Measuring the Stock of Human Capital for Australia: A Lifetime Labour Income Approach

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Executive Summary

Human capital is an important concept in many aspects of economics including growth theory and labour economics. Unfortunately, direct measures of human capital stocks are available for very few countries. This paper provides experimental measures of the stock of human capital for Australia.

The paper adopts a 'lifetime labour income approach'. This method measures the stock of human capital as the discounted present value of expected lifetime labour market income. Expected income streams are derived by using cross-sectional information on labour income, employment rates and school participation rates. This approach is also able to account for the value inherent in unfinished investment in human capital - that is, it can account for those individuals who are still participating in formal schooling and who anticipate improved employment and income prospects as a result of this schooling.

The standard human capital theory underpins this experimental study. In projecting future income streams, a number of assumptions have been made about the duration of alternative schooling activities, income growth rate and discount rate. In addition, human capital provides a plethora of benefits both in and out of the labour market. As this study is confined to market labour activities, many nonmarket returns to human capital may not be reflected in these measures.

Using Australian Census data for 1981, 1986, 1991 and 1996, this study calculates lifetime labour market incomes for 410 age/sex/education cohorts. Preliminary results show that there has been a significant increase in the stock of human capital in Australia.

Possible future developments include sensitivity tests of alternative assumptions, expansion of estimates into non-Census years, valuation of nonmarket labour activities, investment in and rates of return to different types of education.

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Hui Wei

1. Introduction

1. In the Australian System of National Accounts (ASNA), measures of capital stocks are confined to physical capital. It is not yet standard practice for any official statistical agency to include human capital in their capital stock measures. As human capital is one of the most important assets of a country, it is unfortunate to leave it out of in the national accounts. The purpose of this paper is to present systematic (but still experimental) measures of the stock of human capital for Australia.

2. The concept of human capital has been popular in economic theory and practice for nearly forty years since the publication of seminal works by Schultz (1961) and Becker (1964). The human capital model is applied in many fields of economics for example, in economic growth theory, income distribution analysis, and labour market studies.[1] In empirical studies, economists have employed various measures of human capital to test theories and hypotheses. It would be hard to imagine that these investigations of economic growth were not sensitive to alternative measures or proxies of human capital.[2] Hence one important issue that arises in considering the effect of human capital on other economic variables is how should human capital stock be measured? Clearly, more comprehensive measures of human capital stocks could contribute to a number of economic analyses.

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[1] Mincer (1995) provides a thoughtful discussion of the role of human capital theory in new growth theory and labour economics.

[2] See Hanushek and Kimko (2000) for a discussion of the explanatory power of alternative measures of human capital for economic growth theory.

3. This study uses the lifetime labour income method as outlined in Jorgenson and Fraumeni (1989, 1992a, 1992b) to measure the stock of human capital in Australia. The lifetime labour income method measures the human capital embodied in individuals as the total income that could be generated in the labour market over their lifetime. This approach views labour incomes as monetary returns to investments in human capital. As education is one of the most important forms of investment in human capital, the measures developed in this paper include not only the value embodied in 'finished products', but also the value inherent in 'unfinished products'. The 'finished products' are those individuals who have already obtained their highest educational attainment and are participating in the labour market by applying the skills and knowledge represented in their educational qualifications. The 'unfinished products' are those individuals who are still participating in formal schooling and who anticipate improved income and employment prospects as a result of this schooling. The contribution to labour incomes of past and current investments in education is captured through comparing incomes of individuals with identical age/sex characteristics but different amounts of educational attainment. Estimates of the potential value of current schooling in addition to estimates of the value of past schooling are an important feature of this study.

4. Estimates of physical capital stock are usually derived by cost methods. Cost methods value capital using the expenses incurred in its production.[3] The cost method is popular because of the general availability of expenditure data on capital goods. In addition, the historical cost approach is still the standard accounting practice in financial and management reports. The application of the cost method to valuing the human capital embodied in an individual encounters a particular problem: how to distinguish between the consumption and investment components of an educational expense?[4] Furthermore, the market returns to human capital - wages and salaries - are observable in the labour market. Given this context, the yield method may be a more suitable approach to measuring human capital.

[3] Kendrick (1976) is a seminal example of cost approach applied to physical capital valuation.

[4] Schultz (1961) provides a detailed discussion of this problem and suggests that because of this problem the cost method is less useful for measuring human capital than it is for measuring physical capital.

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. Under certain conditions, these two approaches are equal to each other. But, because these conditions are seldom satisfied, the two measures may give widely different estimates of the value of the capital stock.

5. The paper is structured as follows: Section 2 introduces the method used to estimate human capital and details the estimation approach. Section 3 describes the data sources and defines the variables used. Section 4 presents experimental estimates of human capital. Section 5 summarises my findings and outlines some proposals for future research. Section 6 suggests discussion points for MAC members.

2. Method

6 As noted in the Introduction, this study closely follows the method proposed by Jorgenson and Fraumeni, using expected future earnings in valuing human capital. Very broadly, the estimation proceeds in the following three major steps:

A. Construct a data base showing the economic value of market labour activities for various groups of people. This data base includes demographic accounts for adult individuals, cross-classified by sex, age, and educational attainment. The data items include the number of people, market labour income, employment rate and school participation rate.

