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Measuring Human Capital Formation for Australia:
A Lifetime Labour Income Approach

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Abstract

This paper presents experimental measures of human capital formation for Australia. The proposed accounting system draws on the Jorgenson and Fraumeni human capital accounting system, with a few modifications consistent with the purpose of this study. Based on the concept of human capital measured as lifetime labour income, gross human capital formation is measured as the sum of investment in education and training, new members of the working- age population due to the under working-age population becoming working-age and net migration. Depreciation on human capital is measured as the decreases in lifetime labour incomes due to ageing. Net human capital formation is the difference between gross human capital formation and depreciation. Total changes in the stock of human capital between the beginning and the end of the accounting period is the sum of net human capital formation, demographic changes in the under working-age population and revaluation.

Using the full Census data for 1981, 1986, 1991, 1996 and 2001, this study compiles experimental human capital accumulation account for Australia. These figures show that since the early 1990s the stock of human capital in Australia has been depreciating at a much faster rate than the growth of human capital driven by population growth, and the key issue for sustainable development of human capital is investment in education and training.

1   Introduction

In May 2004 the ABS published a working paper on measuring the stock of human capital for Australia. This study adopts a 'lifetime labour income approach', developed by Jorgenson and Fraumeni (1989, 1992a, 1992b). This method measures the stock of human capital as the discounted present value of expected lifetime labour market income. Expected income streams are derived from using cross-sectional information on labour income, employment rates and school participation rates. Using the full Australian Census data for 1981, 1986, 1991, 1996 and 2001, this paper provides five snapshots of age-earnings profiles for four categories of educational attainment for both men and women over this twenty year period. Based on these age-earnings profiles, this study derives per capita measures of lifetime labour market incomes for each age/sex/education cohort, and applies these per capita measures to the number of people in the corresponding cohort. It then aggregates across all cohorts to estimate the human capital stock for Australia.

As a natural extension of the stock measurement paper mentioned above, the present paper presents experimental measures of human capital formation for Australia. Stocks are connected with flows. At an individual level, the growth of human capital takes various forms, such as parenting, formal education, on-the-job training and informal learning. At the aggregate level, the stock of human capital also depends on demographic changes such as birth and net migration.

In order to provide a full account of the growth of human capital, it is necessary to establish an integrated stock-flow accounting system in which changes in the stock of human capital can be fully explained by investment and other flows in human capital. Consistent with our measures of the human capital stock, this study uses the Jorgenson-Fraumeni (JF thereafter) accounting framework to estimate human capital formation over periods and integrate them with the changes in the human capital stock between periods.

The JF accounting system is based on the concept of human capital measured as the lifetime labour incomes for all individuals in the economy. The changes in human capital stock from period to period is viewed as the sum of human capital formation, net of depreciation on human capital and the revaluation of human capital. Human capital formation results from population growth and increments to lifetime incomes due to investment in formal education. Depreciation on human capital is viewed to be due to ageing, deaths and emigration. The difference between gross human capital formation and depreciation on human capital is net human capital

formation. Revaluation on human capital is viewed to be due to changes in lifetime labour incomes over time for each age/sex/education groups.

The standard human capital theory emphasizes the role of education and training in the human capital formation process. The JF accounting system only covers education in its estimates of investment in human capital at the disaggregate level, with the component of on-the-job training being mixed with its estimation of depreciation on human capital. This study attempts to provide estimates of on-the-job training investment as a separate component.

Another modification to the JF accounting system adopted in this paper is the separate treatments in accounting for human capital formation of working-age population and under working-age population. The JF accounting system values market as well as non-market activities in its accounting for human capital. As a result of this, under working-age individuals are treated in much the same way as working-age individuals. As this study is confined to the estimation of economic values of human capital, it recognizes the different forms of under working-age population and working-age population in the production of human capital. Like its counterpart —physical capital, under working-age individuals are treated like inventories, such as raw material and unfinished products, while working-age individuals are treated like capital goods functioning in the production process, such as machines and buildings.

The rest of the paper is structured as follows. Section 2 presents the accounting framework for developing human capital accumulation accounts. Section 3 addresses the data issues and presents preliminary results. Section 4 concludes.

