study uses the Bureau of Labor Statistics methodology, our work is most similar to this Australian study given the similarity between New Zealand and Australia, including similarities in data availability.

2.2 New Zealand studies

There has been some relevant research on labour quality in New Zealand, including work showing how quality adjustment can be applied in the New Zealand context by McNaughton (2006). Several data issues are outlined by the author, including small sample sizes in some datasets and, as is the case overseas, the need for a number of crude assumptions to estimate labour quality (eg, wages as a proxy for productivity). Although the estimated wage model from the Bureau of Labor Statistics is acknowledged

as providing additional information, the author recommends that the average wage model from Jorgensen *et al* (1987) also be used to provide quality assurance to the results. He notes that a combination of household surveys may be the best sources to use at the moment, although LEED is a rich source of data that may be more useful in the future if it includes information on education and working hours.

The IMF (2002) uses a simplified version of the average wage model to estimate the change in labour quality from 1987 to 2000 in the market sector of New Zealand. They split workers into three groups – no secondary school certification, secondary education, and tertiary education – and relative wages are used to weight the three groups. Average hours worked are assumed to be the same across the three groups of workers and no account is made for work experience. They estimate that New Zealand experienced a rise in labour quality of 0.4% per annum from 1987 to 2000.

Hyslop and Maré (2008) examine compositional changes among workers from 1999 to 2007 using the Linked Employer-Employee Dataset (LEED). They note that real average annual earnings for a full-time equivalent worker rose by about 9% over this period, but that this rise would have been around 15% without compositional changes in employment. The economic upturn from 1999 to 2007 brought many lower-skilled people into the workforce and dampened growth in average real wages (and, by proxy, potentially dampened growth in labour productivity). Hyslop and Maré (2008) find that new entrants to work have earnings that are about 19% lower than the overall sample.

Drew, Dupuy, Downing and Karagedikli (2005) decompose the 18% rise in employment from 1998 to 2005 into five different components to estimate the plausible impact of changes in labour quality. They assume people entering work from short-term unemployment and net immigration are experienced workers, while those from outside the labour force, long-term unemployment and natural population increase are inexperienced. With inexperienced workers accounting for about two thirds of net employment growth from 1998 to 2005, the authors suggest the -0.5 estimate of the dampening effect on labour productivity from Belorgey *et al* (2004), mentioned above, is plausible.

In work comparing productivity levels by industry in New Zealand with the United Kingdom, Mason and Osborne (2007) estimate the impact of changes in labour quality on labour productivity growth for the market sector (excluding the public sector) over the 1995-2004 period. They find that average labour quality is higher in New Zealand than the United Kingdom, although this gap narrowed from 10% in 1998 to 2% in 2004.

3 Dataset and methodology of current study

3.1 Dataset

The data we use come from the Household Labour Force Survey (HLFS) and the New Zealand Income Survey (NZIS). HLFS data on a consistent basis are available from the start of 1986. The HLFS contains information on hours worked for the working-age population[3] and a rich set of variables describing the characteristics of workers that may be useful in identifying labour quality. The HLFS does not include data on wages, which are also needed to estimate differences in labour quality between workers. These data are available from the NZIS. The NZIS has been running each June quarter since 1997 to collect data on incomes and wages as an annual supplement to the HLFS. In this study, each individual unit record of NZIS was linked to the HLFS for the corresponding quarter by a unique identifier. The linked data were made available to the Treasury in the Statistics New Zealand data laboratory.

The sampling unit of the HLFS is household dwellings and the sample size is around 15,000 households. This number of households equates to approximately 30,000 people (almost 1% of the New Zealand working-age population), with a response rate of around 85% to 90%. Households are part of the HLFS sample for up to eight quarters before they are replaced by a new group of households. Usually, there are eight different cohorts of households each quarter. For each quarter, individuals have observations of their labour force status for up to eight successive quarters, although this varies depending on how long each person has been in the survey. For example, a new cohort does not have any measure of labour force status for the previous period. Respondents are classified to one of three labour force states for the week they are surveyed: employment (in work of at least one hour a week for pay or profit), unemployment (not in work but *both* available for *and* actively seeking work), or not in the labour force (not in work and *either* not available for work *or* not actively seeking work).

The dataset allows us to construct a partial indicator to proxy whether or not a person was unemployed or not in the labour force in previous periods. It is important to note that the data do not give us the historical labour force status for all the individuals for the same period due to the rolling panel design of the survey.

The Quarterly Employment Survey (QES) has been the basis of labour input data used by Statistics New Zealand to estimate productivity, with any gaps filled by the HLFS and Census of Population and Dwellings (the QES has a smaller coverage of industries and self-employment). Statistics New Zealand chose the QES because household data can have poor industry coding and larger sample errors than a survey of businesses such as the QES.[4] Nevertheless, HLFS hours worked are preferred in this study because the QES lacks information for quality adjustment (eg, qualifications, age) and measures only paid hours, which can differ from actual hours worked (eg, due to paid leave).

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[3] The HLFS defines working-age population as the usually resident, non-institutionalised, civilian population of New Zealand aged 15 years and over. This differs from a common definition overseas that restricts working age to those aged 15-64 years.

[4] In measuring labour input, Statistics New Zealand has moved to make more use of LEED, partly because of its large sample size and full coverage of industries. With detailed data on job tenure, LEED may be able to measure labour quality in the future once a long enough time series is available (1999 is the first year of LEED) and if information on education and working hours is included.

3.2 Wages as a proxy for productivity

For determining the impact of changes in labour quality on productivity, we use wages as a proxy for productivity. Wages are measured as actual hourly earnings from the main wage and salary job worked by individuals aged 15 years and over. This coverage includes self-employed people if they earn a wage or salary. Following the approach developed by the Bureau of Labor Statistics (1993), the first step in developing an index of quality-adjusted labour inputs is to estimate wage equations for men and women separately. These equations relate hourly earnings to a range of explanatory factors such as education and age. For estimation, we use the log of hourly wages in the NZIS as the dependent variable in the weighted regression. In this study, we specifically introduce a dummy variable to indicate whether or not a person was unemployed or not in the labour force in any of the previous quarters (up to seven) they were included in the survey. The dummy variable (L) takes on values of one or zero, with one indicating they were out of work in any of the previous quarters they were in the survey and zero indicating they were not out of work in any of the previous quarters they were in the survey. The purpose of this dummy variable is to examine the effect of new entrants into employment on wages. Apart from the entry dummy variable, other explanatory variables we use in the estimation are as follows.