B. Model the time-paths of the income stream for wage-salary earners from the above data base. The basic notion is that an individual with a certain age and level of educational attainment will base his/her expectations of earnings next year on the observed earnings today of people who are one year older (but possess the same educational qualifications and are the same sex). So, for example, one might assume that next year's income for 45 year old males with a PhD is

approximated by this year's income for 46 year old males with a PhD. Of course, other factors are also considered in the estimation, such as income growth rate, survival rate, employment rate and discount rate.

C. Apply per capita measures for wage-salary earners to all individuals (including employers and self-employed). Compute the discounted future income stream for each group of people, and sum them to estimate the aggregate value of human capital stock.

7 In applying the Jorgenson and Fraumeni (hereafter JF) method to Australian data, this study has made a number of modifications:

- One important innovation introduced by JF is the imputed valuation of nonmarket labour activities from information on market labour activities. But my estimates of human capital are confined to market labour activities. There are many other forms of returns to human capital, such as the values created in household production. These are beyond the scope of the present study though they are by no means less important. A future extension of this study might address this issue.

- Jorgenson and Fraumeni accounted for all individuals in the US. But my experimental study focuses on the Australian working population, defined as all individuals aged between 25 and 65 years. This somewhat arbitrary definition is not crucial, of course, and can be revised.

- In the JF method educational attainment is measured in calendar years of schooling. While this measure of formal schooling in calendar years can simplify mathematical manipulations and empirical computations, it does have the limitation of mixing up alternative kinds of education of the same length. For example, a young individual without any post-school qualification could choose to study for a TAFE qualification or an university degree. In the JF method, this individual's one year of study at TAFE or university is treated as identical, and thus the returns to TAFE or university study are assumed to be the same. In my study, educational

attainment is measured using various institutional qualifications. Using levels of highest qualification completed as a measure of formal schooling, I hope to capture the impacts of alternative kinds of education on human capital formation. Five classes of education attainment have been used for my experimental estimates - unqualified, skilled, diploma, bachelor degree and higher degree. For a full description of the education categories see Appendix A.

- JF use after-tax wage rates to estimate lifetime labour income. I use before-tax income figures to estimate the stock of human capital (see Para.13 for details).

8 It is fairly straightforward to compute lifetime labour incomes for individuals in the work-only stage, when individuals can by assumption only take one course of action: work. The present value of lifetime labour income per capita is given by

$$PV_a^{e_i}(x) = W_a^{e_i} X_0^{e_i} + S_{a+1} W_{a+1}^{e_i} PV_{a+1}^{e_i}(x)(1+g)/(1+i) \qquad (1)$$

where $PV(x)$ = present value of lifetime labour income per capita
X_0 = current annual labour income per capita of those employed
W = employment rate
S = probability of surveying one more year
e_i = educational attainment of level i
a = age
g = income growth rate
i = discount rate

9 I assume that there exists an age limit a^* at which all individuals will retire and their lifetime labour incomes are set to zero. I set the age limit at 65 years. Once the age limit is set, Equation (1) is well defined by backward recursion: first, the lifetime labour income per capita of a cohort of the oldest working age (65 years) is

estimated, followed by an estimate for the cohort with the next highest working age (64 years) and so on.

10 At the work-study stage, individuals pursue two possible courses of action: work and study. Since these two activities yield two possible earnings streams, annual labour incomes and hence lifetime labour incomes for any given cohort, are a linear combination of these two earnings streams. Furthermore, study may take various forms and be at different periods. For instance, a youth with secondary qualifications may embark on university or TAFE study, and a university student may be in the first year or final year of study. All these scenarios are associated with alternative earnings streams. As a result, an earnings stream stemming from study activity is treated as a linear combination of earnings streams associated with various types of studies with different study periods. Hence, the present value of lifetime labour income per capita for any given cohort in the work-study stage is given by

$$PV_a^{e_i}(x) = W_a^{e_i} X_0^{e_i} + \{(1 - \sum_{j \in E} \sum_{t \in T} Q_a^{jt}) W_{a+1}^{e_i} PV_{a+1}^{e_i} + \sum_{j \in E} \sum_{t \in T} Q_a^{jt} W_{a+t}^{e_j} PV_{a+t}^{e_j}(x)\} S_{a+t} \{(1+g)/(1+i)\}^t \quad (2)$$

where Q_a^{jt} = percentage of those individuals undertaking *j*th type of study in its *t*th period

E = all the levels of education attainment (except for the lowest)

T = all the study periods of E

11 Equation (2) is based on the assumption, often adopted in empirical human capital research, that during the study period students' direct schooling costs are exactly offset by their part-time earnings.[5] This simplifies the calculation process and is unlikely to have a major influence on the aggregate estimates of human capital stock. All variations of Equation (2) under various studies and associated assumptions are presented in Appendix B.

[5] See Mincer (1974), pp 7-8.

