A FORWARD-LOOKING MEASURE OF THE STOCK OF HUMAN CAPITAL IN NEW ZEALAND

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Abstract: Human capital is increasingly believed to play an important role in the growth process; however, adequately measuring its stock still remains controversial. Because the estimated impact that human capital has on economic growth is sensitive to the measures or proxies of human capital, accurate and consistent measures of human capital are needed. While many measures of human capital have been developed, most rely on some proxy of educational experience and are thus plagued with limitations. In this study, we adopted the lifetime labour income approach outlined by Jorgenson and Fraumeni (1989, 1992) to measure the monetary value of the stock of human capital for New Zealand. Jorgenson and Fraumeni's method is innovative in that it simplifies the estimation process, as well as taking into account the potential value of current schooling in addition to that of past schooling. Based on data from the New Zealand Census of Population, we find that the human capital stock of the country's employed work force grew by half between 1981 and 2001, mostly due to the rise in employment level. This stock of human capital was also well over double that of physical capital in all the census years studied.

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1. Introduction

Human capital is frequently discussed but poorly measured. Modern theories of economic growth, such as those of Romer (1986) and Jones and Manuelli (1990), emphasise human capital in their explanation of the growth process. But the empirical support for these theories has been hampered by the lack of reliable measures of human capital. Moreover, even in countries where attempts are made to estimate the value of human capital, it is not yet standard practice for official statistical agencies to include human capital in their capital stock measures (Wei, 2001). This is a surprising omission because estimates of the value of human capital predate the formal development of National Accounts statistics. For example, Petty (1690) estimated the total human capital of England to be £520 million or £80 per capita.

Various measures of human capital have been developed. But instead of placing a value on human capital, the more recent practice in economics has been to estimate human capital on the basis of years of schooling or formal educational attainment levels, regardless of actual productive capacity (Miller, 1996). For example, Treasury (2001) compare human capital in New Zealand to other OECD countries using as indicators, average years of education, expected years of tertiary education, and participation rates in adult education and training. This educational stock approach has been popular mainly because it uses measures that are relatively easy to quantify. But despite shedding some light on the gross differences in growth differentials between "rich" and "poor" countries, these crude proxies for knowledge have been unable to satisfactorily explain the performance of more economically advanced economies like New Zealand.

The proxy measures of human capital used by authors such as Nehru et al. (1995) and Barro and Lee (1993, 1996) have attracted considerable criticism (de la Fuente and Doménech, 2000).

Recently, some improvements have been made to the measurement of human capital, including de la Fuente and Doménech (2000), Cohen and Soto (2001), Barro and Lee (2001), and Wößmann (2003), yet they still suffer from some drawbacks. In particular, by focusing on the education so far experienced, these new measures still fail to capture the richness of knowledge embodied in humans. For a recent survey of the literature on alternative measures of human capital see, Le, Gibson and Oxley (2003).

Because of these deficiencies in the educational stock-based approach, Jorgenson and Fraumeni (1989, 1992) have returned to the earlier approach to valuing human capital, introduced by Farr (1853). The basic idea is to value the human capital embodied in individuals as the total income that could be generated in the labour market over their lifetime. These expected labour earnings contribute to an extended notion of capital, which Jorgensen and Fraumeni include in a proposed new system of national accounts for the US economy. Outside the U.S., this method has been applied to the estimate the human capital stock for Sweden (Ahlroth et al, 1997) and Australia (Wei, 2001), both of which studies found the stock of human capital to greatly exceed that of physical capital.

In this paper we modify the formula outlined by Jorgenson and Fraumeni (1989, 1992) and Wei (2001)[11] to place a value on the stock of human capital of the employed work force, or the *effective* human capital stock, for New Zealand.[12] We focus only on those individuals in employment, since these people are directly participating in economic production and so their human capital is arguably a better measure of the country's productive capacity. Our estimates are based on the discounted present value of expected lifetime labour market incomes. Thus, our study is an example of a forward looking (or prospective) method of measuring human capital. Such methods contrast with backward looking (retrospective) methods based on cost of production concepts, and with the widely used educational stock approach.

In the empirical part of the paper we work mainly with Census of Population data from 1981-2001 to calculate the future stream of incomes that a worker of a given age, gender and education level can expect to earn. This expected income is based on cross-sectional age-income profiles, which are then combined with the probability of enrolment in further education (allowing the worker to "jump" from one profile to another), the probability of participating in the labour force and of continued employment, and age-specific mortality rates. After incorporating expected growth rates and a discount factor, it is possible to calculate the present value of lifetime income, for a person of a given gender and education level. When these per capita estimates are combined with information on the population size of each cohort, the aggregate value of human capital can be calculated. Of course, these estimates relate only to market income so the value of human capital stocks used in non-market production may be

[11] We use different equations from Wei (2001) who appears to have double counted unemployment.
[12] Hendy at al. (2002) also focus on the same part of the population.

missed, but such a restricted focus is also common in studies measuring the returns to education.[13]

In addition to presenting valuations for, and describing trends in, the stock of human capital, we also use our model to carry out various sensitivity analyses. We are particularly interested in showing what impact certain modelling assumptions have on the estimates because the "full" method that we use involves onerous calculations, so accurate short-cuts would be desirable. Our measures of human capital are also contrasted with estimates of the physical capital stock, although we note that physical capital is usually measured in terms of the cost of production.[14] Finally, the estimates of the human capital stock for New Zealand (and its size relative to physical capital) are contrasted with the estimates from other local studies.

2. Models

If the possibility of future enrolment to gain a higher level of education is initially ignored, it is relatively easy to get an estimate of the present value of lifetime labour income from a cross-section (Jorgenson and Fraumeni, 1992). The general principle used is that a person aged t years with a certain level of education bases their expected earnings n years in the future on the current earnings of people of the same education and gender who are $t+n$ years old. Early applications of this theory included Houthakker (1959), Weisbrod (1961), Miller (1965), and Graham and Webb (1979).

[13] Haveman and Wolfe (1984) list and attempt to quantify these non-market effects.
[14] However, as Shultz (1961) points out, according to capital theory, the value of a capital asset can be evaluated both by the total costs devoted to its formation and by the discounted flow of future yields.

Jorgenson and Fraumeni (1989) simplified the calculations by pointing out the fact that the present value of lifetime labour income for a person of given age is just their expected current annual labour income plus the present value of their expected lifetime income in the next period (where this expectation depends on survival probabilities). Thus, by backwards recursion it is possible to calculate the present value of lifetime income at each age. For example, Jorgenson and Fraumeni assume that all individuals retire when they are 75 years old, so for a 74-year-old person, the present value of lifetime labour income is just their current labour income. The lifetime labour income of a 73-year-old individual is equal to the present value of lifetime labour income of the 74-year-old plus their current labour income. And so forth.

A more formal statement of this approach, as will be applied in our study, is:

$$HK_{a}^{e_i}(x) = W_{a}^{e_i} Y_{a}^{e_i} + HK_{a+1}^{e_i}(x)\, S_{a,a+1}(1+g)/(1+i) \qquad (1)$$

where $HK(x)$ = human capital per capita, defined as the present value of lifetime labour income per capita

Y = current annual labour income per capita of those employed

W = employment rate

$S_{a,\,a+1}$ = probability of surviving one more year from age a

g = income growth rate

i = discount rate

e_i = educational attainment of level i

a = age

To implement equation (1), we make the following assumptions:

- The retirement age is 66 years, at which point lifetime labour incomes are set to zero,
- The equation holds separately for men and women
- $g = 2\%$ and $i = 6\%$ (base case). These rates apply to all cohorts unless otherwise specified.

Based on these assumptions, it would be possible to estimate the per capita lifetime labour income for people with any particular level of education.

While equation (1) is likely to hold for most of the population over most of their working life, there are also people enrolled in further study who in the context of the model are, essentially, trying to jump onto a higher age-earnings profile. An important innovation of the Jorgenson and Fraumeni method is that they incorporate the extra human capital of these individuals. In contrast, previous methods assumed that people undertaking further study would remain in their current cohort of educational attainment, so their further study did not count for anything. When the model allows further study, individuals face two possible earnings streams; one with continuous work and one with the possibility of delaying work for further study. Hence, lifetime labour incomes for any given cohort are a linear combination of these two earnings streams, where the weights on each depend on the probability of enrolment. Also, since the focus of our study is on the labour force, the expected contribution of students, who are not currently participating in the labour force, should be weighted by the probability that those students will enter the labour force and will be employed upon graduation: Formally,

$$HK_{a}^{e_i}(x) = W_{a}^{e_i} Y_{a}^{e_i} + HK_{a+1}^{e_i}(x) S_{a,a+1}(1+g)/(1+i) + \sum_{j \in E} \sum_{t \in T} E_{a}^{jt} L_{a+t}^{e_i} W_{a+t}^{e_i} HK_{a+t}^{e_i}(x) S_{a,a+t} \{(1+g)/(1+i)\}^{t} \quad (2)$$

where E_a^{jt} = percentage of those individuals (of the working age population) undertaking j^{th} type of study in its t^{th} period.

E = all the levels of educational attainment e except the lowest, and

T = all the study periods of E.

L = labour force participation rate

Similar to Wei (2001), we assume that the potential working life is from age 21 to 65. A work-study phase occurs from 21-34, where equation (2) holds. A work-only phase occurs from age 35, where equation (1) applies.[15] While equations (1) and (2) can be estimated for any variety of education levels, we initially followed Wei and specified five groups defined by their highest qualification: higher degree; Bachelors degree; diploma; skilled labour; and unqualified. The particular qualification levels that those headings cover are listed in Appendix 1.

However, it is apparent that in New Zealand there is not much difference between the annual labour incomes of people in the diploma group and those in the skilled labour group. The problem is that workers with a post-school qualification other than a university degree (which places them in the diploma group), are very heterogeneous. This group includes people who left school without any qualifications and then did a one-year vocational certificate, as well as people who stayed to the end of 7th Form and

[15] This is a simplification of Jorgenson and Fraumeni, who specify five stages during the entire life.

then did a three-year diploma. We therefore aggregated these two groups, leaving us with the following breakdown:

- *h*=higher degree
- *b*=Bachelors degree
- *s*=skilled labour (UE/6th Form Certificate, Bursary/7th Form Certificate and any post-school qualifications recognised by the Census)
- *u*=unqualified (School Certificate, not classifiable, other, no qualifications).