3.2.1 Formal education

The skills gained from formal educational qualifications in school and/or post-school (tertiary) are a key element of a worker's labour quality. We group workers into one of five classifications: no qualifications; school qualifications only (ie, no post-school qualification); post-school qualifications only (ie, no school qualification); school qualifications and either a vocational certificate or a diploma; and school qualifications and a Bachelor degree and/or higher degree as the worker's highest qualification. One limitation of this approach is that the quality of qualifications will vary by educational institution and over time. Changes in relative wages by qualification will partly account for these differences, although not before 1997 as we use wage information from 1997, the first year of the NZIS, to estimate labour quality from 1988 to 1997.

3.2.2 Work experience and on-the-job training

We use age as a simple proxy for the human capital not accumulated from formal educational qualifications. Wages and productivity are likely to increase with age, at least up until prime age. This relationship is expected to be concave, with diminishing returns to work experience caused by workers investing less in human capital as they approach retirement.

3.2.3 Other variables

Other variables used in the wage equation are whether the person lives in an urban or rural location, ethnicity (Māori, Pacific, Asian, European),[5] full-time (30 hours or more a week) or part-time (fewer than 30 hours a week) employment status, and marital status

[5] For simplicity, this study groups people with multiple ethnicities into European. The Asian ethnic group largely consists of people of Chinese or Indian ethnicity but includes a small number of people with other (sole) ethnicities (eg, African). In published HLFS and NZIS data, the Asian ethnic group is termed 'Other', and people with multiple ethnicities are assigned to one group using the following prioritisation: Māori, Pacific, Other, and European (eg, someone who is Māori and Pacific will be counted as Māori).

(married/living as married, separated, divorced/marriage dissolved, widowed, never married). The dummy variable for marital status takes on a value of one if respondents are married/living as married.

3.3 Wage equations

The functional form of the wage equation is expressed as follows:

$$\ln(W) = \alpha + \beta_1 AGE + \beta_2 AGE^2 + \beta_3 L + \beta_4 E1 + \beta_5 E2 + \beta_6 E3 + \beta_7 E4 + \lambda' X \quad (1)$$

where W is the hourly wage, AGE refers to age of the individual and L is the dummy variable for individuals who were out of work for any of the last seven quarters. The control variables also include four qualification dummy variables, E1 for school only, E2 for post school only, E3 for school and certificate/diploma and E4 for school and degree. X is a 6-element vector of other dummy variables that account for differences in urban/rural areas, ethnicity, full-time/part-time employment status and marital status, and λ is the coefficient vector for the corresponding dummy variables. The linear and quadratic terms for age represent a parabolic age-earnings profile.

In our base case, we adjust the quality of the labour input by only taking account of changes in the skills of workers arising from changes in education, work experience and gender. Therefore, the price of labour used to weigh the labour input cannot be derived directly from equation (1) but from the following equation:

$$\ln(W) = \omega + \beta_1 AGE + \beta_2 AGE^2 + \beta_4 E1 + \beta_5 E2 + \beta_6 E3 + \beta_7 E4 \quad (2)$$

where

$\omega = \alpha + \beta_3 \bar{L} + \lambda' \bar{X}$ and the overhead bar denotes the mean value of the variable.

In the case of using work experience as the only factor affecting labour composition, the equation used to predict wages is shown as follows:

$$\ln(W) = \omega + \beta_1 AGE + \beta_2 AGE^2 + \beta_4 \overline{E1} + \beta_5 \overline{E2} + \beta_6 \overline{E3} + \beta_7 \overline{E4} \quad (3)$$

In this study, we estimate wage equations for each year for the period 1997 to 2004. Using the estimated equation (2), we construct the predicted wages for each unit of the HLFS for the corresponding March year. Prior to the March 1997 year, we use the coefficients of the estimated wage equation for 1997 to obtain the predicted hourly wages. For the March 2005 year, we predict wages based on coefficient estimates for the previous year.

3.4 Constructing an index of labour input

Before we construct an index of labour input, we group workers into different categories. In our base case, each unit of the data is classified by gender, five education categories and ten age categories. Workers are grouped into five-year age bands from age 15 to 59 years, with a final age group of 60 years and over. As a result, there are one hundred types of worker in our base case. A matrix of hours worked by gender, education and age is constructed for each year for the period 1988 to 2005.

In this study, we choose the chained Tornqvist index formula to aggregate labour inputs, following the approach used by Statistics New Zealand (2007). McLellan (2004) discusses various index formulae, suggesting the Tornqvist index is "exact" for translog production technology. In other words, the Tornqvist index formula has an implicit economic underpinning. Furthermore, the Tornqvist passes three of four axiomatic tests: the constant quantities test, the proportionality test and the time reversal test. The Tornqvist index does not pass the constant basket test.

In our base case, the matrix of hourly wages is based on the weighted average of the predicted wages for each type of worker. As discussed in the previous section, the predicted wage of each individual in the HLFS is based on coefficient estimates from equation (2). The matrix of hourly wages is then combined with information on the matrix of hours worked to estimate each group's total wages, which are then used as the weights for each type of worker in the Tornqvist formula.

In order to test the robustness of our weights, we also construct the weights using the average wage method developed by Jorgenson *et al* (1987). A wage rate for each type of worker is based on the weighted average of actual wages for each NZIS.

The Tornqvist index formula is defined as follows:

$$Q_t = \prod_{i=1}^{I} \left(\frac{H_{it}}{H_{it-1}} \right)^{\frac{1}{2}(w_{it}+w_{it-1})} \tag{4}$$

where Q_t is the aggregate labour input, H_{it} refers to total hours worked of the i^{th} type of the labour force in period t and w_{it} represents the weight for the i^{th} type of workers for period t.

The weight w_{it} is given by:

$$w_{it} = \frac{\hat{W}_{it} H_{it}}{\sum_i \hat{W}_{it} H_{it}} \tag{5}$$

where $\hat{W}_{it}$ is the estimated hourly wage for the i^{th} type of worker and is based on the hourly wage matrix we have just discussed above.

Changes in the aggregate labour index can be decomposed into changes in total hours worked (H) and changes in labour composition (LC). The growth rate of LC can be computed using the following equation:

$$\Delta \ln LC = \Delta \ln Q - \Delta \ln H \tag{6}$$

4 Results

4.1 Estimated wage equations

The results of the estimation of wage equations for men and women are presented in *Table 1* and *Table 2* respectively. In general, all the estimated coefficients have the expected signs and are all significantly different from zero at the 1% level. In particular, the wage equation for men fits the data reasonably well with adjusted R-squared values ranging from 0.30 to 0.37 between 1997 and 2004. The measure of fit is slightly worse for the female wage equation, implying it is more difficult to model female earnings. The adjusted R-squared values for the female wage equation vary from 0.23 to 0.32.

Although the intercept term of the wage equation is higher for women than men on average, male workers still earn more than female workers because the estimated age coefficients for men are larger than those for women. In other words, the return to work experience (age) is higher for men than for women. This is likely to be because women tend to spend more time out of the workforce, for example, to raise children.