3. The Data

12 In order to measure the stock of human capital, I have constructed a data base for measuring lifetime labour incomes for all individuals in the Australian working-population. My basic data comes from Australian Censuses in 1981, 1986, 1991 and 1996.

13 For each age/sex/education cohort I derive the following variables: annual gross income, the employment rate, and the school enrolment rate. Ideally, I need labour compensation data as a measure of the price of labour services. Unfortunately, the Census data only contains information on gross personal income from all sources. Thus, I have to use income as a proxy variable for labour market earnings.[6] Furthermore, since my focus is on the price of labour services, I derive annual labour income per capita from weekly income data for employees and apply employees' income-age-educational qualification structure to employer and self-employed persons. Income tax and any other levies are not deducted, and other forms of labour compensation such as superannuation are not added to my calculations of annual incomes. Detailed information on income tax, various levies and forms of labour compensation could be incorporated into my estimates to yield net labour income streams. Appendix C summarises information on the number of people, school participation rates, employment rates and annual incomes of each group.

14 Figures 1-2 present annual income per capita for all 410 cohorts estimated from 1996 Census to illustrate the characteristics of age-earnings profiles. The greatest income gaps occur between those with degrees and those with no degrees. The educational differences in income between the bottom two education groups are relatively small. It also appears that annual income levels reach a peak much earlier for non-degree groups than for those with degree qualifications, which implies that it could take some years to reap the full monetary benefits flowing from investments in higher education.

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[6] For example, Dockery and Norris (1996) adopt the same approach.

FIGURE 1. ANNUAL LABOUR INCOME PER CAPITA, MALE, 1996

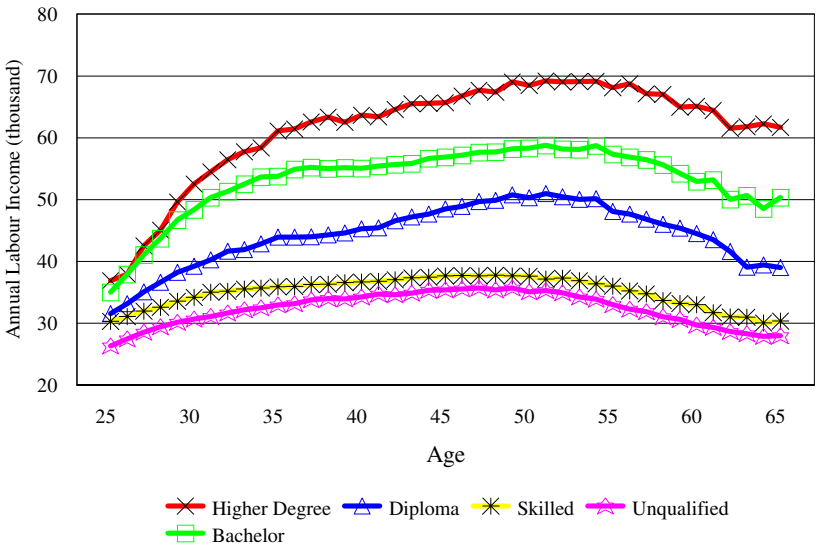
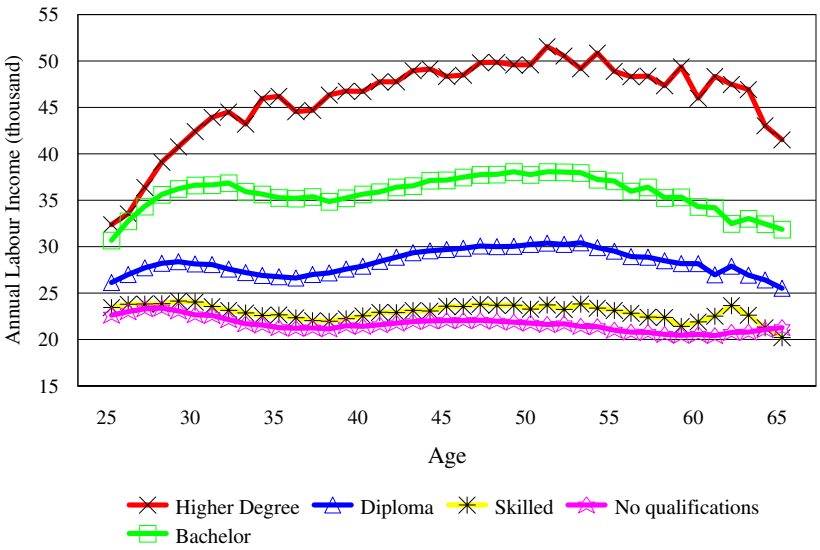


FIGURE 2. ANNUAL LABOUR INCOME PER CAPITA, FEMALE, 1996



4. Results

15 I estimate lifetime labour income for all 410 age/sex/education cohorts using Equations 3.3 - 3.7. My calculations of lifetime labour income per capita assume a discount rate of 4.58 percent and an expected income growth rate of 1.32 percent for all cohorts. These are the same rates that Jorgenson and Fraumeni used in their calculations.