The assumptions used to implement equation (2) for the work-study stage are:

- The study period for a higher degree is two years, conditional on holding a Bachelors degree;
- The study period for a Bachelors degree is three years, regardless of previous qualification;
- The study period for a skilled labour qualification is two years;
- Individuals can only study for a higher educational attainment than they already have (Bachelors degree holders studying for a second Bachelors degree count as studying for a higher degree in the model);
- Students enrolled in anything that requires more than one period are evenly distributed among different study stages.
- Direct costs of study are offset by part-time earnings, so that there is no need to apply negative values of current earnings while studying.

For higher degree holders the calculation of expected lifetime labour income is simplified by the fact that they have reached the highest educational level allowed by

the model. Hence, they are in the work-only stage, regardless of their age. Their lifetime labour income is:

$$HK\ {}^{h}_{a}(x) = W\ {}^{h}_{a} Y\ {}^{h}_{a} + HK\ {}^{h}_{a+1}(x)\, S\ {}_{a,a+1}(1+g)/(1+i) \tag{3}$$

For the cohorts whose highest current qualification is a Bachelors degree, lifetime labour income is given by:

$$\begin{aligned} HK^{b}_{a}(x) &= W^{b}_{a} Y^{b}_{a} + HK^{b}_{a+1} S_{a,a+1}(1+g)/(1+i) + \frac{1}{2} E^{b-h}_{a} L^{h}_{a+1} W^{h}_{a+1} HK^{h}_{a+1}(x) S_{a,a+1}(1+g)/(1+i) \\ &+ \frac{1}{2} E^{b-h}_{a} L^{h}_{a+2} W^{h}_{a+2} HK^{h}_{a+2}(x) S_{a,a+2}\{(1+g)/(1+i)\}^{2} \end{aligned} \tag{4}$$

where E^{b-h}_{a} is the enrolment rate for people *a* year old, with Bachelors degrees studying for a higher degree. For the cohorts whose highest current qualification falls within the "skilled" group, lifetime labour income is given by:

$$\begin{aligned} HK^{s}_{a}(x) &= W^{s}_{a} Y^{s}_{a} + HK^{s}_{a+1} S_{a,a+1}(1+g)/(1+i) + \frac{1}{3} E^{s-b}_{a} L^{b}_{a+1} W^{b}_{a+1} HK^{b}_{a+1}(x) S_{a,a+1}(1+g)/(1+i) \\ &+ \frac{1}{3} E^{s-b}_{a} L^{b}_{a+2} W^{b}_{a+2} HK^{b}_{a+2}(x) S_{a,a+2}\{(1+g)/(1+i)\}^{2} + \frac{1}{3} E^{s-b}_{a} L^{b}_{a+3} W^{b}_{a+3} HK^{b}_{a+3}(x) S_{a,a+3}\{(1+g)/(1+i)\}^{3} \end{aligned}$$

(5)

where E^{s-b}_{a} is the proportion of "skilled" individuals enrolling in a Bachelors degree. The lifetime labour income for the unqualified group is the most complex to calculate because they have the possibility of enrolling either in study towards a skilled labour qualification or in study towards a Bachelors degree:

$$\begin{aligned} HK^{u}_{a}(x) &= W^{u}_{a} Y^{u}_{a} + HK^{u}_{a+1}(x) S_{a,a+1}(1+g)/(1+i) \\ &+ \{\frac{1}{2} E^{u-s}_{a} L^{s}_{a+1} W^{s}_{a+1} HK^{s}_{a+1}(x) + \frac{1}{3} E^{u-b}_{a} W^{b}_{a+1} HK^{b}_{a+1}(x)\} S_{a,a+1}(1+g)/(1+i) \\ &+ \{\frac{1}{2} E^{u-s}_{a} L^{s}_{a+2} W^{s}_{a+2} HK^{s}_{a+2}(x) + \frac{1}{3} E^{u-b}_{a} L^{b}_{a+2} W^{b}_{a+2} HK^{b}_{a+2}(x)\} S_{a,a+2}\{(1+g)/(1+i)\}^{2} \\ &+ \frac{1}{3} E^{u-b}_{a} L^{b}_{a+3} W^{b}_{a+3} HK^{b}_{a+3}(x) S_{a,a+3}\{(1+g)/(1+i)\}^{3} \end{aligned} \tag{6}$$

where E_a^{u-s} is the enrolment rate for those studying for a skilled labour qualification and E_a^{u-b} is the rate for those going directly to degree study.

3. Data description

Data were obtained from each Census of Population from 1981 to 2001. The data were in the form of population counts within homogeneous cells defined by age, gender, educational level (as described above), employment status, and income bracket. Depending on the particular Census, the number of cells approached 100,000, but for most of the analysis we formed the data into 360 cohorts defined by 45 ages (21-65), gender, and four educational levels. For each of these cohorts we calculated the mean annual gross income of the employed, the employment rate, and the enrolment rate.

Educational attainment

Table 1A shows the distribution of the population aged 21-65 by gender and education. It is apparent that the share of university educated people has increased sharply, from 4.6 percent in 1981 to 12.8 percent in 2001. While the educational stocks approach would note this change as an improvement in human capital, it is not able to give it a monetary value. It is also notable that the gender gap in education has almost disappeared. It is also clear from Table 1B that the probability of participating in the labour force rises with the level of education.

Employment rates

Table 2 shows the employment rate, which is defined here as the proportion of those in the labour force who were working for pay. Full-time and part-time employment is weighted equally. Since our focus is on market activities, those who work for family without pay are not counted in the labour force and neither are those whose employment status is "not specified". On average, the employment rate dropped by over three percentage points from 1981 to 2001.

Annual incomes

Table 3 contains average income estimates for employees, each weighted by the number of people in the age, gender and education cohort. Many caveats are needed when interpreting these estimates. First, because New Zealand Censuses do not collect data on earnings, we have to use (gross) income as a proxy for market labour earnings. Income in New Zealand Censuses (except for NZ Census 1981) counts all sources and in this way is more broadly defined than in Australian Censuses, where income excludes superannuation. Hopefully by using only the incomes of employees, for whom earnings are likely to predominate, we eliminate obvious biases.[16] The annual income for paid employees is applied to employers and self-employed persons with the same gender-education-age-income profile. This adjustment keeps the focus on the price of labour services, because the reported income of employers and self-employed people may also include returns to non-labour inputs. Because the data are in (varying) intervals, we use the mid-point of the closed intervals. For the open-ended interval at the top of the income distribution (e.g. >$100,000) the mean income for the interval was set at 30

[16] Moreover, many other studies in New Zealand use the Census data to estimate "wages" (e.g., Papps, 2001).

percent above the lower bound, while for the lowest income interval it was set at 80 percent of the upper bound (recommended by Chen, Datt and Ravallion, 1991). Those who earn nil or negative income are assumed to have a zero income and we distributed those who did not specify their income evenly across the income ranges.

The estimates in Table 3 show that on average, real income fell slightly from 1981 to 1991 but the trend has reversed since.[17] This trend, however, is not universal across all groups. Over the 20 year period, the unqualified have seen their real income stagnate, whereas the rest of the work force have experienced rising income. There is a large income gap between university degree holders and the less educated, and this gap appears to have widened over time.

The top panels of Figures 1-5 plot the age-income profiles for employed New Zealanders. The income profiles are steeper for males than for females, and for university degree holders. One can also observe that in 1981 and 1986, incomes of university degree holders tended to increase steadily with age. By contrast, in later census years, incomes peaked at around age 45 and stabilised from there on. The volatility in the profiles for the university educated is due to the small size of the populations in each cell.

Enrolment rates

For our analysis, enrolment data in the Census have several deficiencies. In particular, the last three censuses did not collect information on whether or not a person was

[17] If consumer prices replace labour costs as the deflator, the fall in real income since 1981 is greater.

studying for a qualification. Although the 1986 Census asked about student status, it did not ask about the type of qualification one was studying for, therefore we are unable to determine from this census if an enrolee was studying to improve his/her educational level or not. The 1981 Census is the only one to contain relatively satisfactory information on enrolment,[18] (as do Australian Censuses since 1986, see Appendix 2). If one were to measure the value of the New Zealand human capital stock using Jorgenson and Fraumeni's lifetime labour income approach, New Zealand's recent censuses would not provide sufficient information. Indeed, although the model can still be run on zero enrolment, these estimates do not take into account the fact that some people withdraw from the labour force and study for a higher qualification because they expect to increase their earnings as a result of the study. Therefore, by not incorporating enrolment in the model, students' potential to contribute to the country's human capital stock is not adequately accounted for.

Since the most recent three Censuses did not ask about student status, we had to turn to another type of question for enrolment rates. In particular, enrolment is defined as attending study or training courses in the last week (Census 1991, Q20), or attending/studying for a course at school or anywhere else in the last seven days (Census 1996, Q30), or attending/studying for more or less than twenty hours per week at school or any other places in the last four weeks (Census 2001, Q41). We only consider full-time study and training, to be consistent with the 1981 and 1986 Censuses. Also, those who were attending full time study or training courses over the last week

[18] The 1981 collected information on the type of institution attended, and we infer the type of qualification one was studying for based on the type of institution he/she was enrolled at and his/her existing qualification. For example, a person whose highest educational attainment is 7th form and who is attending university is assumed to be pursuing a Bachelors degree.

(or, in Census 2001, four weeks) are more likely to be students than part-timers. The 1981 Census is the only one to give enrolment information by current level of study, so we apply the enrolment *pattern* from the 1981 Census to the enrolment *rates* (by existing qualification) for the other Censuses. For example, if 80 percent of students from within the "skilled" group were attending university in 1981, we assume that 80 percent of enrolees from the "skilled" group in other Census years are undertaking study for a degree, while letting the overall enrolment rate fluctuate from Census to Census.[19]

Enrolment rates for the population aged 21-34, classified by gender and current highest education level are reported in Table 4. Those who already hold a university degree are much more likely to be enrolled. Overall, enrolment rates in 1991 and 1996 are considerably higher than in 1981 and 1986, perhaps due to enrolment being more loosely defined in these Censuses. Enrolment rates in 2001 appear low, since "enrolment" in this Census counts studying/training activities for more than 20 hours a week only, whereas "full-time" in the two preceding Censuses can include courses that last as short as one day. Nevertheless, the inconsistency in how enrolment is defined across Censuses clearly casts doubt on our enrolment data.