Table 1: Estimated male wage equations for the period 1997-2004

Parameter	1997	1998	1999	2000	2001	2002	2003	2004
Age	0.049	0.058	0.046	0.053	0.044	0.050	0.046	0.043
	(192.1)	(226.3)	(184.3)	(203.4)	(183.0)	(205.7)	(179.3)	(207.7)
Age^2	-0.0005	-0.0006	0.0005	-0.0006	0.0005	-0.0005	0.0005	0.0004
	(-167.0)	(-196.0)	(-155.1)	(-175.5)	(-153.5)	(-181.0)	(-151.7)	(-174.6)
L	-0.101	-0.062	-0.097	-0.097	-0.079	-0.117	-0.072	-0.094
	(-53.9)	(-34.9)	(-44.3)	(-51.2)	(-45.9)	(-65.2)	(-38.0)	(-61.1)
E1	0.191	0.140	0.190	0.194	0.164	0.148	0.143	0.164
	(127.7)	(98.0)	(124.8)	(128.0)	(110.1)	(96.3)	(88.0)	(123.1)
E2	0.125	0.131	0.115	0.131	0.112	0.095	0.080	0.123
	(68.1)	(75.9)	(62.1)	(70.6)	(61.3)	(53.0)	(41.3)	(76.6)
E3	0.275	0.240	0.275	0.272	0.246	0.253	0.242	0.269
	(194.6)	(180.0)	(189.0)	(191.1)	(174.1)	(175.4)	(156.3)	(208.2)
E4	0.488	0.465	0.501	0.488	0.460	0.485	0.527	0.523
	(271.8)	(277.7)	(281.2)	(277.3)	(271.7)	(276.0)	(281.7)	(345.8)
Urban	0.078	0.072	0.092	0.087	0.076	0.081	0.073	0.073
	(65.9)	(66.8)	(78.8)	(74.8)	(67.0)	(70.2)	(59.9)	(73.8)
Asia	-0.122	-0.107	-0.062	-0.088	-0.157	-0.168	-0.186	-0.171
	-(47.7)	-(46.6)	-(27.0)	-(38.4)	-(78.1)	-(83.3)	-(88.8)	-(107.0)
Pacific	-0.187	-0.181	-0.187	-0.188	-0.211	-0.220	-0.202	-0.143
	-(71.6)	-(70.7)	-(75.3)	-(78.2)	-(88.2)	-(93.2)	-(82.5)	-(72.5)
Māori	-0.075	-0.025	-0.019	-0.064	-0.068	-0.055	-0.026	-0.060
	-(36.8)	-(12.9)	-(9.0)	-(32.9)	-(35.8)	-(29.7)	-(12.9)	-(34.8)
Fulltime	0.228	0.176	0.252	0.251	0.219	0.185	0.206	0.191
	(126.8)	(106.5)	(146.8)	(148.6)	(131.1)	(110.0)	(113.7)	(129.6)
Married	0.098	0.106	0.137	0.084	0.121	0.102	0.105	0.089
	(77.9)	(92.0)	(111.3)	(68.7)	(103.2)	(85.2)	(83.3)	(85.7)
Constant	1.121	1.055	1.128	1.090	1.305	1.279	1.345	1.444
	(248.7)	(238.1)	(250.9)	(239.5)	(301.6)	(290.9)	(288.7)	(381.0)
Adjusted R^2	0.36	0.37	0.35	0.34	0.33	0.32	0.30	0.37

Note: t-statistics reported in parentheses

Figures 3 and *4* show the indexes of hourly wages for selected years by age for men and women respectively. The indexes are derived from the estimated coefficients on age and the quadratic term of age. The most striking difference between the profiles by gender is that earnings for men peak at a higher level than for women. Earnings for both men and women peak around the age of 45 to 50 years and then fall slightly thereafter.

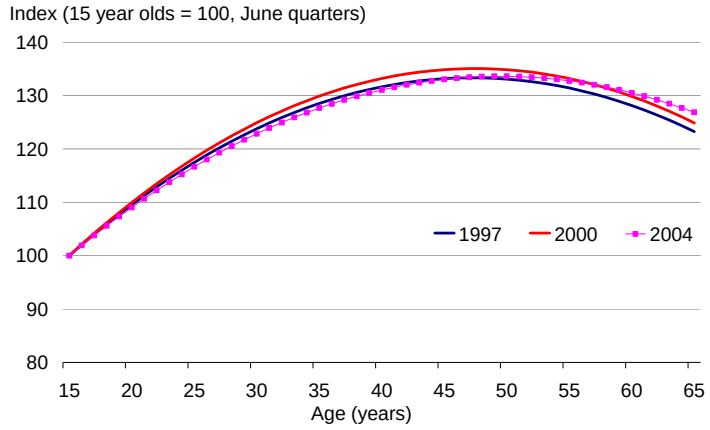
From the estimated education dummy variable coefficients, our results suggest the payoff of additional education for women is similar to that for men. *Figure 5* shows indexes of hourly wages by education level for New Zealand men and women. Again, the indexes are constructed using the estimated coefficients of the dummy qualification variables. The index is equal to 100 for workers with no qualification. On average, a New Zealand male with a degree or higher earned 49% more per hour than a male with no qualification over the period 1997–2004. The comparable figure for women was 47%. Our findings are different from those in Australia. After holding other explanatory variables constant, the hourly wages for an Australian male degree graduate in 1999 were 43% higher than an Australian male with no qualification while the comparable figure was only 34% for Australian women.