16 Figures 3-4 plot lifetime labour income per capita for males and females computed from 1996 Census data. The two figures show the present value of the discounted income stream of income for any level of educational attainment for males and females aged 25 to 65. A common pattern emerges from these figures: lifetime labour incomes rise and then gradually decline for all levels of educational attainment. Two factors affect the shape of the lifetime labour income curves: the first is the age at which annual labour incomes peak and the second is the discount rate adopted in deriving present values. At any given discount rate, the shapes of the lifetime labour income curves critically depend on the age at which highest annual incomes enter the income streams of individuals' life cycles. If annual incomes peak at older ages, then lifetime labour incomes will peak at older age cohorts.

FIGURE 3. LIFETIME LABOUR INCOME PER CAPITA, MALE, 1996

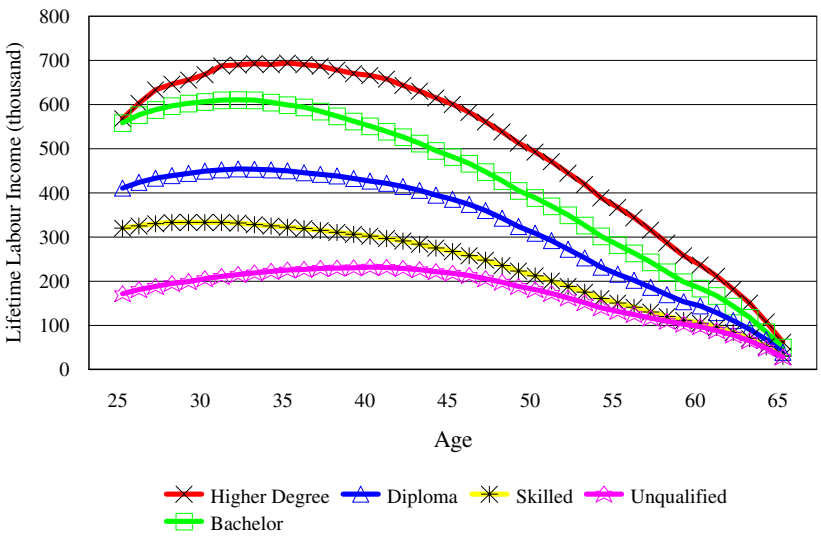
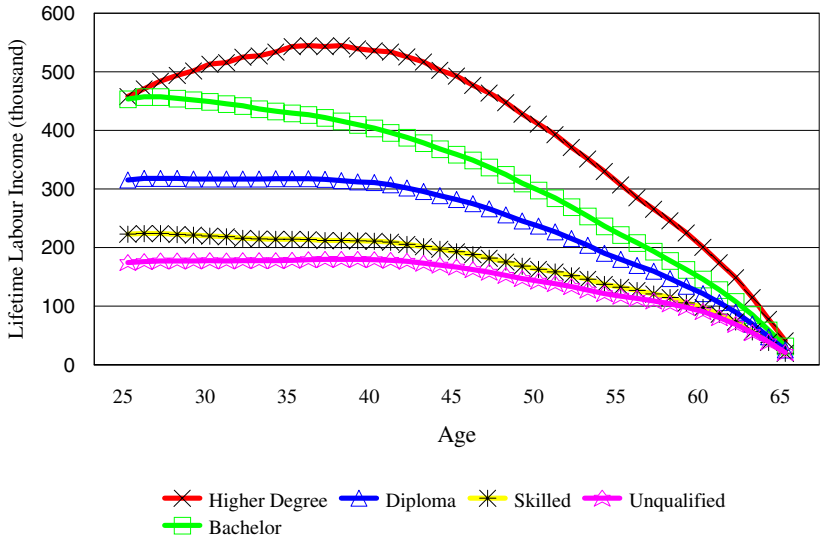


FIGURE 4. LIFETIME LABOUR INCOME PER CAPITA, FEMALE, 1996



17 The discount rate also affects the shape of lifetime labour income curves through its effect on the value of future annual incomes. The higher the discount rate, the lower the values of future incomes, and hence the earlier lifetime labour incomes peak. In the extreme case of a zero discount rate, the shape of lifetime labour income curves would be continuously declining.

18 The information on differences between lifetime labour incomes for cohorts with alternative educational attainment is very useful for extrapolating the values created in investing in additional education. Table 1 presents weighted average lifetime labour incomes for five categories of educational attainment. According to the JF's general framework, the product of the education industry is investment in human capital, and the output of education is thus defined as additions to lifetime labour incomes due to additional schooling. Within this framework, the information contained in Table 1 could be used to estimate investment in human capital and the output of education in corresponding years. For example, for a male bachelor degree holder, the total gain from investment would be $3,629 in 1981, $17,055 in 1986, $43,398 in 1991 and $54,943 in 1996. Of course, an investment of this kind is not restricted to a single period, and the amount of investment in each period has to be estimated on the basis of certain assumptions.