The last variable needed to calculate the expected value of lifetime income is survival rates, which were obtained from *New Zealand Life Tables*. Since survival rates are classified by gender and age only, we assume that the probabilities of surviving do not vary with the level of education. Survival rates were unavailable for 2001, so we use

[19] We also sought additional information from the 1996 Education and Training Survey but had problems with cells being suppressed for confidentiality reasons. We also used the database of the Ministry of Education but it was not flexible enough to give us age-specific enrolment rate by highest qualification and qualification currently enrolled in.

estimates for 1998-2000 from *Demographic Trends*, which are in 5-year age intervals rather than by individual year of age used with the other Census years.

4. Estimation results

4.1. Basic results

Table 5 reports lifetime labour incomes for all 360 gender/age/education cohorts initially estimated based on equations 4-7, with a discount rate of six percent and a growth rate of two percent. The estimates for 1996 are unusually high and this appears to be due to the high "enrolment" rates in 1996 compared with other years.[20] Indeed, when the model is estimated without accounting for enrolment (that is, using equation (1) only), the "outliers" disappear. Taking into account enrolment raises per capita human capital in 1981 and 1986, where enrolment data were the most accurate, by 3.3 percent and 5.1 percent respectively. By contrast, for 1996, where "enrolment" is most loosely defined, the corresponding effect is an increase of 29.2 percent. We find the results that incorporate the impact of enrolment questionable, given the lack of reliability in our enrolment data. Therefore, we have decided to entirely ignore the option of study.

In theory, the impact of ignoring enrolments (with accurate data on enrolment) should be small, because further study affects only a small fraction of the population in the age ranges we have considered (recalling that the enrolment of higher degree holders does not count because they have no higher earnings profile to jump to). In contrast to our

[20] Increasing study periods (i.e. varying the assumptions on page 4, for example, assuming that it takes "unqualified" individuals four years, rather than three years, to complete a Bachelors degree) produces marginally lower estimates.

results, incorporating enrolment in the model by Jorgenson and Fraumeni (1989) was innovative because they estimated the value of human capital for the US population aged from 0 to 74. It can be seen from the full enrolment among school-age children, who make up a large proportion of the population, and the high returns to basic education, that the effect of enrolment on the country's total human capital stock is substantial. For a "mature" population, the overwhelming majority of whom have acquired sufficient education and are working, the effect of enrolment is therefore lost.

Our new baseline estimates can be found in the bottom panels of Figures 1-5, which display the present value of per capita lifetime incomes for New Zealanders aged 21-65, classified by gender, age, and education. It is obvious from these figures that initially lifetime income tends to increase until somewhere around age 25-30, after which it decreases steadily. The peak in lifetime income occurs some five years earlier for women than for men. A similar time lag is also observed between degree holders and less qualified people. This is because the time devoted to further education postpones reaping the higher returns until older ages.

Apparently the shape of the annual income profiles affects lifetime income profiles. Lifetime income profiles are flatter for females than for males, and also flatter for "unqualified" and "skilled" people than for the university educated, reflecting what was observed earlier about annual income profiles.

The average per capita lifetime labour incomes (in 2001 dollars) are reported in Table 6. These figures are weighted averages of the lifetime income profiles in Figures 1-5,

where the weights are the number of people at each year of age. Consistent with the time trend for annual incomes, as revealed in Table 3, average lifetime incomes declined in real terms during 1981-91 and started to increase since. The difference is, however, that although average annual income in 2001 is 9 percent higher than in 1981, average lifetime grew by less than two percent over the period. The major cause of this fall is the decrease in employment rates over the years, as observed from Table 2. In particular, compared with 1981, both employment and real annual income in 1986 were lower, which explained the lower average lifetime income. Annual income rose slightly in the next inter-censual period, but employment declined dramatically, especially for the less educated, who make up the majority of the population. As a result, expected annual income and lifetime income increased only marginally. In the last 10 years since 1991, both employment and real annual income have risen over time, improving average lifetime income consequently. These temporal patterns do not seem to be affected by the particular deflator used, and if anything the decline from 1981 is even greater if a price index (rather than a wage index) is used (see Figure 6).

The contribution to the stock of New Zealand human capital by each education and gender group can be found in Table 7. The share of "unqualified" people in the stock of human capital has declined from one-half of the male total in 1981 to just one-third in 2001, while the proportionate decline is even greater for women. By contrast, the human capital contributed by university degree holders has grown, in both relative and absolute terms. Indeed, this is to be expected, from what was observed earlier that annual incomes of these people have improved relatively the most and that their shares of the population have also grown. For example, in 1991, when the total human capital stock

increased by a mere three percent from 1986, the capital accounted for by the university educated grew by 27 percent. While total human capital increased by half, university degree holders' capital almost quadrupled over the last twenty years. This growth is due primarily to the larger size of the labour force, since expected annual labour income in 2001 is marginally higher than in 1981.

Despite their equal share of the population, women contributed only one quarter to the country's economically productive human capital in 1981, rising to 37 percent in 2001. This follows directly from the fact that women are under-represented in the labour force and that their annual labour income is only two thirds of men's.

4.2. Sensitivity analyses

The effects of varying several of the modelling assumptions on the calculated value of human capital are reported in Table 8 and Figure 7. In general, the sensitivity analyses indicate certain robustness in our results, although more extreme variations in methods could be tested. Changing the discount and growth rates to the values used by Jorgenson and Fraumeni (1989, 1992) and Wei (2001) would raise the estimated value of the human capital stock by 8 percent and would leave the pattern across Census years unchanged. A bigger change comes from excluding ages 21-24, which reduces the aggregate value of human capital by 11 percent (because of the smaller population) and lowers the per capita lifetime income slightly. Varying the categorisation of education levels produces no effect in the per capita and aggregate values.

Furthermore, the observed data on earnings and employment rates, especially for the degree-qualified cohorts and the older age cohorts, contain considerable fluctuations, which are due largely to the small sample size among these cohorts. We attempted to smooth out the data by using a regression-based method. In particular, we regressed earnings and the employment rate on age, age squared, education, interaction between age and education, and a dummy for gender for both intercept and slopes, and used the predicted values to compute lifetime income. This correction, however, hardly affects the aggregate results, although it does greatly smooth out the life cycle profiles for annual earnings and lifetime earnings and thereby makes predictions more reliable.

4.3. More on Sensitivity Analysis – the IALS

In addition to the sensitivity analyses reported in Table 8, we also re-did the entire analysis using a different dataset – the International Adult Literacy Survey (IALS). In principle, the IALS is an attractive source of information for studies like ours because it provides consistent treatment of variables across countries and collects data on earnings rather than income. Thus, if one were serious about measuring and comparing human capital across countries, IALS is the very data set that one should use.

Data

The IALS has by now been conducted in over 20 countries. It collects information primarily on literacy and training, but rich data on employment, income, earnings and many other socio-economic variables were also obtained. The New Zealand part of the survey was carried out in 1996, which covered 2,481 individuals aged from 16 to 65.

We exclude from this analysis those who were younger than 21, which leaves a potential sample of 2,280 observations.

Due to data constraints, the two lower education levels are defined somewhat differently from those in the Census data (see Appendix 1). This should not be a concern, as we have shown earlier with Census data that how the population is categorised by education does not affect the total value of human capital. The share of degree-qualified people in this sample matches very well with the Census parameters and this attests to the reliability of the IALS data.

We determine enrolment status based on the highest qualification and the type of qualification[21] one is enrolled at. An enrolee is defined as one who reported to be a student and who was studying for a qualification higher than his/her current qualification. We treat part time work as full time to be consistent with Census data. Of the 2004 employed people in the sample, 475 were working part time; but it is not known if this indicates an over-representation of part-time workers.

A very attractive feature of the IALS data is the availability of data on earnings, which is what the labour income approach needs. We do not need to adjust earnings of employers and self-employed people, since all respondents were paid employees. Sample weights are used to obtain estimates for the population.

[21] There could be up to three programmes mentioned for each person, but we count only the first mention.

Overall, women make up 55 percent of the sample. The respondents have an average age of 39, 91 percent of whom were working or seeking employment. Among labour force participants, 96.4 percent were employed, earning on average $30,116 per annum.[22] However, the figures vary considerably from cohort to cohort. Most disappointingly, employment rates and earnings do not seem to bear any discernable relationships with age and education. This stems from the fact that there are only 2079 observations (labour force participants) for 360 age/sex/education cohorts. Since there are too few observations per cohort, it is not uncommon for cohorts to have "extreme" values or to contain no observations. Following Ahlroth et al. (1997), we attempted to alleviate this problem by using a regression-based method. Since earnings data are categorical, we used an interval regression model to predict earnings based on age, age squared, education, interaction between age and education, and a dummy for gender for both intercept and slopes (see the top panel of Figure 8).[23] The same set of explanatory variables was used to predict the employment and enrolment rates using a probit model. The predicted values of these variables were then used to estimate lifetime income.

Table 9 shows how our predicted values compare with the sample (weighted) statistics and the corresponding parameters from the 1996 Census. A small dissimilarity is seen between the different income estimates. Indeed, using simple regression with mid-point earnings as the dependent variable would give predicted values that are more similar to the average reported mid-point earnings, but there are no firm grounds to believe that mid-point earnings are more reliable statistics. We believe that if anything, annual

[22] These are unweighted sample statistics. Men make up a bigger share (52%) when weights are taken into account. As with earnings, data on this variable are categorical; the above mentioned figure was calculated using midpoints of the intervals.
[23] The use of log earnings does not prove superior with the data.

income in the IALS should be lower than in the Census since this variable in the survey strictly refers to earnings. It is also clear that labour force participants and the employed are over-represented and over-weighted in the sample.