Table 2: Estimated female wage equations for the period 1997-2004

Parameters	1997	1998	1999	2000	2001	2002	2003	2004
Age	0.032	0.043	0.041	0.038	0.040	0.043	0.037	0.039
	(145.5)	(193.9)	(192.0)	(145.7)	(196.1)	(189.4)	(149.7)	(180.9)
Age^2	-0.0003	-0.0005	-0.0004	-0.0004	-0.0004	-0.0005	-0.0004	-0.0004
	-116.5	-166.2	-163.1	-117.9	-167.7	-166.4	-126.8	-156.4
L	-0.089	-0.051	-0.101	-0.060	-0.087	-0.061	-0.078	-0.080
	-60.5	-36.8	-63.6	-35.4	-68.6	-42.5	-50.4	-57.8
E1	0.197	0.147	0.182	0.159	0.145	0.139	0.130	0.161
	(136.3)	(106.7)	(132.3)	(102.5)	(110.7)	(95.2)	(81.8)	(114.8)
E2	0.179	0.085	0.119	0.066	0.118	0.083	0.082	0.120
	(83.7)	(40.7)	(58.6)	(29.0)	(60.5)	(41.0)	(35.7)	(58.9)
E3	0.315	0.253	0.277	0.253	0.252	0.234	0.248	0.282
	(222.5)	(188.4)	(207.5)	(166.3)	(199.7)	(165.5)	(159.2)	(204.1)
E4	0.462	0.489	0.509	0.456	0.468	0.458	0.459	0.477
	(244.6)	(281.2)	(303.1)	(238.8)	(296.7)	(262.6)	(249.6)	(291.6)
Urban	0.095	0.068	0.099	0.116	0.109	0.096	0.097	0.097
	(80.0)	(60.6)	(92.5)	(94.6)	(108.4)	(85.3)	(80.0)	(91.1)
Asia	-0.083	-0.109	-0.041	-0.059	-0.110	-0.097	-0.072	-0.130
	-33.1	-47.1	-20.1	-24.2	-59.2	-48.2	-35.0	-72.5
Pacific	-0.143	-0.069	-0.109	-0.152	-0.175	-0.174	-0.137	-0.150
	-55.2	-27.0	-46.3	-59.4	-80.7	-73.1	-53.4	-65.8
Māori	-0.074	-0.031	-0.050	-0.089	-0.081	-0.095	-0.089	-0.037
	-36.0	-16.1	-26.1	-43.8	-47.6	-52.1	-45.1	-20.1
Fulltime	0.119	0.122	0.179	0.181	0.145	0.144	0.131	0.147
	(113.0)	(121.6)	(187.4)	(163.4)	(158.7)	(139.3)	(118.8)	(149.1)
Married	0.060	0.067	0.062	0.077	0.067	0.070	0.080	0.050
	(52.2)	(61.0)	(58.2)	(63.9)	(67.5)	(63.3)	(68.0)	(47.7)
Constant	1.392	1.295	1.271	1.352	1.385	1.387	1.508	1.504
	(334.7)	(317.3)	(313.7)	(285.9)	(363.7)	(330.7)	(326.2)	(375.0)
Adjusted R^2	0.24	0.27	0.32	0.25	0.31	0.26	0.23	0.28

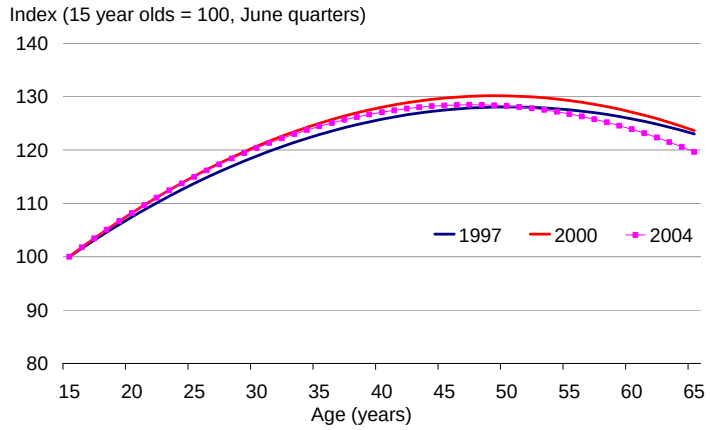
Note: t-statistics reported in parentheses

Figure 3: Indexes of hourly wages for men by age group



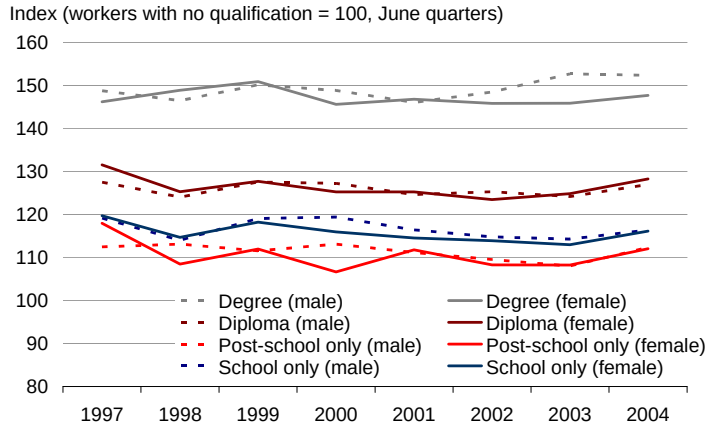
Sources: Statistics New Zealand, The Treasury

Figure 4: Indexes of hourly wages for women by age group



Sources: Statistics New Zealand, The Treasury

Figure 5: Indexes of hourly wages by qualification by gender



Sources: Statistics New Zealand, The Treasury

The coefficients on the "out of work" dummy variable vary from -0.062 to -0.117 with an average of -0.09 for the male wage equation. The results suggest the wage premium paid to male workers already in employment over male workers newly entering a job is in the order of 10%. The wage gap for women is estimated to be around 7% over the same period. Our estimates are smaller than those in the United Kingdom of approximately 30-

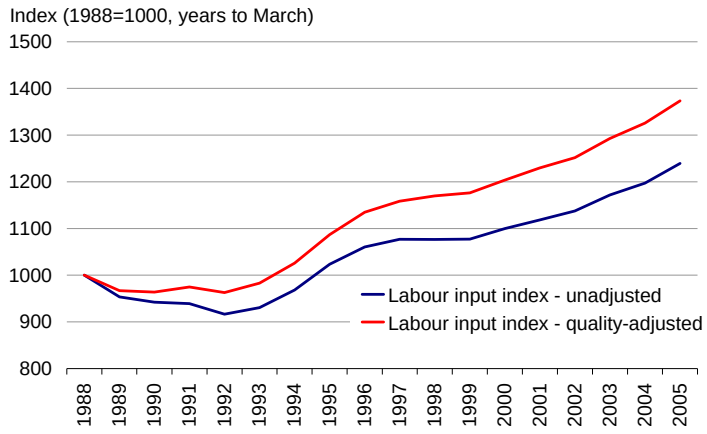
40% (Gregg and Wadsworth, 2000), and those in previous estimates for New Zealand of around 19% (Hyslop and Maré, 2008). The difference is likely to be due to different definitions of new entrant. In our study, a new entrant is a worker who was not in work in any of up to seven quarters previously, which may be picking up the effect of employment churn (people exiting work and entering work again) rather than just the effect of new entrants to the workforce. In Gregg and Wadsworth (2000), a new entry job was defined as a job with tenure of up to three months filled by an individual out of work in the previous quarter. In Hyslop and Maré (2008), a new entrant was someone not observed in the first year (1999) but observed in the last year (2007) of the study.

From the estimated coefficients for the Asian ethnic group, the relative wages for an Asian male underwent a dramatic fall. In 1997, the hourly wage of an Asian male was about 12% less than the hourly wage of a European male; by 2004, the difference had expanded to 17%. This reduction likely reflects the influx of Asian migrants over this period. Another possible explanation is that qualifications and work experience gained by migrants overseas are not fully recognized or are discounted in New Zealand.