2 The Accounting Framework

The micro foundation of the accounting framework for human capital accumulation accounts is based on the human capital theory. The differences in earnings among alternative education groups are viewed as reflecting the differences of their investment behaviour in human capital. Investment in education is measured by the increments to lifetime labour incomes arising from additional schooling. Similarly, the differences in earnings among alternative age groups with the same education cohort are attributed to differences in their potential working experience, and hence treated as returns to their on-the-job investment. At the aggregate level, quantitative changes in the human capital stock also consist of demographic changes through birth and net migration.

Like any other type of assets produced or acquired, human capital is subject to depreciation. Each type of capital goods has a normal working life and is subject to deterioration and obsolescence. In the case of human capital, skills may become rusty and knowledge may be forgotten. As the progress of the knowledge-based economy accelerates, human capital skills may also become obsolete. However, it is the finite working life of an individual that is ultimately responsible for the depreciation of human capital embodied in this person. The value of an asset in economic theory is equal to the present value of its future earnings. As the asset ages, the net present value of its remaining earnings declines, all else remaining equal, this is what is meant by 'economic depreciation'. For example, in the official System of National Accounts (SNA), depreciation of capital goods (or consumption of fixed capital) is measured as the difference between the real economic value of the asset at the beginning of the accounting period and at the end of the accounting period.

However, unlike physical capital, human capital embodied in an individual can grow through regular use and working experience. One additional year of working experience in the labour market means improved productive capacity but at the cost of one less year available to reap rewards from investment in this person's human capital. The net effect of being one year older on one's human capital depends on this person's age/education characteristics. The net effect is positive for more educated groups at the early stage of their working life, but becomes negative once they become old enough. In the JF approach, depreciation is measured as changes in lifetime labour incomes (measures of human capital) through ageing. As Rosen (1989) comments '*the depreciation estimates (compiled in this way)…seem to include gross on-the-job*

investment as one of its components. It would be of substantial interest to present those estimates separately.' This study obtains separate estimates of investment in on-the-job training from depreciation (loss of human capital value due to ageing).

All individuals in the economy are divided into three broad age groups: (1) under working-age population, defined as 0-17 year olds; (2) working-age group, defined as 18-65 year olds; and (3) retirement-age group, defined as those over 65 years old. The first age group is the source of the working-age population. As the function of this age group in the production of human capital is analogous to that of unfinished capital goods and raw materials in the production of physical capital, changes in the stock of human capital represented by this age group are classified as changes in inventories. The working-age group is analogous to fixed assets for physical capital goods, and changes in the stock of human capital represented by this component are the measurement focus of human capital flows. Because the retirement age group is assumed to be inactive in the labour market for the rest of its life, it is excluded in the human capital measures.

In this study, educational attainment is measured by highest level of qualifications obtained instead of calendar years of schooling. There are four broad categories of educational attainment: higher degree — master degree equivalents and above, bachelor degree — three-year university degree equivalents and above, skilled labour — vocational qualifications such as TAFE qualifications, and unskilled labour — without post secondary qualifications. The minimum ages for an individual to obtain certain educational qualifications are assumed as: 20 year old for a skilled labour, 21 year old for a bachelor degree and 23 year old for a higher degree. In this way, all individuals in the working-age population are cross-classified by sex/education/age dimensions with a total of 364 groups.

The conventional SNA estimates of physical capital begin with estimating gross capital formation and extrapolating estimates of capital stocks on the basis of certain assumptions about asset economic/efficiency life, depreciation patterns and asset price changes. In contrast, this study starts with estimates of human capital stocks and extrapolates estimates of human capital formation by decomposing changes in stocks during the accounting period into various flow components.[1] To measure net additions to the human capital stock for the working-age population, the changes in the human capital stock during any accounting period are decomposed into the following elements:

- investment in education;

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[1] See Appendix A for details on the decomposition procedures.

- investment in on-the-job training;

- new workers joining the labour force;

- net migration;

- depreciation;

- revaluation.