Results

The annual and lifetime labour incomes obtained from the IALS are depicted in Figure 8. All the life cycle income profiles look quite "smooth" due to the use of the predicted values. These graphs appear rather similar to the 1996 Census graphs (Figure 4), except that the distinction between Bachelors and higher degree profiles blurs. As revealed from Table 10, the per capita lifetime income for New Zealand in 1996 was $468,608, which is just slightly lower than the corresponding estimate from the 1996 Census of $489,280. Since the IALS uses earnings rather than income, this difference in per capita lifetime income figures is hardly surprising. Yet the IALS estimate is likely to be biased upwards, since the survey over-samples employed individuals. The extent of gender inequality is similar between the two sets of results, although there is much less inequality in lifetime earnings across education levels in the IALS results.

Furthermore, the availability of information on enrolment enables us to incorporate the option of study in the model. Accounting for enrolment would raise the average lifetime income by 4.45%. This confirms our belief that the enrolment statistics for the 1996 Census are heavily overstated. However, the IALS sample is biased towards labour force participants and thus underestimates the popularity of further study in the population. Hence, enrolment data from this survey is not reliable either.

The biggest deficiency from the IALS is that it did not cover all the possible gender/education/age cohorts, which makes the total weights in this survey 22 percent lower than the Census population count. As a result, the total human capital stock obtained from the survey is understated by a quarter.

In conclusion, the small sample size problem with the IALS (between 2000-5000 for most countries) can be overcome, to some extent, by the use of regression-based corrections. Although richer data like Census data are clearly more desirable, our analysis confirms Ahlroth et al.'s (1997) claim that the Jorgenson and Fraumeni method also works with a typical micro data set like the IALS. Therefore, the IALS could be a practical source of information if one was interested in conducting this type of study across countries.

4.4. Human Capital and Physical Capital compared

Some preliminary comparisons between human and physical capital stocks for New Zeeland are reported in Table 11. It appears that the value of the economically effective human capital stock is more than double that of the physical capital stock in New Zealand, and this ratio is rising over time.

But this comparison is rather naïve, since the human capital stock estimates are "gross" in that maintenance costs are not deducted from labour incomes, whereas estimates are physical capital are net. However, whether maintenance costs should be deducted is

open to debate. On one hand, some authors argue that physical capital estimates are net figures, so human capital should also be net of maintenance costs to be consistent. Eisner (1988), for example, criticise the income-based method to overestimate human capital by not deducting maintenance costs from gross earnings. Weisbrod (1961) attempted to account for maintenance, but he encountered many difficulties. What types of expenditures should be classified as maintenance, how to account for economies of scale and "public" goods when estimating per capita consumption for members in the same household are those problems that are not easily resolved. On the other hand, others maintain that consumption is an end, rather than a means, of investment and production, hence gross earnings are a more relevant variable to use when estimating human capital using a lifetime labour income approach. It is argued that net productivity is a more relevant measure of a person's value to others; whereas gross productivity is a superior estimate of his total output to the society (Graham and Webb, 1979).

On another hand, human capital excludes non-market activities which have been found by Jorgenson and Fraumeni (1989, 1992) and Ahlroth et al. (1997) to be of significance. According to Jorgenson and Fraumeni (1989), the stock of U.S. human capital exceeded that of physical capital by 11 times during 1948-1984, whereas Ahlroth et al. observed that even their lowest estimates of the human capital stock (net of taxes, excluding leisure income) were 6-10 times higher than the stock of machinery and buildings.[24]

[24] Ahlroth et al.'s human capital estimates are also based on the population aged 0-74.

5. **Comparisons with other New Zealand Studies**

The paper by Oxley and Zhu (2002) is also an income-based approach to creating a monetary measure of the stock of human capital in New Zealand. However, it takes the approach of Dagum and Slottje (2000) as its starting point where the distinction between a static and dynamic measure of human capital is a central theme.[25]

Our baseline estimates and those from Oxley and Zhu (2002), as reported in Table 12, are not comparable. Oxley and Zhu (2002) use income data disaggregated by gender and five year age bands, regardless of education, labour force status and employment status. In principle, their estimates should be lower because of the higher discount rate (8% vs. 6%). The effect of the broader population base is unclear, since the inclusion of younger people raises the population average lifetime income, but this tends to be offset by the presence of older people.

When adjustments are made for the two studies to best resemble each other (in terms of population base, discount rates, growth rates, and enrolment effect) our estimates are 15% to 21% higher than those obtained using Oxley and Zhu's estimation model (see rows *c* and *e*, Table 12). Apparently, Oxley and Zhu's results are overestimated by not allowing for the fact that gross income may include non-labour income. However, this upward bias is not sufficient to balance the downward bias that arises because the income used in their analysis is averaged over the entire working age population,

[25] Their static measure is based upon zero productivity growth in the economy, whereas the dynamic measure allows for positive growth in productivity (g=3% for ages 21-29, 2% for ages 30-54, 1% for ages 55-64, and 0% for ages 65 and above).

whereas the income in our study is for the labour force only. Indeed, around a quarter of the population are out of the labour force (Table 1A) and effectively have zero expected labour income; average expected income for the working age population should be lower than for the labour force. Thus, we would expect that the average per capita human capital lifetime obtained from the two studies would be very similar when the same parameters are used, even though Oxley and Zhu draw on much less disaggregated data.

However, the ease with the calculations comes at the expense of information. Without the richness of data on education and employment, it is difficult to determine from their study what caused human capital to vary over time. Education is arguably the most important determinant of earnings, omitting this variable is likely to lead to biased results in more detailed analyses.

In another study on New Zealand, Hendy et al. (2002) found that between 1986 and 1991 the human capital of those New Zealanders in employment declined by one percent and increased by 11.7 percent in the subsequent inter-censual period. This evidence differs somewhat from our findings that New Zealand effective human capital in 1996 was 16.1 percent higher in 1991, the human capital stock for which year reflected an increase by 3.2 percent from the preceding Census year (Table 7). Nevertheless, out study concurs with Hendy et al. in that most of the change in the stock of human capital during this period comes from the change employment level.[26]

[26] Hendy et al. cover the age range 20-59. Their estimates are deflated using the CPI (excluding the impact of GST). When this deflator is used in place of the Wage Index in our analysis, the stock of human capital would increase by 7 percent between 1986 and 1991 and by 11.7 percent subsequently. Which deflator is more appropriate, however, is open to debate.

6. Did human capital really decline? Biases in the estimation method

As is clear from Table 1A, degree-qualified people have increased both in number and proportion of the working age population. Any education based measure of human capital would suggest that New Zealand human capital has grown steadily in the last twenty years. Another question springs up: Did human capital actually decrease in 1986 and 1991 or was it just due to the bias in the Jorgenson and Fraumeni method?

Unlike the education-based measures of human capital, the lifetime labour-income based approach does not estimate human capital by counting how much education the population has. Being labour market-oriented, this method argues that the knowledge and skills that are not used in economic activities are useless. Accordingly, educating people is not sufficient to raise the country's stock of human capital; it is necessary that those people be employed so that the knowledge and skills that they have acquired are turned into productive capital rather than being wasted through unemployment and non-participation.

The Jorgenson and Fraumeni approach is based, as are other labour income-based method to measuring human capital, on the assumption that differences in wages perfectly mirror differences in marginal productivity of labour and that productivity is a proxy for human capital. If wages vary for reasons other than changes in productivity, the results obtained from this method will be biased.

Indeed, there is evidence that actual real wages diverged from "warranted" real wages. As mentioned earlier, pre-reform real wages were believed to be overvalued because they were traditionally set on the basis of occupational relativities rather than on productivity. Some authors, including Grimes (1981) and the Reserve Bank of New Zealand (1982), assert that real wage overvaluation was a major cause of rising unemployment. The presence of effective legislated wage floors, which can be as high as 53% of average earnings,[27] also indicates that wages may reflect equity considerations rather than market conditions. Besides, in an attempt to fight inflation, a price and wage freeze was introduced in June 1982. Real wages then declined for the next three years and this appeared to be part of the reason why real labour earnings in 1986 were so low. Real wages continued to trend downward until 1990 although this trend has been slightly reversed in the second phase of the reform. Despite rising productivity, real wages fell in the first phase of the reform to ease the pressure on high unemployment at that time (Dalziel and Lattimore, 1999). According to the data gathered by Maloney and Savage (1996), productivity grew rather steadily during 1981-1994 while real wages experienced considerable fluctuations over the period. So apparently the assumption that wages reflect labour productivity does not always hold in reality.

The fact that the equality between wages and labour productivity fails to hold casts doubts on the results of this study. If labor productivity is a good proxy for human capital, the rising productivity means that during 1981-1991, New Zealand human capital may have decreased in per capita terms to a lesser extent than indicated by the

[27] In 1987, see Maloney and Savage (1996)

labour income-based measure. This may suggest that a measure of human capital based solely on labour productivity should be less biased. Indeed, such a measure of human capital is an approach that Jorgenson, Gollop and Fraumeni (1987) have proposed. However, by being indices, that productivity-based measure of human capital is not always a superior solution. The labour income-based measure gives a monetary value which is more meaningful than indices in comparisons with other types of capital or with human capital from other countries. Also, the labour income-based approach is based on an assumption which, however controversial, is widely accepted in economics and which tends to hold reasonably well in the long term. Therefore, the lifetime labour income method has many merits of a good measure of human capital after all, in spite of the imperfections.

But there are still a few other issues around the lifetime labour income approach to measuring human capital. Omitted variables obviously create a bias, since it has been well established in labour economics that sex, education and age are not sufficient to explain differences in earnings.[28] Several important factors, including ability, family background, quality of schooling, and work experience, have been left out of the model. However, we would argue that this bias matters more to the results for individuals and cohorts than to the population's aggregate results. This is clear from the similarity between our per capita human capital estimates and those obtained by Oxley and Zhu (2002) based on a much less disaggregated dataset.[29]

[28] See, for example, the comprehensive review by Card (1999).
[29] The use of cross-sectional mortality rates could create another bias. Yet for a developed country like New Zealand where mortality rates are already very low, survival probabilities are unlikely to improve much over time. So any bias from this source should be negligible.