4.2 Quality-adjusted labour input

Once adjusted for changes in the composition of workers by gender, age and qualification, the labour input index grew by 37.3%, or an annual rate of 1.9%, over the period 1988-2005 (*Figure 6,* and *Table A1* in the Appendix). For the corresponding period, the unadjusted index (ie, total hours worked) grew by 23.9%, or an annual rate of 1.3%.

Figure 6: Indexes of labour input



Sources: Statistics New Zealand, The Treasury

The difference between the growth in quality-adjusted labour input and total hours worked is equal to the change in the composition of workers. Using equation (6), we find that the index of labour composition increased by 11.1% or by 0.6% per annum on average from 1988 to 2005.[6] Therefore, about one-third of the growth in labour input came from the increase in labour quality over the entire period.

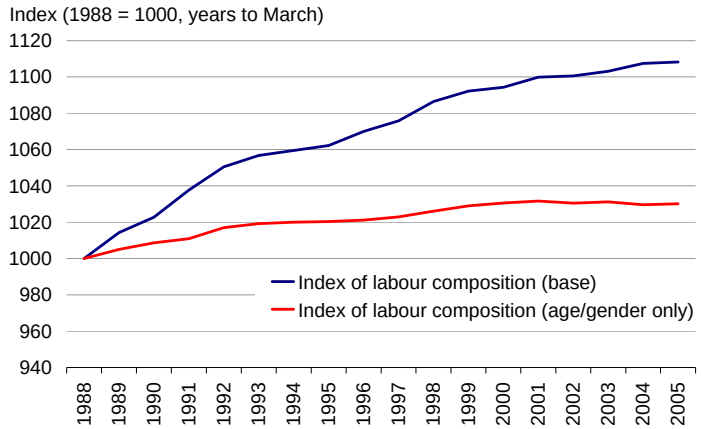
[6] Using the average wage model (Jorgenson method), the quality-adjusted labour input index grew at an annual rate of 1.7% and the labour composition index grew at an annual rate of 0.5% over the 1988-2005 period. These results are similar to the 1.9% rise in the quality-adjusted labour input index and the 0.6% rise in the labour composition index using the Bureau of Labor Statistics method.

If we adjust only for changes in labour composition resulting from the demographic variables age and gender, the quality-adjusted labour index grew by about 28% between 1988 and 2005 and the index of labour composition grew by only 3%. Therefore, changes in demographic structures accounted for less than 30% of the growth in labour composition and the remaining 70% came from rising qualification levels among workers.

Although average labour quality rose in every year of this period, the rise was not constant over time. To show the difference within the full sample period, we split our sample period roughly in half for simplicity: 1988 to 1997 and 1997 to 2005. The increase over the first half of the period (1988-1997) was 0.8% per annum on average and the increase over the second half of the period (1997-2005) was 0.4% per annum on average. The different pattern of labour composition growth in the two periods is partly driven by changes in the age structure of the workforce and partly by changes in qualification levels.

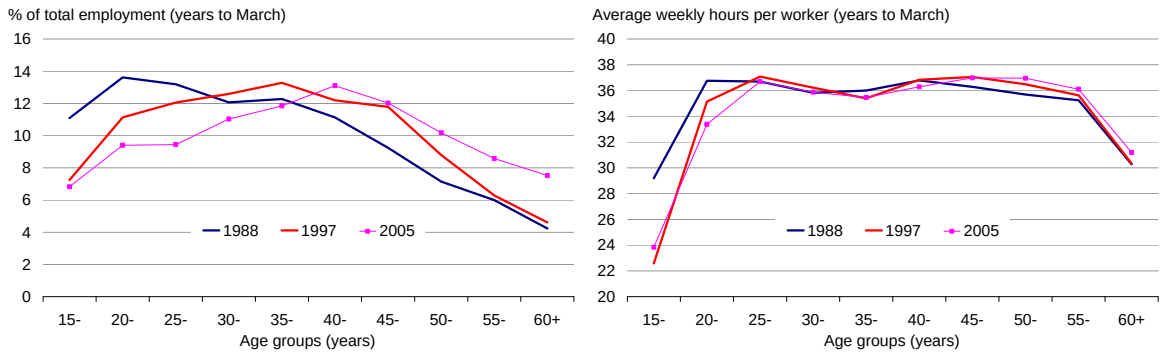
Labour composition adjusted for gender/age rose slowly from 1988 until the late 1990s and was then virtually unchanged (*Figure 7*). From 1988 to 1997, the share of hours worked by 15 to 24-year-olds dropped significantly and the peak of the distribution shifted from 20 to 24-year-olds to 35 to 40-year-olds as a smaller proportion of younger people were in work and average working hours for younger people declined (*Figure 8*). Since 1997, the age structure of the distribution of hours worked has been more stable.

Figure 7: Indexes of labour composition



Sources: Statistics New Zealand, The Treasury

Figure 8: Employment and average hours worked by age group

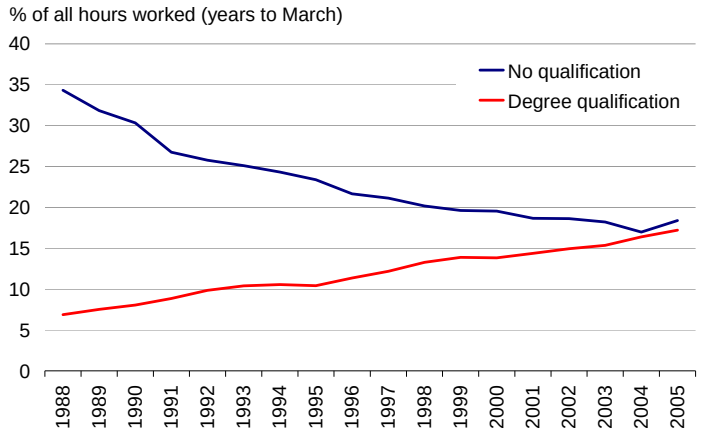


Sources: Statistics New Zealand, The Treasury

As indicated above, rising educational attainment among workers accounted for more than 70% of the growth in labour composition. Factors behind this include raising the school leaving age from 15 to 16 years in the 1990s and a sharp rise in tertiary education participation. The proportion of hours worked by people with a degree qualification rose from 7% in the March 1988 year to 17% in the March 2005 year (*Figure 9*). Conversely, only 18% of hours worked were by people without qualifications in the March 2005 year, down from 34% in the March 1988 year, although largely unchanged from 19% in the March 2001 year. It can therefore be seen that growth in the level of education was more rapid over the first half of the sample period in comparison with the later half of the sample period.