The changes in inventories for human capital (under working-age population) are decomposed into the following elements:

- investment in child rearing, primary and secondary education

- net migration;

- children reaching working-age (maturity);

- revaluation

The above decomposition procedure is used for linking the opening and the closing balance sheet values for human capital. This can be summarized as follows:

(a) The value of human capital stock in the opening balance sheet;

Plus

(b) Investment in education;

Plus

(c) Investment in on-the-job training;

Plus

(d) The total value of new workers;

Plus

(e) The total value of working-age migrants;

Minus

The total value of working-age emigrants;

(Is identical with Gross Human Capital formation)

Minus

(f) Depreciation caused by ageing;

(Is identical with Net Human Capital Formation)

Plus

(g) The changes in inventories;

 Plus

(h) Revaluation (positive or negative) of human capital;

Equals

(i) The stock value of human capital in the closing balance sheet.

Table 2.1 Accumulation Account, Human Capital

(1) Gross Capital Formation	(2) Depreciation	(3) Net Capital Formation	(4) Changes in inventories	(5) Revaluation	(6) Change in Human Capital Stock
Investment in education		(1) - (2)			(3)+(4)+(5)
On-the-job investment					
New workers					
Net migration					

The accounting identity depicted above is illustrated in Table 2.1. Each element could be measured directly without the others. However, in case of missing information for any single element, the value of that element can be determined residually. In the case of human capital, as revaluation and depreciation can be directly estimated, other items can be more conveniently estimated as residual. In contrast, in the case of physical capital, revaluation is more conveniently estimated as a residual item.

3   Data and Preliminary Results

3.1 Data Issues

The foregoing accounting framework for human capital formation has been applied to four Census periods — 1981-86, 1986-91, 1991-96 and 1996-2001.

The stock measurement of human capital has two components: the working-age and the under working-age. Accordingly, the flow measurement of human capital consists of two components —human capital formation for working-age population and flow changes for under working-age population (equivalent to fixed capital formation and changes in inventories respectively in the Australian System of National Accounts). The essence of human capital flow measures is to decompose the change in the net worth of human wealth between the beginning and end of the accounting period into that part due to demographic changes including migration, that part due

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to enhanced productive capacity (investment in education and on-the-job investment), and that part due to price effect. As education and migration are the key determinants of Australian human capital resource, the accuracy of our flow measures of human capital largely depends on data availability and its quality on education and migration.

For any sex/age/education cohort, the number of persons at the end of the accounting period is given by

$$n_{y,s,e,a} = n_{y-t,s,e,a-t} + n_{y,s,e\neq4,a}^{in} - n_{y,s,e\neq1,a}^{out} + n_{y,s,e,a}^{im} - n_{y,s,e,a}^{em}$$ (3.1)

where n^{in} = number of persons who have been 'promoted' into this education group
    from a lower education group;
  n^{out} = number of persons who have left this education group to join a higher
    education group;
  n^{im} = number of immigrants;
  n^{em} = number of emigrants.

If any five elements in the identity (3.1) are known, the remaining one can be determined residually. In reality, as empirical observations for n^{in}, n^{out}, n^{im} and n^{em} are rarely available, it is a challenge to extrapolate figures for demographic changes. This implies that the sum of separately estimated flow components may not be exactly equal to the actual changes in the human capital stock during the accounting period. A residual element could be inevitable for decomposition analysis.

To estimate the numbers of persons who obtained additional (higher) education qualifications during the accounting period from Census data, we could use the information contained in the variables '*Is the person attending a school or any other educational institutions*' and '*What type of educational institution is the person attending*'. Such information alone could not enable us to directly derive these numbers, and certain assumptions have to be made in regard to the lengths and completion rates of students.

The numbers of migrants could be estimated by using the two variables in the Census: '*In what year did the person first arrive in Australia to live here for one year or more*' and '*in which year did the person complete their highest qualification*'. Again there are two possible data problems. Between two consecutive Census years, the following events may occur: (1) A person may enter Australia in earlier years to live for more than one year, but actually migrates to Australia in current period. Under this circumstance, this person will not be accounted in our estimation of migrants. Therefore our accounting for migrants based on the first variable may underestimate the true migration figures; (2) A migrant's current educational attainment may be

higher than what he obtained when he first arrived in Australia. This scenario would mean that the value of this migrant was overestimated.