Women contribute disproportionately less to the stock of human capital. This does not necessarily mean that women's capital is less valuable than men's; it merely reflects the fact that women do not participate as much as men in labour market activities. If non-labour market activities were accounted for, women's human capital should be more highly valued. But as reviewed earlier, the way that Jorgenson and Fraumeni impute non-labour market activities has attracted considerable criticism. Hence, how to appropriately take account of non-economic human capital remains a challenge.

7. Conclusions

The paper presents some new results on the monetary value of human capital in New Zealand using a forward-looking, lifetime labour income approach. The results are preliminary and reflect some of the modelling assumptions that the imperfect New Zealand data necessitate. However, given the current activity of other researchers in the area of measuring and valuing human capital stocks, we are optimistic that some consensus about the value of the human capital stock may soon emerge.

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Table 1A: Distribution of the 21-65 Year-old Population by Education Level (Percent)

	1981	1986	1991	1996	2001
Males					
Unqualified	30.3	24.7	22.5	23.8	25.4
Skilled	16.1	21.2	22.6	19.9	16.9
Bachelors	2.1	2.5	2.9	3.6	4.2
Higher	1.0	1.6	1.6	1.9	2.1
Subtotal	**49.5**	**50.0**	**49.6**	**49.2**	**48.6**
Females					
Unqualified	36.0	31.4	27.8	27.4	27.5
Skilled	13.0	16.2	19.3	18.8	17.5
Bachelors	1.2	1.6	2.2	3.2	4.6
Higher	0.3	0.9	1.1	1.4	1.9
Subtotal	**50.5**	**50.0**	**50.4**	**50.8**	**51.4**
Total Number	**1,581,717**	**1,796,418**	**1,893,873**	**2,075,742**	**2,148,501**
Change from last Census		13.57%	5.42%	9.60%	3.51%

Source: New Zealand Census of Population, 1981, 1986, 1991, 1996, 2001.

Table 1B: Labour Force Participation Rates (Percent) by Education Level

	1981	1986	1991	1996	2001
Males					
Unqualified	89.9	85.1	74.3	69.0	71.5
Skilled	93.5	91.5	86.6	86.5	89.3
Bachelors	91.2	92.7	89.8	90.0	90.5
Higher	94.2	94.0	92.2	90.8	91.3
Weighted average	**91.2**	**88.6**	**81.9**	**79.5**	**81.2**
Females					
Unqualified	38.9	54.0	50.7	52.2	55.9
Skilled	51.9	69.3	69.6	72.4	76.7
Bachelors	60.5	76.8	77.3	80.1	81.7
Higher	64.1	80.1	82.3	82.8	84.6
Weighted average	**43.9**	**61.2**	**61.5**	**64.3**	**68.3**
Overall average	**75.9**	**77.5**	**73.2**	**72.7**	**75.2**
Total Number	**1,056,564**	**1,334,007**	**1,335,375**	**1,457,865**	**1,569,399**
Change from last Census		26.26%	0.10%	9.17%	7.65%

Source: New Zealand Census of Population, 1981, 1986, 1991, 1996, 2001.

Table 2: Employment Rates (Percent) by Education Level

	1981	1986	1991	1996	2001
Males					
Unqualified	96.3	95.4	88.3	90.9	91.7
Skilled	98.2	97.7	92.9	95.6	95.9
Bachelors	97.9	97.4	94.3	95.1	95.8
Higher	98.8	98.4	96.7	95.4	96.4
Weighted average	**97.0**	**96.6**	**91.2**	**93.6**	**94.0**
Females					
Unqualified	96.5	91.4	89.7	90.5	91.0
Skilled	97.2	94.4	92.2	94.4	94.8
Bachelors	95.3	94.0	92.7	94.5	95.5
Higher	95.8	95.8	95.1	95.2	96.2
Weighted average	**96.7**	**92.7**	**91.1**	**92.7**	**93.2**
Overall average	**96.9**	**95.0**	**91.2**	**93.1**	**93.6**
Total Number	**1,023,999**	**1,267,728**	**1,217,622**	**1,357,989**	**1,469,280**
Change from last Census		23.8%	-4.0%	11.5%	8.2%

Source: New Zealand Census of Population, 1981, 1986, 1991, 1996, 2001.

Table 3: Real Annual Incomes for Employees

	1981	1986	1991	1996	2001
Males					
Unqualified	33,152	31,226	31,442	33,390	33,405
Skilled	38,948	38,297	39,475	41,276	43,408
Bachelors	46,789	48,298	53,237	55,891	58,915
Higher	57,912	56,420	62,162	65,716	67,268
Weighted average	**36,176**	**36,079**	**37,898**	**40,261**	**41,444**
Females					
Unqualified	21,873	18,471	20,090	21,930	22,701
Skilled	27,116	24,141	25,976	27,012	28,876
Bachelors	31,860	29,930	33,788	33,926	37,327
Higher	38,864	34,287	39,797	41,699	45,693
Weighted average	**24,015**	**21,418**	**24,054**	**25,802**	**27,793**
Overall average	**32,226**	**30,144**	**31,990**	**33,752**	**35,068**
Expected Income [a]	31,233	28,646	29,170	31,440	32,831

Source: New Zealand Census of Population, 1981, 1986, 1991, 1996, 2001.

Adjusted to 2001 dollars using the Prevailing Weekly Wage Index PWIQ.S4329 and All Salary & Wage Rates LCIQ.SA53Z9.

Note: [a] Expected labour income for labour force participants, calculated by multiplying income for the employed by the employment rate.

Table 4: Enrolment Rates (Percent) by Gender and Highest Qualification

	1981	1986	1991	1996	2001
Males					
Unqualified	0.09	0.32	1.34	1.84	1.04
Skilled	1.86	1.53	2.95	9.96	3.49
Bachelors	5.55	5.49	6.36	7.21	3.93
Higher	1.80	2.64	3.90	6.13	2.64
Females					
Unqualified	0.07	0.24	1.23	1.96	1.10
Skilled	1.33	1.74	3.59	15.27	3.50
Bachelors	5.36	6.40	7.63	8.50	3.21
Higher	2.48	3.21	4.69	6.96	2.32

Source: New Zealand Census of Population, 1981, 1986, 1991, 1996, 2001.

Note: These are raw data from the Censuses. In our calculations, we have allowed for the fact that not all enrolments are for a higher qualification.

Table 5: The Impact of Incorporating Educational Enrolment in Estimates of Human Capital

	1981		1986		1991		1996		2001	
Males	With Enrolment[a]	Without Enrolment[b]	With Enrolment	Without Enrolment	With Enrolment	Without Enrolment	With Enrolment	Without Enrolment	With Enrolment	Without Enrolment
Unqualified	200,100	198,901	292,880	286,028	428,003	389,970	496,294	438,497	487,903	455,641
Skilled	286,396	269,742	403,300	377,704	618,231	541,860	916,900	618,495	809,214	701,763
Bachelors	422,648	372,763	654,638	569,883	984,993	843,129	1,130,388	921,900	1,111,225	997,022
Higher	393,994	393,994	568,048	568,048	845,185	845,185	963,841	963,841	1,022,189	1,022,189
Females										
Unqualified	136,778	136,442	167,221	165,348	261,237	248,165	306,539	281,701	312,717	299,945
Skilled	197,337	189,953	251,654	238,325	401,818	361,205	593,131	409,702	518,461	470,244
Bachelors	310,238	268,332	399,727	336,518	658,564	540,849	754,490	584,895	744,046	674,362
Higher	288,571	288,571	358,860	358,860	573,448	573,448	649,094	649,094	758,011	758,011
Overall average	**216,581**	**209,635**	**306,055**	**291,321**	**479,536**	**430,840**	**632,372**	**489,280**	**588,276**	**537,081**
In 2001 prices [c]	**545,053**	**527,573**	**513,513**	**488,791**	**560,747**	**503,803**	**692,247**	**535,607**	**588,276**	**537,081**
Relative difference	3.3%		5.1%		11.3%		29.2%		9.5%	

Source: Authors calculation from New Zealand Census of Population, 1981, 1986, 1991, 1996, 2001.

Notes: All estimates are in current prices unless otherwise stated. [a] Accounting for the impact of enrolment, using equations 3-6. [b] Ignoring the impact of enrolment, using equation (1) only. [c] The averages adjusted to 2001 dollars using the Prevailing Weekly Wage Index PWIQ.S4329 and All Salary & Wage Rates LCIQ.SA53Z9.

Table 6: Average Lifetime Labour Income Per Capita ($2001)

	1981	1986	1991	1996	2001
Males					
Unqualified	500,558	479,910	456,012	480,015	455,641
Skilled	678,840	633,728	633,625	677,056	701,763
Bachelors	938,104	956,174	985,915	1,009,189	997,022
Higher	991,535	953,096	988,319	1,055,101	1,022,189
Weighted average	**588,742**	**588,451**	**596,444**	**638,471**	**631,766**
Females					
Unqualified	343,374	277,427	290,192	308,373	299,945
Skilled	478,039	399,872	422,376	448,494	470,244
Bachelors	675,291	564,624	632,443	640,275	674,362
Higher	726,225	602,110	670,562	710,553	758,011
Weighted average	**400,420**	**342,272**	**379,348**	**409,976**	**429,034**
Overall average	**527,573**	**488,791**	**503,803**	**535,607**	**537,081**
Change from last Census		**-7.35%**	**3.07%**	**6.31%**	**0.28%**

Source: Authors calculation from New Zealand Census of Population, 1981, 1986, 1991, 1996, 2001. Adjusted to 2001 dollars using the Prevailing Weekly Wage Index PWIQ.S4329 and All Salary & Wage Rates LCIQ.SA53Z9.

Table 7: Aggregate Value of Human Capital in New Zealand ($2001 billion)

	1981	1986	1991	1996	2001
Males					
Unqualified	215.5	181.1	144.2	163.3	177.6
Skilled	161.4	220.3	235.0	242.1	227.0
Bachelors	28.4	40.0	49.3	68.4	81.3
Higher	14.7	25.7	28.1	38.0	42.5
Subtotal	**420.0**	**467.2**	**456.6**	**511.8**	**528.4**
Females					
Unqualified	76.0	84.4	77.4	91.6	99.2
Skilled	51.0	80.6	107.7	126.8	135.6
Bachelors	7.9	12.2	20.1	33.6	53.9
Higher	2.5	7.6	11.0	17.1	25.8
Subtotal	**137.4**	**184.8**	**216.2**	**269.1**	**314.5**
Total	**557.4**	**652.1**	**672.8**	**780.8**	**842.9**
Change from last Census		**16.98%**	**3.18%**	**16.06%**	**7.95%**

Source: Authors calculation from New Zealand Census of Population, 1981, 1986, 1991, 1996, 2001. Adjusted to 2001 dollars using the Prevailing Weekly Wage Index PWIQ.S4329 and All Salary & Wage Rates LCIQ.SA53Z9.