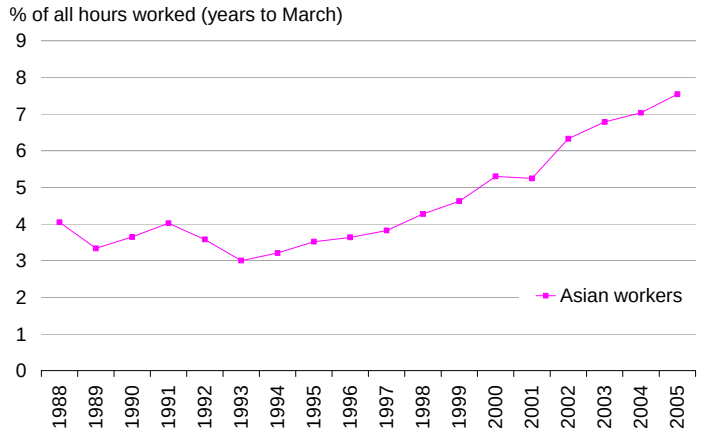
The recent large net inflow of migrants, especially from Asian countries, appears to have had little impact on average labour quality. The proportion of hours worked by Asian workers rose sharply from 3.8% in 1997 to 7.5% in 2005 (*Figure 10*). Also, the results of the estimated wage equations above suggest there was an average negative wage gap of 13% and 9% for Asian men and women respectively compared with European workers. However, the impact of the negative wage gap on growth in labour quality is fully offset by the higher education level of Asian workers. For Asian workers, the proportion of hours worked by a graduate at degree level or above increased from 26.8% in 1997 to 37.6% in 2005. The comparable figures for Europeans were 12.5% in 1997 and 16.8% in 2005.

Figure 9: Hours worked by qualification



Sources: Statistics New Zealand, The Treasury

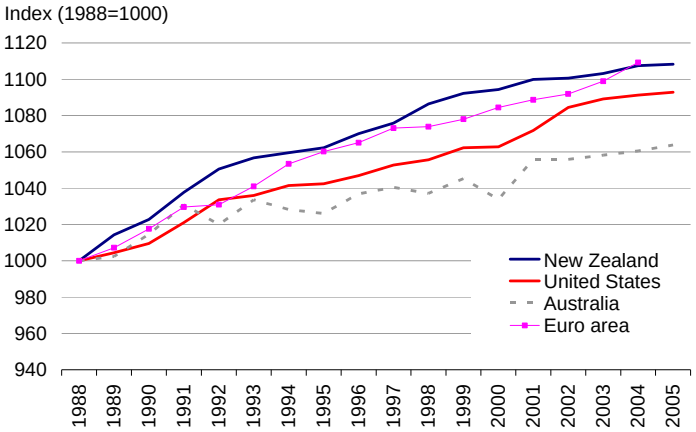
Figure 10: Hours worked by Asian workers



Sources: Statistics New Zealand, The Treasury

The average rise in labour quality of 0.6% per annum in New Zealand from 1988 to 2005 is relatively similar to the experience of Australia (0.4%) and the United States (0.5%). For the euro area, labour quality rose by 0.6% per annum on average from 1988 to 2004 (*Figure 11*). The slightly larger rise in New Zealand and the euro area may be because the other estimates cover only the market sector rather than the whole economy.

Figure 11: Comparisons with labour composition indexes from other countries



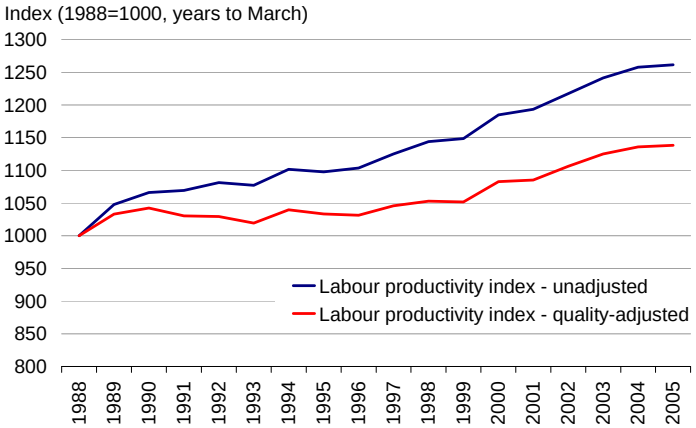
Sources: Statistics New Zealand, The Treasury, Australian Bureau of Statistics, Bureau of Labor Statistics, European Central Bank

4.3 Labour productivity indexes

Adjusting for labour quality helps us understand the recent productivity performance. From 1988 to 2005, labour productivity measured as output per quality-adjusted labour input rose 0.8% per annum, with annual growth of 1.1% in the second half of the period (1997 to 2005) and 0.5% in the first half (1988 to 1997). By comparison, unadjusted labour productivity growth averaged 1.3% to 1.4% in both halves of the period (*Figure 12* and *Table A2* in the Appendix compare unadjusted and quality-adjusted figures).

Although the rise in labour quality in New Zealand was broadly comparable to that of other nations from 1988 to 2005, as discussed above, annual growth in quality-adjusted labour productivity of 0.8% in New Zealand over this period was lower than in the euro area and United States (both around 1.3%) and Australia (around 2%).

Figure 12: Labour productivity indexes



Sources: Statistics New Zealand, The Treasury

5 Implications and future research

5.1 Implications

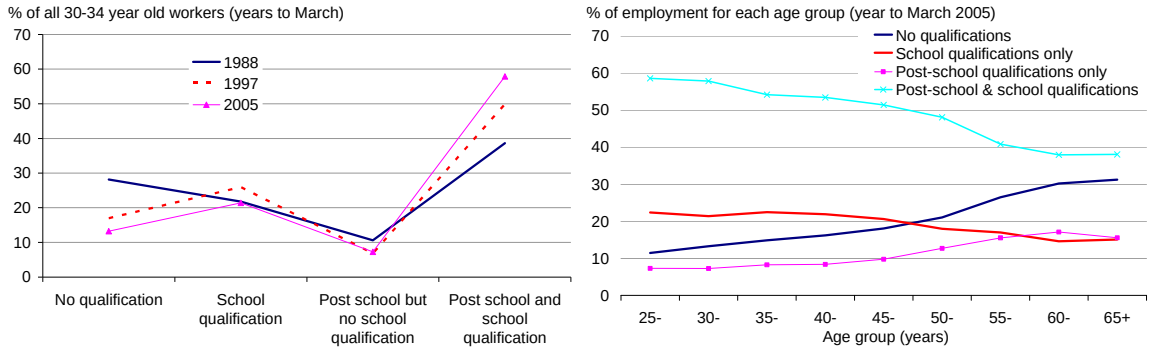
There has been much debate about whether productivity growth has slowed in recent years and, if so, why it has slowed. A common comparison shows lower labour productivity in the period since 2000 relative to the 1990s. This paper suggests current productivity growth estimates are inflated for much of the 1990s relative to the late 1990s and 2000s by changes in labour quality. If labour input is adjusted for changes in quality, in addition to quantity, labour productivity growth rises since the late 1990s.