Table 1 Lifetime Labour Income By Educational Attainment and Sex
Australia, 1981 - 96 Census Data (Current Prices)

		1981	1986	1991	1996
Male	Higher Degree	253,524	397,116	452,240	554,978
	Bachelor Degree	249,895	380,061	408,842	503,505
	Diploma	195,325	280,518	295,510	359,694
	Skilled Labour	134,834	183,045	181,086	260,059
	Unqualified	95,742	122,832	128,382	181,744
Female	Higher Degree	196,747	292,334	371,844	469,455
	Bachelor Degree	180,458	267,704	319,129	387,777
	Diploma	153,147	208,120	239,192	271,185
	Skilled Labour	103,480	128,559	158,501	193,715
	Unqualified	71,516	88,591	106,173	150,352

19 The ultimate objective of this paper is to compute aggregate measures of human capital that could serve as counterparts to the measures of physical capital in the Australian National Accounts. For this purpose, the paper applies the per capita measures of lifetime labour incomes to total numbers of persons in each cohort to derive estimates of the stock of human capital in corresponding categories. The results of this exercise are reported in Table 2. To make estimates in each Census year comparable, the measure for each year has been converted to 1996 dollars using the CPI.

Table 2 Human Capital in Australia

Billions of 1996 Dollars

		1981	1986	1991	1996
Male	Higher Degree	24.16	30.81	43.62	64.65
	Bachelor Degree	122.59	168.43	179.68	260.71
	Diploma	68.37	72.29	87.09	118.99
	Skilled Labour	312.51	371.82	225.86	299.56
	Unqualified	509.94	438.79	360.85	459.90
	Sub total	1,038	1,082	897	1,204
Female	Higher Degree	5.16	7.48	14.16	28.27
	Bachelor Degree	48.36	77.71	127.00	210.71
	Diploma	63.13	63.53	107.41	123.15
	Skilled Labour	101.31	140.43	56.23	68.21
	Unqualified	484.23	406.28	386.32	492.48
	Sub total	702.19	695.43	691.12	922.83
Total		1,740	1,778	1,588	2,127

19 Key features of these results includes the following:

- The stock of human capital in Australia increased by around 22 per cent between 1981 and 1996. There was a marked decline in 1991, reflecting the recession and falls in real wage rates in this period.

- The overall growth in the stock of human capital is characterised by increases in the more highly qualified components of human capital. Even in the recession year, 1991, degree-qualified human capital was

increasing, compared with dramatic drops in the skilled and unqualified components of human capital.

- Increases in the more highly qualified components of human capital are much faster for women than for men. In the 15 year period, the value of female higher degree holders are close to six times higher than 15 years ago. This can be compared with values for men which tripled in the same period. The value of female bachelor degree holders are four times higher in 1996 compared to 1981, while during the same period the value for men just doubled.

21 It is instructive to compare these experimental measures of human capital with counterpart measures of physical capital (as measured in the ASNA). Table 3 presents estimates of human and physical capital in 1996 dollars. The estimates of physical capital are the sum of net physical capital of the private and public sectors. Table 3 shows that the size of human capital is much larger than that of physical capital for all years.

Table 3 Comparison Between Physical and Human Capital

Billions of 1996 Dollars

Year	Human Capital	Physical Capital*
1981	1,740	890
1986	1,778	1,034
1991	1,588	1,202
1996	2,127	1,332

* Australian National Accounts: ABS Cat. 5204.0.

22 However, in making this comparison there are a number important caveats to keep in mind particularly as these experimental measures of human capital are confined to the working population and market labour activities:

- The concept of working population used in this paper is arbitrarily defined to be those aged between 25-65 years. Thus, the estimates of the human capital stock are obviously subject to this definition. For instance, expanding the lower end of the age range from 25 to 18 year old, would possibly significantly push up the estimates of the human capital stock.

- Previous studies show that the values of nonmarket labour activities are much higher than those of market labour activities, see for example JF (1989, 1992a).[7] Adding the values of nonmarket labour activities to my estimates of the human capital stock would also dramatically change the picture depicted by Table 2.

- My estimates of the human capital stock, like the studies mentioned earlier, are gross estimates in the sense that maintenance costs are not deducted from labour incomes. The estimates of physical capital, presented in Table 6, are net figures. If maintenance costs were netted out, as they are for physical capital, then my estimates of the human capital stock would be smaller. Of course, whether maintenance costs should be deducted from the gross figures is a contentious issue in itself.[8]

5. Conclusion and Possible Future Developments

23 In this paper, I have presented some experimental measures of human capital for Australia. It is hoped that these measures (once verified and refined) could serve as useful counterparts to measures of physical capital in establishing a more complete national capital account. Using the JF method, I have demonstrated how human capital can be estimated by a lifetime labour income approach and estimated the values of human capital stock embodied in the working population of Australia for the Census years 1981, 1986, 1991 and 1996. The results of this exercise show

[7] For example, Jorgension and Fraumeni (1989, 1992a and 1992b) and Ahlroth *et al*. (1997).
[8] Graham and Webb (1979) support the gross estimates for human capital by arguing "Given that consumption is the ultimate raison d'etre of both investment and production, it seems reasonable to consider all consumption expenditure as an end in itself rather than as a means to an end."

that the more highly qualified components of Australian human capital stocks have increased dramatically, particularly for women.