Table 8: Sensitivity Analyses on Per Capita and Aggregate Human Capital (for 2001)

	Average Lifetime Labour Income Per Capita ($)	Relative Change Compared with Baseline	Aggregate Value of Human Capital ($billion)	Relative Change Compared with Baseline
Baseline	**537,081**		**842.9**	
Classifying by 5 education levels [a]	537,041	-0.01%	842.8	-0.01%
Accounting for enrolment [b]	588,276	9.53%	923.2	9.53%
Smoothing the data [c]	537,186	0.02%	843.1	0.02%
$g = 1.32\%$ and $i = 4.58\%$	580,060	8.0%	910.3	8.0%
Excluding ages 21-24	521,879	-2.83%	748.4	-11.21%
Working-age population	496,926	-7.48%	1067.65	26.66%

Source: Authors calculation from New Zealand Census of Population, 1981, 1986, 1991, 1996, 2001.
Notes: [a] Classifying the population by 5 education levels, as in Wei (2001), but ignoring educational enrolment. [b] Using equations 3-6 instead of equation (1). [c] By using a regression method, see text for details.

Table 10: Estimates of Human Capital for New Zealand: the 1996 IALS and the 1996 Census compared

	IALS			**1996 Census**		
	Share of Labour Force (%)	Baseline	With Enrolment [a]	Share of Labour Force (%)	Baseline	With Enrolment [a]
Males						
Unqualified	35.9	519,893	542,325	23.3	438,497	496,294
Skilled	10.6	631,926	702,820	24.5	618,495	916,900
Bachelors	4.7	822,187	822,187	4.7	921,900	1,130,388
Higher Degree	2.7	829,127	829,127	2.5	963,841	963,841
Females						
Unqualified	32.1	281,157	294,140	20.4	281,701	306,539
Skilled	8.3	383,987	394,374	19.4	409,702	593,131
Bachelors	3.9	566,637	574,052	3.6	584,895	754,490
Higher Degree	1.8	540,185	540,185	1.6	649,094	649,094
Weighted average		**468,608**	**489,480**		**489,280**	**632,372**
Total Number	**1,129,095**	**529.1 billion**	**552.7 billion**	**1,457,865**	**713.3 billion**	**921.9 billion**
Women's share	46.17%	32.94%	32.62%	45.02%	34.46%	34.05%

Source: Authors calculation from the IALS (New Zealand, 1996) and New Zealand Census of Population, 1996.
Note: [a] Accounting for the effect of enrolment, using equations 3-6 instead of equation (1).

Table 9: Comparing Data from the 1996 Census and the 1996 IALS

	Labour Force Participation (Percent)			Employment Rates (Percent)			Annual Earnings for Employees ($)			Enrolment Rates (Percent)		
	1996 IALS		1996 Census	1996 IALS		1996 Census	1996 IALS		1996 Census	1996 IALS		1996 Census
	Raw data	Predicted [a]		Raw data	Predicted [a]		Raw data [b]	Predicted [a]		Raw data	Predicted [a]	
Males												
Unqualified	95.7	95.4	69.0	96.1	96.2	90.9	34,662	33,157	30,502	3.53	3.53	1.84
Skilled	93.3	94.8	86.5	98.4	98.0	95.6	39,946	40,061	37,706	5.69	5.69	9.96
Bachelors	95.4	96.0	90.0	93.8	95.1	95.1	52,446	48,285	51,057	0.0	0.0	7.21
Higher Degree	98.6	95.0	90.8	99.3	98.6	95.4	54,335	48,468	60,032	0.0	0.0	6.13
Females												
Unqualified	86.3	86.6	52.2	95.2	95.2	90.5	19,549	19,505	20,033	3.42	3.43	1.96
Skilled	90.5	88.9	72.4	97.2	97.7	94.4	25,105	22,766	24,676	0.82	0.82	15.27
Bachelors	90.8	89.9	80.1	95.8	94.3	94.5	27,080	27,494	30,992	3.38	3.06	8.50
Higher Degree	88.7	92.9	82.8	97.6	98.6	95.2	26,493	29,275	38,092	0.0	0.0	6.96
Weighted average	**91.6**	**91.6**	**70.2**	**96.2**	**96.2**	**93.1**	**30,494**	**29,473**	**30,833**			

Source: The IALS (New Zealand, 1996) and New Zealand Census of Population, 1996.

Notes: [a] Authors calculation from the IALS (New Zealand, 1996) by using a regression method, see text for details. [b] Calculated using midpoints of the intervals.

Table 11: Comparisons of Human and Physical Capital Stocks, New Zealand 1981-2001 ($billion)

	1981	1986	1991	1996	2001
Human Capital	221.5	388.6	575.3	713.3	842.9
Physical Capital	[a]	169.4 [b]	214.8	264.6	309.0
Human: Physical		**2.29**	**2.68**	**2.70**	**2.73**

Source: Authors calculation from New Zealand Census of Population, 1981, 1986, 1991, 1996, 2001, PC-INFOS Series SNCA.S5NK90ZZ.

Notes: [a] Statistics not publicly available. [b] This figure is for 1986/1987; it is used because the corresponding value for 1985/1986 is not publicly available either. All values are current prices.[20]

Table 12: Estimates of Per Capita Human Capital for New Zealand: A Comparison with Oxley and Zhu (2002)

	1986	1991	1996
Oxley and Zhu			
Baseline [a]	180,644	250,141	282,727
Baseline (2001 prices) [b]	303,092	292,503	309,497
Change from last Census		-3.5%	5.8%
Ages 25-64 [c]	**201,753**	**285,125**	**323,779**
Population aged 25-64 [d]	1,543,197	1,654,440	1,828,790
Current Study			
Baseline	291,321	430,840	489,280
Baseline (2001 prices) [b]	488,791	503,803	535,607
Change from last Census		4%	6.3%
Replicating Oxley and Zhu [e]	**231,951**	**346,043**	**392,985**
Population aged 25-64 [d]	1,542,981	1,654,191	1,828,809
Labour force aged 25-64	1,143,741	1,173,216	1,293,162

Source: Authors calculation from New Zealand Census of Population, 1986, 1991, 1996.

Oxley and Zhu's estimates are from Oxley and Zhu (2002).

Notes: All estimates are in current prices unless otherwise stated. [a] Ages 15 and older. [b] Adjusted to 2001 dollars using the Prevailing Weekly Wage Index PWIQ.S4329 and All Salary & Wage Rates LCIQ.SA53Z9. [c] Calculated using worksheet obtained from Oxley and Zhu. [d] Differences in the two sets of results are due to summation error, since our data are more disaggregated and as mentioned earlier, cell counts are randomly rounded to base 3. [e] Adjusted to best resemble Oxley and Zhu (row *c*): Ages 25-64; no enrolment effect; *i*=8%, *g*=3% for ages 21-29, 2% for ages 30-54, and 1% for ages 55-64.

[20] We keep the stock values in current prices, because in this section we are interested in how human capital compares with physical capital in each year, rather than how human capital changes over time. Another reason is that human capital in this case is lifetime labour income and so is deflated by the Wage Index; whereas what deflator should be used to adjust physical capital is controversial.

Figure 1: Annual and Lifetime Labour Incomes, 1981 (current prices)

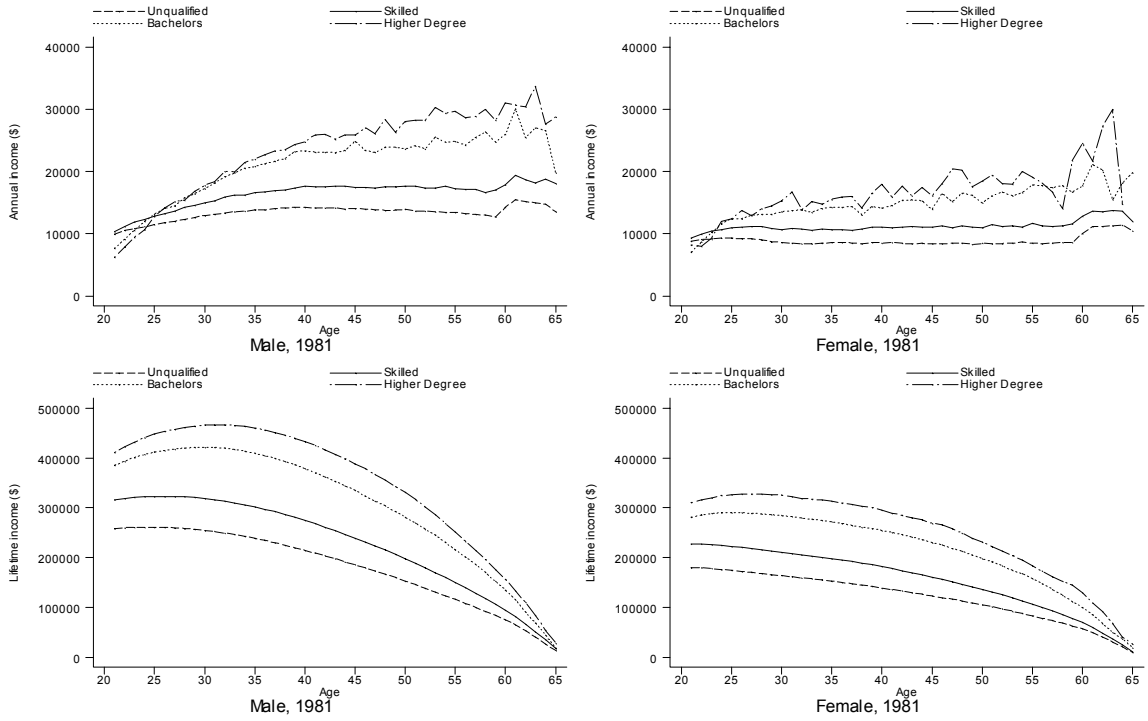


Figure 2: Annual and Lifetime Labour Incomes, 1986 (current prices)