The rise in labour quality has been less in the recent period because the upskilling and ageing of the workforce largely occurs before 2000. Qualifications at degree level rose from a low base in the mid 1980s to a rate more typical of developed economies by the late 1990s, with some stabilisation since. This rise lifted qualification levels and lowered the proportion of hours worked by 15 to 24-year-olds because of time spent studying. An ageing of the workforce also shifted the distribution of hours worked to older age groups, but not by as much in recent years.

The business cycle is also likely to have had an impact on labour quality. The only times the labour quality index grows by at least 1% per annum are in economic downturns (ie, 1989, 1991, 1992, and 1998) because low-skilled workers are generally the first to be laid off in a downturn. The relatively long economic upturn since 1999 has led to a large rise in the number of workers and this rise appears to have been concentrated among the lower-skilled. These compositional changes may have lowered growth in the average quality of labour input from that seen in the late 1980s and 1990s.

Looking forward, labour quality is likely to rise further over the medium term. Firstly, we will likely see a further increase in qualification levels of the workforce as older cohorts with lower average qualification levels continue to be replaced by younger cohorts with higher average qualification levels (*Figure 13*).

Figure 13: Qualifications by age cohort



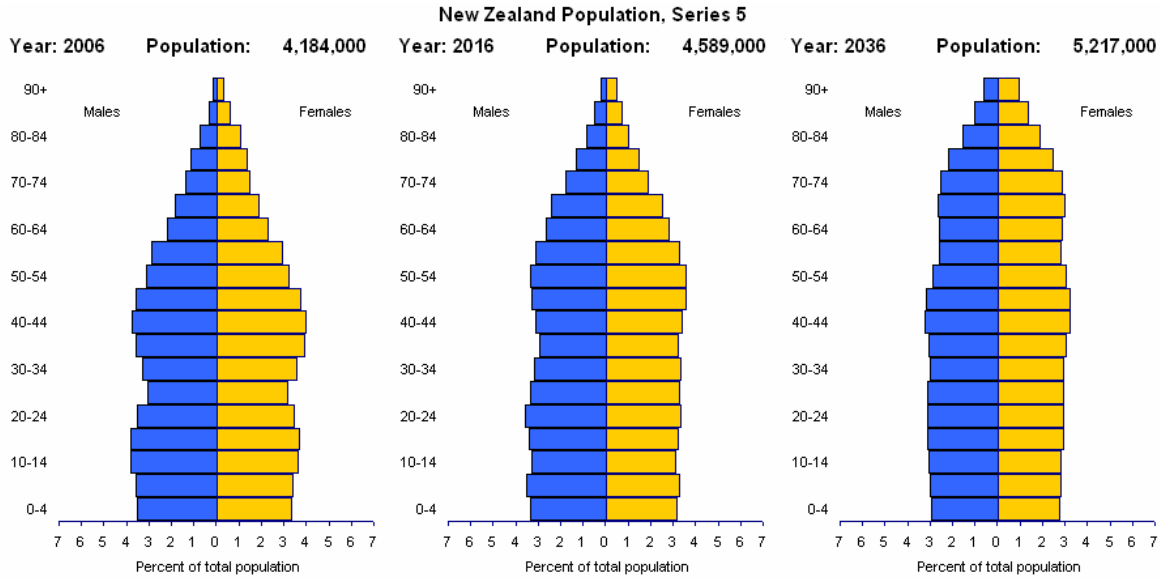
Sources: Statistics New Zealand, The Treasury

Secondly, we do not expect a dampening impact from a large increase in the quantity of lower-skilled labour input as may have occurred since 1999. The unemployment rate has tracked in a low and narrow range of 3.4% to 3.9% for the past three years and the

participation rate is very high on an historical basis and relative to other OECD nations. In the event of a cyclical downturn in the labour market, estimates of average labour quality could be boosted if new entrants to the workforce lose their jobs.

Lastly, an ageing workforce may have a further positive impact in terms of increasing work experience. The baby-blip cohort (currently 15 to 24 years old) moves into older groups over the next decade, and the 40 to 49 year group continues to make up a large proportion of the population (*Figure 14*). The following two decades may see a negative influence on labour quality as the large number of baby boomers retire or pass the age (about 50 years old) up to which average quality rises. However, there may be a positive influence on labour productivity from a flattening age structure if workers of different ages are complementary rather than perfectly substitutable (Prskawetz and Fent, 2007).

Figure 14: Age structure of the New Zealand population, 2006, 2016 and 2036



Source: National Population Projections: 2006 (base) – 2061, Statistics New Zealand

5.2 Future research

One finding from this study that may be worth further investigation is the recent rise in the proportion of hours being worked by people with low levels of qualification. This may be due to the greater incentive to work from a tight labour market and higher minimum wage encouraging people to work rather than study towards higher qualifications. This type of impact may have dampened growth in average labour quality in recent years.

Statistics New Zealand plans to conduct further research on labour quality. An experimental series on labour quality, due for release later in 2008, will add to the debate about how changes in labour quality have affected productivity data. Possible improvements could include a better proxy of work experience rather than using age as in this study, for example age minus years spent in school, which could be based on qualification minus a year for each child for women as in Australia, or from tenure data in LEED.

6 Conclusion

The average characteristics of today's workers are significantly different from their counterparts in the late 1980s. New cohorts of workers have much higher qualification levels than older cohorts, labour force participation among women has continued to trend up, immigrants have increasingly been sourced from Asia, and the large baby-boom cohort has contributed to an ageing of the workforce.

Our estimates of labour quality, based largely on educational attainment and age, suggest labour quality has risen considerably since 1988. The drivers of higher labour quality are increasing qualifications, particularly at university degree level, and, to a lesser extent, an ageing of the workforce. The rise in labour quality in New Zealand is similar to that experienced in Australia, the United States and the euro area.

Adjusting labour input for changes in labour quality has implications for productivity. On the one hand, our results show that labour productivity growth may be overestimated when labour input is not adjusted for changes in labour quality. This overestimation means that labour productivity has made a smaller contribution to economic growth than previously estimated.

On the other hand, rising labour quality, particularly the part caused by rising qualification levels, should be seen as a positive trend. We have also advanced our understanding of the proximate sources of labour productivity growth, with rising labour quality accounting for almost half of existing estimates of labour productivity growth across the New Zealand economy.

Furthermore, how labour quality evolves over time helps us interpret the recent slowdown in labour productivity growth. The rise in labour quality was much smaller in the second half of our sample period than in the first half, possibly due to a large increase in the employment of lower-skilled workers in the recent upturn. A measure of underlying growth in labour productivity (ie, output per quality-adjusted working hour) rose from 0.5% per annum in the first half of the sample period to 1.1% per annum in the second half.