24 However, the experimental estimates presented in this paper have many limitations:

- These measures are based on the assumption that earnings differentials between workers reflect productivity differentials. As is well-known, non-market forces can exert important influences on Australian wage structures both in the past and in the present. With this limitation in mind, the sharp drop in the aggregate stock of human capital in 1991 should be treated with caution. For example, were the significant decreases in real wage rates in 1991, shown by Table 4, reflective of institutional changes in wage rate arrangements or changes in labour productivity? If these decreases were caused by institutional factors, then the estimates for 1991 might need to be reconsidered. Similar caveats would apply to the estimates for other years.

- It is also the case that these experimental measures of human capital are confined to market activity only. Human capital is by no means less important for other non-market activities. With this limitation in mind, one must exercise caution in interpreting the magnitude of the experimental measures of human capital. For example, the figures in Table 2 clearly show that the value of human capital for men is much higher than for women for all age/sex/education cohorts. However, this does not necessarily mean we can conclude that male human capital is more 'valuable' than female human capital.

25 As noted earlier, this study is experimental in nature. If the methodology and data used by this paper prove to be sound, then the following actions are planned to further develop the estimates:

- Assessing the appropriateness of certain assumptions in the Australian circumstance, for example, income growth rates and discount rates;

- Net earnings are usually used in the valuation of physical capital. If we want to strictly make the valuation of human capital comparable to that of physical capital, similarly to JF (1989), then individual income tax rates should be incorporated into my estimates;

- Deriving estimates for non-Census years, using other sources of data, such as Survey of Income and Housing Costs (ABS Cat 6553.0) and Demography (ABS Cat 3311.0);

- Applying per capita measures of market labour values to impute nonmarket labour activities and incorporating these values into my measures of human capital;

- Applying the results of this study to produce some by-products analytical outputs, such as the value of investments in education, the output of the education sector, and rates of return to various types of investment in education.

6. Discussion Points

1. The first question is concerned with my basic approach. Broadly, other analysts' measures of human capital have been based on two major approaches: physical measures (such as educational attainment or skill level) and monetary measures (such as expenditures on education or the lifetime labour incomes, as estimated in this paper). Are we heading in the right direction by adopting the lifetime labour income approach to estimating the stock of human capital?

2. The second question is concerned with particular estimation procedures. Is there any concern with the three steps outlined in Para. 6, such as the classes of people

we have defined, or carrying over the per capita measures calculated for wage-salary earners to employers and self-employed? Is there any comment or concern about the 'backward recursion' method discussed in Para. 9?

3. The third question is concerned with application of the JF method to Australian data. For example -- Do we need to impute value of nonmarket labour activities (first dot point in Para. 7)? Do we need to include all individuals in our human capital account (second dot point in Para. 7)? Which measure of education attainment is preferred: years of schooling or levels of qualification (third dot point in Para. 7)? Should we use after-tax income or before-tax income to measure the stock of human capital (last dot point in Para. 7)?

4. The fourth question is concerned with the assumptions made for Australian circumstances. Is the classification of educational attainment into five categories appropriate? Are the assumptions regarding the duration of each type of study too strong (Appendix B)? How should we choose a suitable income growth rate and discount rate for my future refinement of the estimates?

5. The last question is related to possible publication of these experimental estimates. What information should accompany these measures, to ensure that our users understand their basis and the qualifications attaching to them, and can make intelligent use of them?

Appendix A

Comparison of Categories of Educational Attainment

My Category	1981 Census Category	1986 Census Category	1991 &1996 Census Category
Higher Degree	Higher Degree	Higher Degree	Higher Degree
Bachelor Degree	Graduate Diploma Bachelor Degree	Graduate Diplom Bachelor Degree	Postgraduate Diploma Bachelor Degree
Diploma	Diploma	Diploma	Undergraduate Diploma Associate Diploma
Skilled Labour	Certificate-Trade Level Certificate-Other Level	Certificate-Trade Level Certificate-Other Level	Skilled Vocational Qualifications Basic Vocational Qualifications
Unqualified	Not Classifiable Other Not applicable	Inadequately Described Not Classifiable Not Stated No qualifications Not Applicable	Level of Attainment Inadequately Described Level of Attainment Not Stated Not Applicable

Appendix B

Like any investment analysis that requires information on the length of alternative investment options, I need to specify the study periods for obtaining alternative educational qualifications. I make the following assumptions about investment periods in education:

(1) The study period for a higher degree is two years, conditional on holding a bachelor degree;

(2) The study period for a bachelor degree is three years for an unqualified person, two years for a skilled labourer and one year for a person with an associate diploma qualification;

(3) The study period for an associate diploma is one year for skilled labour and two years for unqualified persons;
(4) The study period for a skilled labour qualification is one year;

(5) Individuals can only study for a higher educational attainment than they already have. For example, if an individual with a bachelor degree in science later studies for a bachelor degree in economics, this model will treat this kind of schooling (schooling in addition to the science degree) as higher degree study;

(6) The number of students enrolled in any kind of education which requires more than one period are evenly distributed among different study stages. For example, half of the higher degree students are assumed to be in their first-year, the other half in their last year of study.