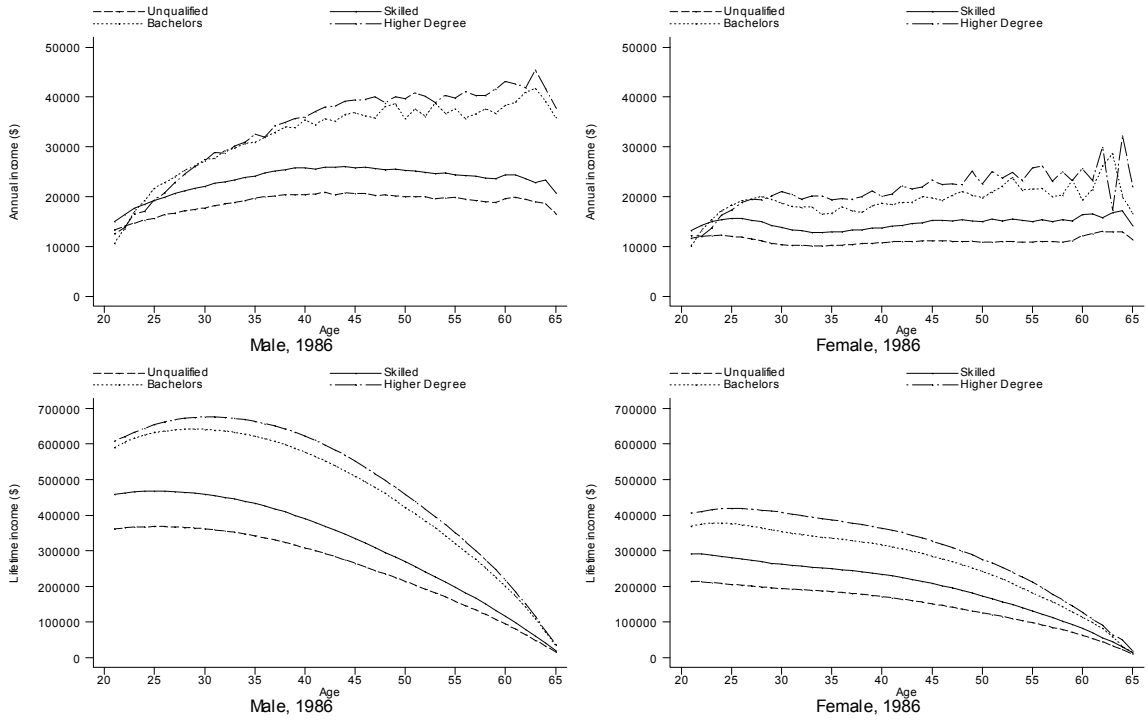


Figure 3: Annual and Lifetime Labour Incomes, 1991 (current prices)

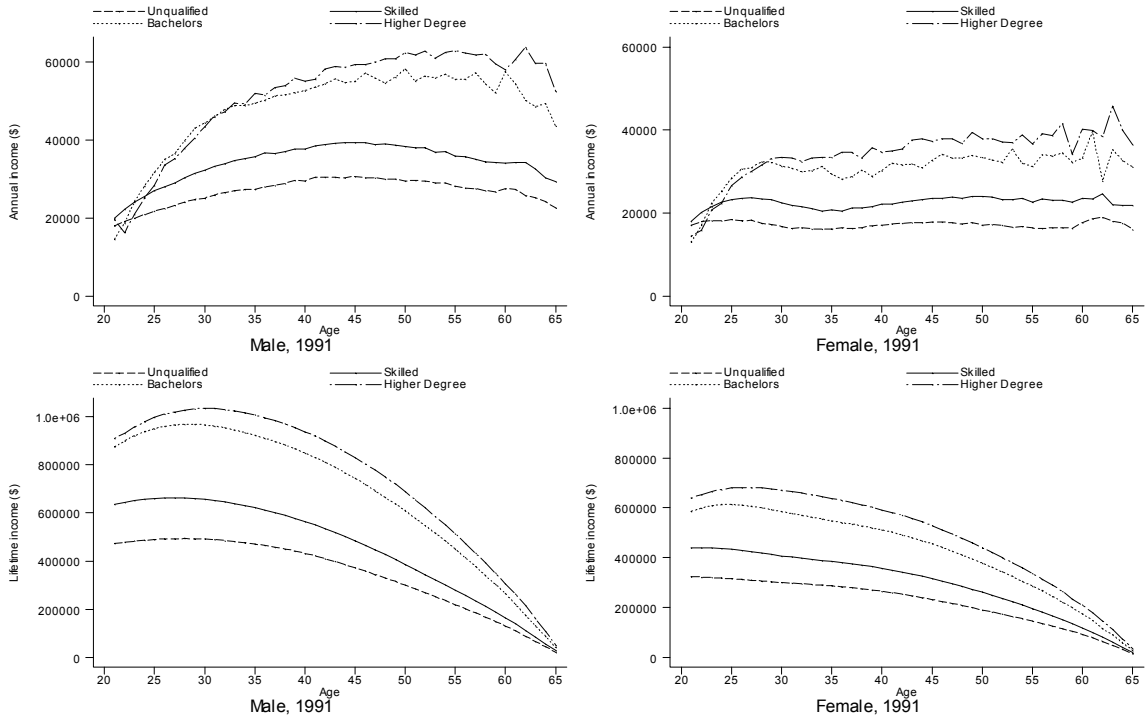


Figure 4: Annual and Lifetime Labour Incomes, 1996 (current prices)

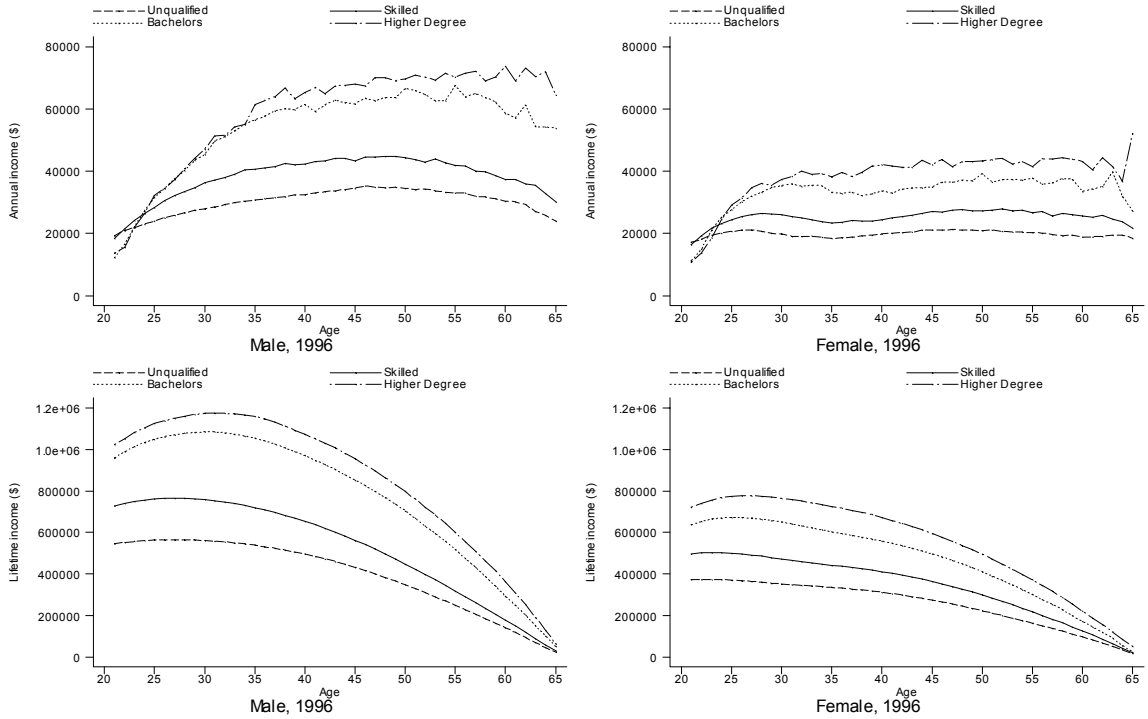


Figure 5: Annual and Lifetime Labour Incomes, 2001 (current prices)