The analysis presented in this paper tentatively suggests that current estimates of labour productivity growth (ie, including changes in labour quality) could return to trend and average around 1½% per annum over the next five years.[7] Our estimate of underlying growth in labour productivity (ie, excluding changes in labour quality) has tracked around 1% per annum in the recent period and the outlook is for labour quality growth to return to a trend rate of around ½% per annum. One cause for optimism is that, since the end of the 1988 to 2005 period we study, economy-wide labour productivity growth has lifted to an eight-year high of 2.6% in the year to December 2007.

[7] The next five years covers the forecast period used in Treasury's *Economic and Fiscal Updates*.

7 Appendix: Tables

Table A1: Labour input indexes and growth, 1988-2005 (1988=1000)

Year to March	Current labour input (hours worked)	Quality-adjusted labour input	Labour quality
1988	1000.0	1000.0	1000.0
1989	953.2	966.8	1014.3
1990	942.2	963.6	1022.7
1991	939.2	974.6	1037.8
1992	916.5	962.8	1050.5
1993	930.3	983.1	1056.7
1994	968.2	1025.8	1059.5
1995	1023.3	1086.9	1062.2
1996	1060.4	1134.6	1070.0
1997	1076.8	1158.4	1075.8
1998	1076.5	1169.5	1086.4
1999	1077.2	1176.5	1092.2
2000	1099.8	1203.6	1094.3
2001	1118.3	1229.9	1099.8
2002	1137.3	1251.7	1100.6
2003	1171.9	1292.7	1103.1
2004	1197.0	1325.6	1107.5
2005	1239.3	1373.4	1108.2
Annual growth			
1988-1997	0.8%	1.6%	0.8%
1997-2005	1.8%	2.1%	0.4%
1988-2005	1.3%	1.9%	0.6%

Table A2: Labour productivity indexes and growth, 1988-2005 (1988=1000)

Year to March	Output (real Gross Domestic Product)	Output per hour worked	Output per quality-adjusted labour input
1988	1000.0	1000.0	1000.0
1989	998.7	1047.7	1033.0
1990	1004.5	1066.2	1042.5
1991	1004.1	1069.1	1030.2
1992	990.9	1081.2	1029.2
1993	1001.9	1077.0	1019.2
1994	1066.4	1101.5	1039.6
1995	1123.2	1097.7	1033.4
1996	1170.1	1103.5	1031.3
1997	1211.3	1124.9	1045.6
1998	1231.5	1144.0	1053.0
1999	1237.1	1148.5	1051.6
2000	1303.1	1184.8	1082.7
2001	1334.5	1193.4	1085.1
2002	1384.7	1217.5	1106.2
2003	1454.7	1241.3	1125.3
2004	1505.7	1257.9	1135.9
2005	1563.3	1261.5	1138.3
Annual growth			
1988-1997	2.1%	1.3%	0.5%
1997-2005	3.2%	1.4%	1.1%
1988-2005	2.6%	1.4%	0.8%

8 References

Australian Bureau of Statistics (2005) “Quality-adjusted labour inputs.”, Canberra, Australian Bureau of Statistics, Category Number 1351.0.55.010, November. <http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/320D6EBEFD72D5D3CA2570BB0072AA95/$File/1351055010_nov%202005.pdf>

Belorgey, N., R. Lecat and T-P. Maury (2004) “Determinants of productivity per employee: An empirical estimation using panel data.”, Banque de France Working Paper Number 110. <http://www.banque-france.fr/gb/publications/telechar/ner/ner110.pdf>

Bureau of Labor Statistics (1993) “Labor composition and U.S. productivity growth, 1948-90.”, Washington DC, U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 2426, December.

Drew, A., M. Dupuy, R. Downing and O. Karagedikli (2005) “Is the cheque in the mail? An assessment of New Zealand medium-term labour productivity prospects.”, Perspectives on Potential Output and Productivity Growth workshop hosted by the Bank of Canada and Banque du France, Enghien-Les-Bain, Paris, April 24-25. <http://www.bankofcanada.ca/en/conference_papers/france2006/drew.pdf>

Gregg, P. and J. Wadsworth (2000) “Mind the gap, please: The changing nature of entry jobs in Britain.”, *Economica* 2000(67): 499-524.

Ho, M. and D. Jorgensen (1999) “The quality of the U.S. workforce.”, Harvard University, unpublished manuscript.

Hyslop, D. and D. Maré (2008) “Cyclical Earnings Variation and the Composition of Employment.”, Statistics New Zealand. < http://www.stats.govt.nz/NR/rdonlyres/4F49AB5B-FEF2-49B0-B83A-22583B6D17E7/0/CyclicalEarningsVariationandtheCompositionofEmploym.pdf>

IMF (2002) “New Zealand: Selected Issues.”, Washington DC. <http://www.imf.org/external/pubs/ft/scr/2002/cr0272.pdf>

IMF (2005) “New Zealand: 2005 Article IV consultation - staff report.”, Washington DC. <http://www.imf.org/external/pubs/ft/scr/2005/cr05152.pdf>

Jorgenson, D., F. Gallop and B. Fraumeni (1987) “Productivity and U.S. economic growth.”, Cambridge MA Harvard University Press.

McNaughton, T. (2006) “Quality-adjusted labour productivity measures: An application to New Zealand.”, Proceedings of the Labour, Employment and Work Conference, November. < http://www.vuw.ac.nz/geo/news-and-events/lew12/papers/LEW12-McNaughton-QualityAdjustedLabourProductivityMeasures.pdf>

McLellan, N. (2004) “Measuring productivity using the index number approach: An Introduction.”, Treasury Working Paper 04/05. <http://www.treasury.govt.nz/publications/research-policy/wp/2004/04-05/twp04-05.pdf>

Mason, G. and M. Osborne (2007) “Productivity, capital-intensity and labour quality at sector level in New Zealand and the UK.”, Treasury Working Paper 07/01. <http://www.treasury.govt.nz/workingpapers/2007/twp07-01.pdf>

OECD (2007) “Employment Outlook, 2007 edition.”, Paris, OECD, July

Prskawetz, A. and T. Fent (2007) “Workforce ageing and the substitution of labour: The role of supply and demand of labour in Austria.”, *Metroeconomica* 58 (1), 95–126

Schwerdt, G. and J. Turunen (2006) “Growth in euro area labour quality.”, European Central Bank, Working Paper Series No. 575. <https://www.ecb.de/pub/pdf/scpwps/ecbwp575.pdf>

Statistics New Zealand (2007) “Productivity statistics: Sources and methods (updated March 2007).”, Wellington, Statistics New Zealand, March. <http://www.stats.govt.nz/NR/rdonlyres/A7B54361-A5B8-4ADB-B68B-0B7E3BC24A04/0/productivitysourcesmethods2007.pdf>