Lifetime labour income per capita for higher degree cohorts is given by

$$PV_a^h(x) = W_a^h X_0^h + S_{a+1} W_{a+1}^h PV_{a+1}^h(x)(1+g)/(1+i) \qquad (1)$$

where h stands for higher degree and, W_a^h is the employment rate for cohorts with higher degree qualifications at *a* years old.

A higher degree is the highest educational attainment in our model, and individuals who possess those educational qualifications are treated as if they were all at a work-only stage regardless of their age.

Lifetime labour income per capita for bachelor degree cohorts is given by

$$PV_a^b(x) = W_a^b X_0^b + \{(1 - Q_a^{b-h}) W_{a+1}^b PV_{a+1}^b(x) + \frac{Q_a^{b-h}}{2} W_{a+1}^h PV_{a+1}^h S_{a+1}(1+g)/(1+i) + \frac{Q_a^{b-h}}{2} W_{a+2}^h PV_{a+2}^h S_{a+2}\{(1+g)/(1+i)\}^2 \quad (2)$$

Where Q_a^{b-h} stands for the school enrolment rates for individuals with bachelor degrees studying for a higher degree at *a* years old. Based on Assumption (6), half of the students finish their study in one year, and the other half in two years.

Lifetime labour income per capita for associate diploma cohorts is given by

$$PV_a^d(x) = W_a^d X_0^d + \{(1 - Q_a^{d-b}) W_{a+1}^d PV_{a+1}^d + Q_a^{d-b} W_{a+1}^b PV_{a+1}^b\} S_{a+1}(1+g)/(1+i) \quad (3)$$

Lifetime labour income per capita for skilled labour cohorts is given by

$$\begin{aligned} PV_a^s(x) = {} & W_a^s X_0^s + (1 - Q_a^{s-d} - Q_a^{s-b}) W_{a+1}^s PV_{a+1}^s(x) S_{a+1}(1+g)/(1+i) \\ & + Q_a^{s-d} W_{a+1}^d PV_{a+1}^d(x) S_{a+1}(1+g)/(1+i) \\ & + \frac{Q_a^{s-b}}{2} W_{a+1}^b PV_{a+1}^b(x) S_{a+1}(1+g)/(1+i) \\ & + \frac{Q_a^{s-b}}{2} W_{a+2}^b PV_{a+2}^b(x) S_{a+2}\{(1+g)/(1+i)\}^2 \end{aligned} \quad (4)$$

Lifetime labour income per capita for unqualified cohorts is given by

$$
\begin{aligned}
PV_a^u(x) = {} & W_a^u X_0^u + (1 - Q_a^{u-s} - Q_a^{u-d} - Q_a^{u-b}) W_{a+1}^u PV_{a+1}^u S_{a+1}(1+g)/(1+i) \\
& + Q_a^{u-s} W_{a+1}^s PV_{a+1}^s(x) S_{a+1}(1+g)/(1+i) \\
& + \frac{Q_a^{u-d}}{2} W_{a+1}^d PV_{a+1}^d(x) S_{a+1}(1+g)/(1+i) \\
& + \frac{Q_a^{u-d}}{2} W_{a+2}^d PV_{a+2}^d(x) S_{a+2}\{(1+g)/(1+i)\}^2 \\
& + \frac{Q_a^{u-b}}{3} W_{a+1}^b PV_{a+1}^b(x) S_{a+1}(1+g)/(1+i) \\
& + \frac{Q_a^{u-b}}{3} W_{a+2}^b PV_{a+2}^b(x) S_{a+2}\{(1+g)/(1+i)\}^2 \\
& + \frac{Q_a^{u-b}}{3} W_{a+3}^b PV_{a+3}^b(x) S_{a+3}\{(1+g)/(1+i)\}^3
\end{aligned}
\qquad (5)
$$

Once the age limit is set, Equations 1 - 5 are well defined by backward recursion: first, the lifetime labour income per capita of a cohort of the oldest working age (65 years) is estimated, followed by an estimate for the cohort with the next highest working age (64 years) and so on.

Finally, the aggregate human capital stock V, embodied in the working-population, is given by

$$V = \Sigma_{e=1}^{5} \Sigma_{a=25}^{65} N_a^e PV_a^e(x) \qquad (6)$$

Where N_a^e = the number of persons aged *a* with *e* educational attainment.