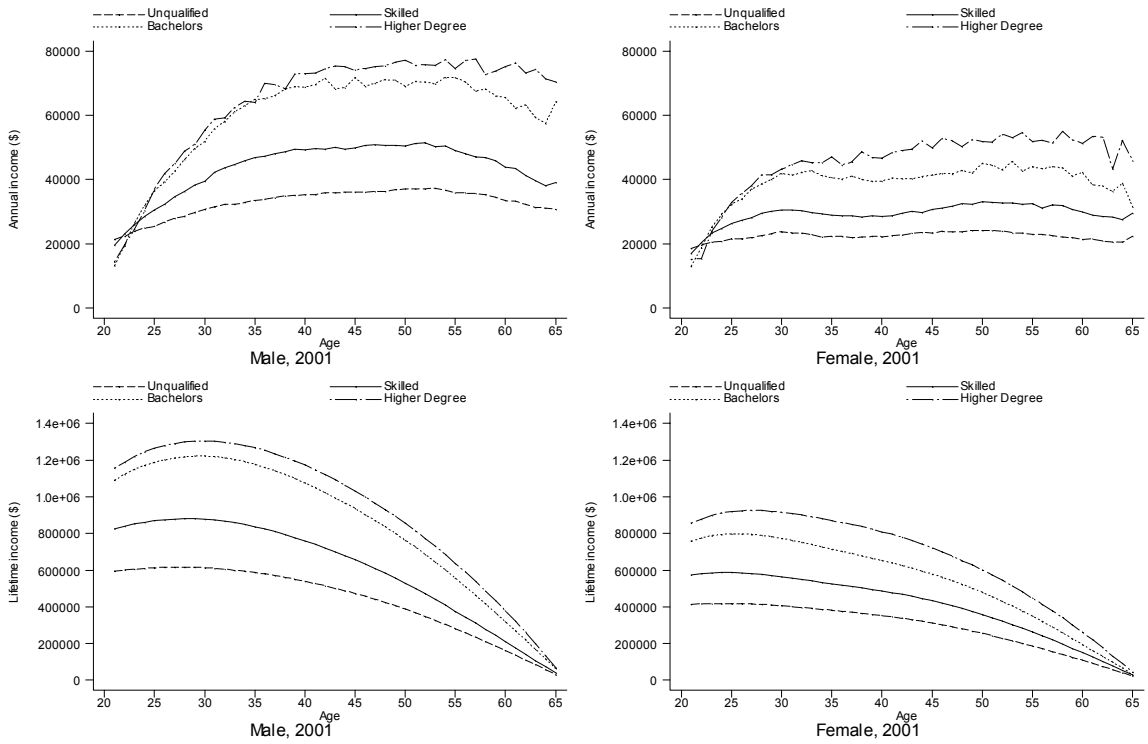


Figure 6: Impact of Deflator on Trend in Per Capita Lifetime Labour Income

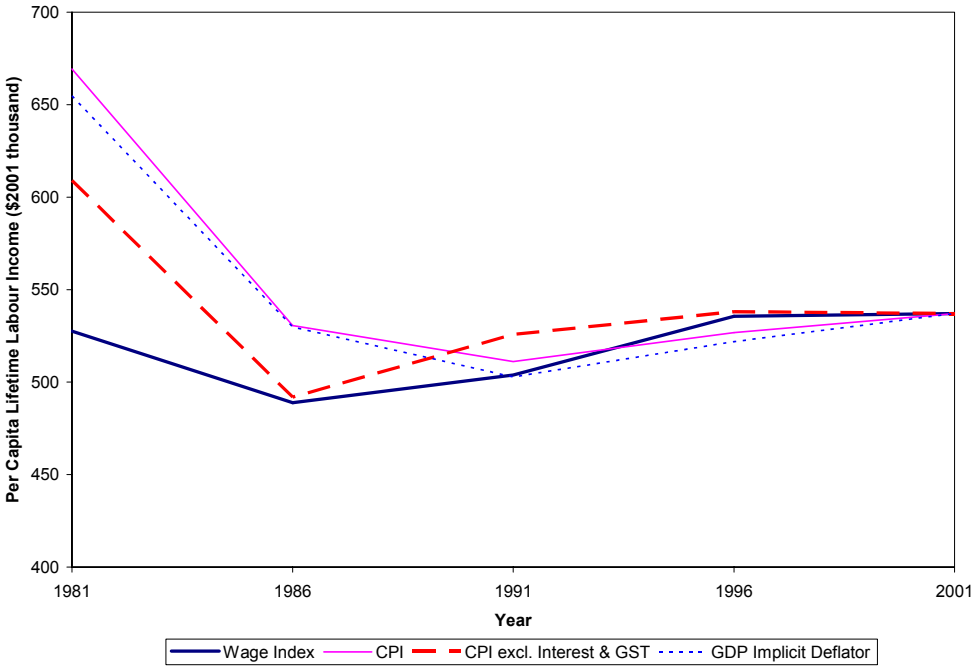


Figure 7: Impact of Variations on Real Total Human Capital

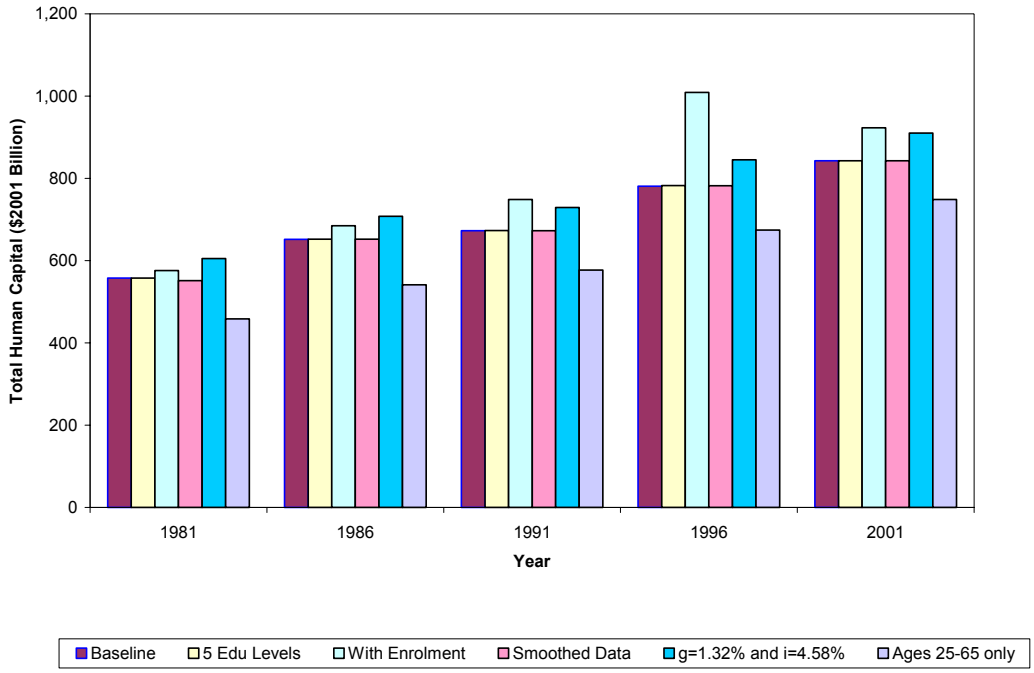
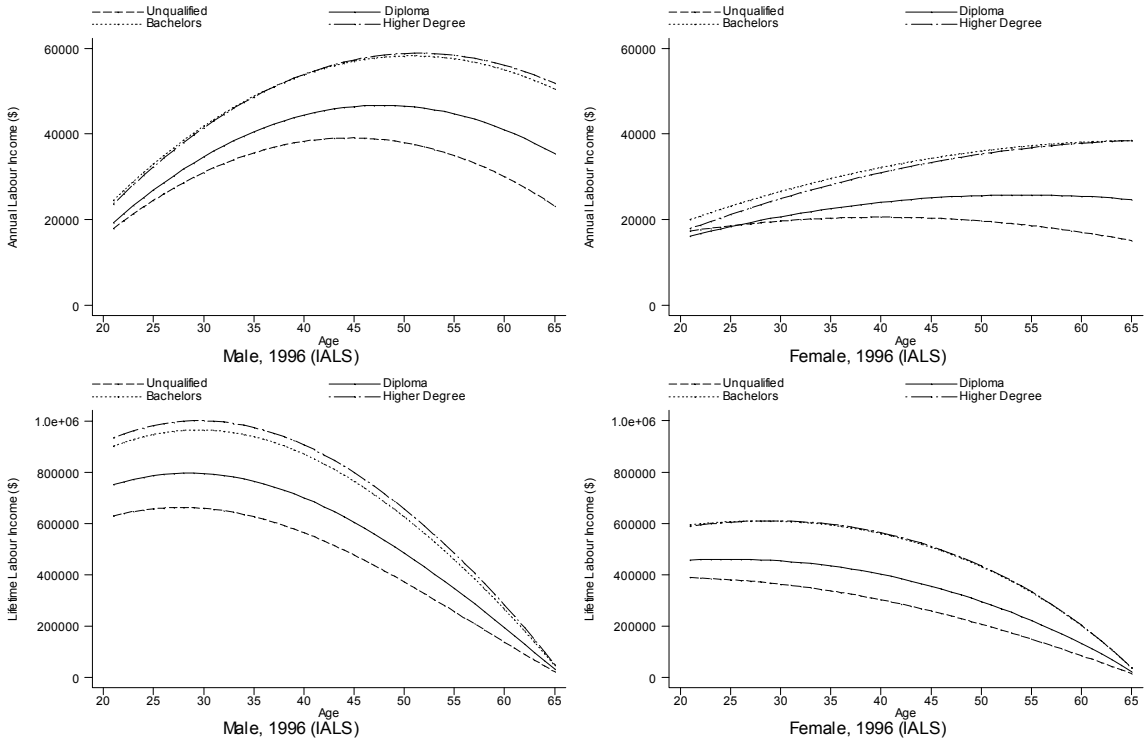


Figure 8: Annual and Lifetime Labour Incomes, 1996 IALS



Appendices

Appendix 1: Comparison of Categories of Educational Attainment

Our category	Superscripts	Census Category	IALS Category
Higher Degree	h	Graduate Diploma Post-graduate Diploma Honours Masters PhD	Graduate Diploma Post-graduate Diploma Honours Masters PhD
Bachelors Degree	b	Bachelors	Bachelors
Skilled Labour	s	Sixth form Certificate/ University Entrance Bursary/ Seventh Form Certificate Vocational Certificates Trade Certificates Other Post-school Qualifications Undergraduate Diploma	Non-degree post-school qualifications
Unqualified	u	School Certificate Not classifiable No qualifications Other	Completed high school or lower

Appendix 2: Questions on Educational Enrolment in New Zealand and Australian Censuses

Census	Questions	Answers
NZ Census 1981	Q17: Employment Status	7- Full time student
	Q28: Other places of education attended or at which enrolled	-Still attending primary or secondary school -None -University -Teachers College -Polytechnic or Technical Institute -Other – please specify…
NZ Census 1986	Q16: What is your main work or activity?	03 -Full time student
NZ Census 1991	Q16: Which of the following activities did you do last week?	48 –Attended full-time study or training course (including job training for unemployed persons) 49 – Attended part-time study or training course
NZ Census 1996	Q30: In the 7 days that ended on Sunday 3 March, did you:	-Attend or study for a full-time course at school or anywhere else -Attend or study for a part-time course at school or anywhere else
NZ Census 2001	Q30: In the last 4 weeks, which of these have you done, without pay?	-Attending or studying for 20 hours or more per week at school or any other place -Attending or studying for less than 20 hours per week at school or any other place
Australia Census 2001	Q22: Is the person attending a school or any other educational institution?	-No -Yes, full-time student? -Yes, part-time student?
	Q23: What type of educational institution is the person attending?	-Preschool -Infants/primary school -Secondary school -Tertiary institution -Other educational institution