Appendix C

Table 1A Working Population (25-65) By Educational Attainment and Sex Australia, 1981 - 96 Census Data (thousands)

		1981	1986	1991	1996
Male	Higher Degree	39.7	48.0	85.6	116.5
	Bachelor Degree	204.3	274.4	389.9	517.8
	Diploma	145.8	159.6	261.4	330.8
	Skilled Labour	965.2	1,257.9	1,106.5	1,151.9
	Unqualified	2,218.1	2,212.1	2,493.5	2,530.5
Female	Higher Degree	10.9	15.8	33.8	60.2
	Bachelor Degree	111.6	179.8	353.0	543.4
	Diploma	171.7	189.0	398.4	454.1
	Skilled Labour	407.7	676.4	314.7	352.1
	Unqualified	2,819.7	2,839.9	3,227.8	3,275.5
Total		7,094.6	7,853.0	8,664.5	9,332.8

Data Sources: Australian Census 1981, 1986, 1991, 1996

Table 1B Working Population (25-65) By Educational Attainment and Sex Australia, 1981 - 96 Census Data (percentage)

		1981	1986	1991	1996
Male	Higher Degree	1.11	1.21	1.97	2.51
	Bachelor Degree	5.72	6.94	8.99	11.14
	Diploma	4.08	4.04	6.03	7.12
	Skilled Labour	27.01	31.83	25.51	24.79
	Unqualified	62.08	55.97	57.49	54.45
Female	Higher Degree	0.31	0.41	0.78	1.28
	Bachelor Degree	3.17	4.61	8.16	11.60
	Diploma	4.88	4.85	9.21	9.69
	Skilled Labour	11.58	17.34	7.27	7.51
	Unqualifie	80.07	72.80	74.58	69.91

Data Sources: Australian Census 1981, 1986, 1991, 1996

Table 2 Schooling Enrolment Rates By Sex and Schooling Type Australia, 1986 - 96 Census Data* (percentage)

		1986	1991	1996
Male	Higher Degree	12.76	15.33	16.43
	Bachelor Degree	2.81	3.34	3.53
	Diploma	3.74	4.61	3.99
	Skilled Labour	0.74	1.12	0.80
Female	Higher Degree	10.80	12.90	14.36
	Bachelor Degree	2.38	3.28	3.67
	Diploma	2.70	3.77	4.04
	Skilled Labour	0.57	1.04	1.02

Data Sources: Australian Census 1981, 1986, 1991, 1996

*The 1981 Census did not collect information on types of educational institutions attended.

Table 2 presents schooling enrolment rates, measured as proportions of those currently enrolled in educational institutions against those qualified for undertaking that level of study. (See Section 3 for a discussion of the assumptions I have made in this regard.) Since my coverage only includes individuals aged between 25 to 65, these proportions should be interpreted as measures of the likelihood of undertaking further education for Australian adults. These figures are used for estimating the proportion of persons changing labour income streams due to additional schooling activities over the life cycle. Keeping in mind the strong assumptions underlying these estimates, we can observe one clear pattern, that is, those individuals with tertiary qualifications are much more likely to undertake further studies.

Table 3 presents employment rates of the working population, measured as percentages of employed persons against the corresponding labour force. One can make two observations: first, higher educational attainment appears to be associated with higher employment rates; second, those with lower qualifications are hardest hit when the general employment situation worsens. For example, the male employment rate dropped over 6 per cent for unqualified persons in the recession year 1991, compared with the figure in 1986; while the corresponding decrease is just 2.1 per cent for higher degree holders over the same period.

Table 3 Employment Rates* By Educational Attainment and Sex Australia, 1981 - 96 Census Data (percentage)

		1981	1986	1991	1996
Male	Higher Degree	98.77	98.19	96.18	96.48
	Bachelor Degree	98.44	97.79	95.38	96.15
	Diploma	98.60	97.50	94.11	94.79
	Skilled Labour	97.25	94.72	89.43	93.49
	Unqualified	95.07	90.68	84.40	88.68
Female	Higher Degree	96.73	95.91	94.42	95.81
	Bachelor Degree	96.97	96.38	95.53	96.47
	Diploma	97.86	96.44	95.47	95.69
	Skilled Labour	96.85	94.11	92.56	93.61
	Unqualified	95.43	91.67	89.06	91.90

Data Sources: Australian Census 1981, 1986, 1991, 1996

*These rates are measured as percentages of employed persons against the corresponding labour force, not the population.

Table 4 Annual Incomes Per Capita By Educational Attainment and Sex Australia, 1981 - 96 Census Data (1996 Dollar)

		1981	1986	1991	1996
Male	Higher Degree	56,752	61,172	58,741	63,369
	Bachelor Degree	50,249	52,168	49,612	52,346
	Diploma	46,100	47,993	42,863	44,540
	Skilled Labour	35,441	37,017	34,680	35,482
	Unqualified	31,439	32,812	31,379	32,767
Female	Higher Degree	41,302	44,439	43,495	46,374
	Bachelor Degree	36,014	37,493	34,316	35,740
	Diploma	30,809	31,646	27,770	28,388
	Skilled Labour	23,704	24,122	21,841	23,183
	Unqualified	20,429	20,797	19,734	21,869

Data Sources: Australian Census 1981, 1986, 1991, 1996

Table 4 reports estimated annual incomes of those employed, by sex and educational attainment in 1996 dollars. These annual income figures were calculated as the weighted averages of the income ranges specified in the corresponding Census questionnaire. There were substantial income disparities among the different education groups as well as between men and women. Differences in income (earnings) by education are suggested by human capita theory and are used to identify compositional change in measuring human capital.

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