As the Australian Census contains very little information on the numbers of persons who have obtained higher qualifications and emigrated, we have to contend ourselves with some partial measures of human capital flows at this stage.

3.2 Gross Human Capital Formation

Investment in Education The objective here is to estimate the numbers of persons who obtained higher educational qualifications during the accounting period. Table 3.1 presents estimates of the numbers of persons who jumped into the next level of educational groups. These estimates are confined to 18-34 age groups. As the numbers of persons who emigrated out of Australia after completion of their highest qualifications are not available from the Census, these figures only cover those who remain in Australia after their completion of highest qualifications.

Table 3.1   Number of Persons Who Obtained Higher Qualifications

		1981-86	1986-91	1991-96	1996-2001
Male	Higher Degree	7,537	25,671	26,224	31,873
	Bachelor Degree	71,590	123,129	152,107	145,349
	Skilled Labour	205,936	195,170	206,619	221,181
Female	Higher Degree	3,517	12,960	21,126	31,740
	Bachelor Degree	66,363	171,362	221,306	228,547
	Skilled Labour	135172	116,948	139,631	156,507

Table 3.2   DETYA University Graduate Statistics

		1991-96	1996-2001
Male	Higher Degree	28,844	
	Bachelor Degree	204,731	
Female	Higher Degree	21,755	
	Bachelor Degree	295,523	

In order to assess how realistic these estimates are, it is useful to compare them with the relevant part of Higher Education Statistics compiled by DETYA. As the most recent figures available from DETYA are up to 1999, the comparison can be done for only one Census period. Table 3.2 presents the numbers of university graduates at higher degree and bachelor degree

levels for non-overseas students during the period 1991-1995. Conceptually, the Census figures are smaller due to the following two reasons: (1) the DETYA figures cover all completed graduates including those who emigrate out of Australia and those who belong to older age groups, whose additional schooling activities are treated as consumption rather than investment in our accounting for human capital framework; (2) the DETYA figures cover those graduates who had obtained the same level qualifications in addition to the one just completed, while the graduate estimates from the Census cover only those who have completed higher qualifications and moved into higher educational groups.

Table 3.3 presents lifetime labour income per capita in current dollars for 25 year-olds, classified by sex and educational attainment. The information on differences between lifetime labour incomes for groups with alternative educational attainment is used for estimating the extra value created by investing in additional education.[2] For example, for a male bachelor degree holder, the total gain from investment in a higher degree, would be around $28,000 in 1981, $53,000 in 1986, $98,000 in 1991, $136,000 in 1996 and $132,000 in 2001 (using nominal dollars).

Table 3.3 Lifetime Labour Income Per Capita for 25 Year-Olds

(thousands of current dollars)

		1981	1986	1991	1996	2001
Male	Higher Degree	490	778	1,068	1,283	1,529
	Bachelor Degree	462	725	969	1,147	1,397
	Skilled Labour	322	507	685	799	991
	Unskilled labour	263	419	578	681	833
Female	Higher Degree	376	598	828	983	1,217
	Bachelor Degree	335	527	688	809	1,013
	Skilled Labour	236	366	503	584	710
	Unskilled labour	180	280	380	477	595

Table 3.4 presents estimates of investment in education, measured by additions to lifetime labour incomes due to higher educational qualifications. The additional lifetime labour incomes per capita are calculated in the following manner: for those who have completed higher degrees, the income gaps between higher degree and bachelor degree groups are used for valuing their investment in higher degrees; for those who have completed bachelor degrees, the income gaps between bachelor degree and unskilled labour groups are used; for those who have completed skilled labour qualifications, the income gaps between skilled labour and unskilled labour groups

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[2] See Wei (2004) for details on how lifetime labour income per capita for each sex/education/age group are calculated and associated assumptions adopted in these estimates.

are used. Obviously, there are various theoretical and practical issues in using the lifetime labour income approach for valuing investment in education, such as issues of selectivity by ability.

Table 3.4   Estimates of Investments in Education
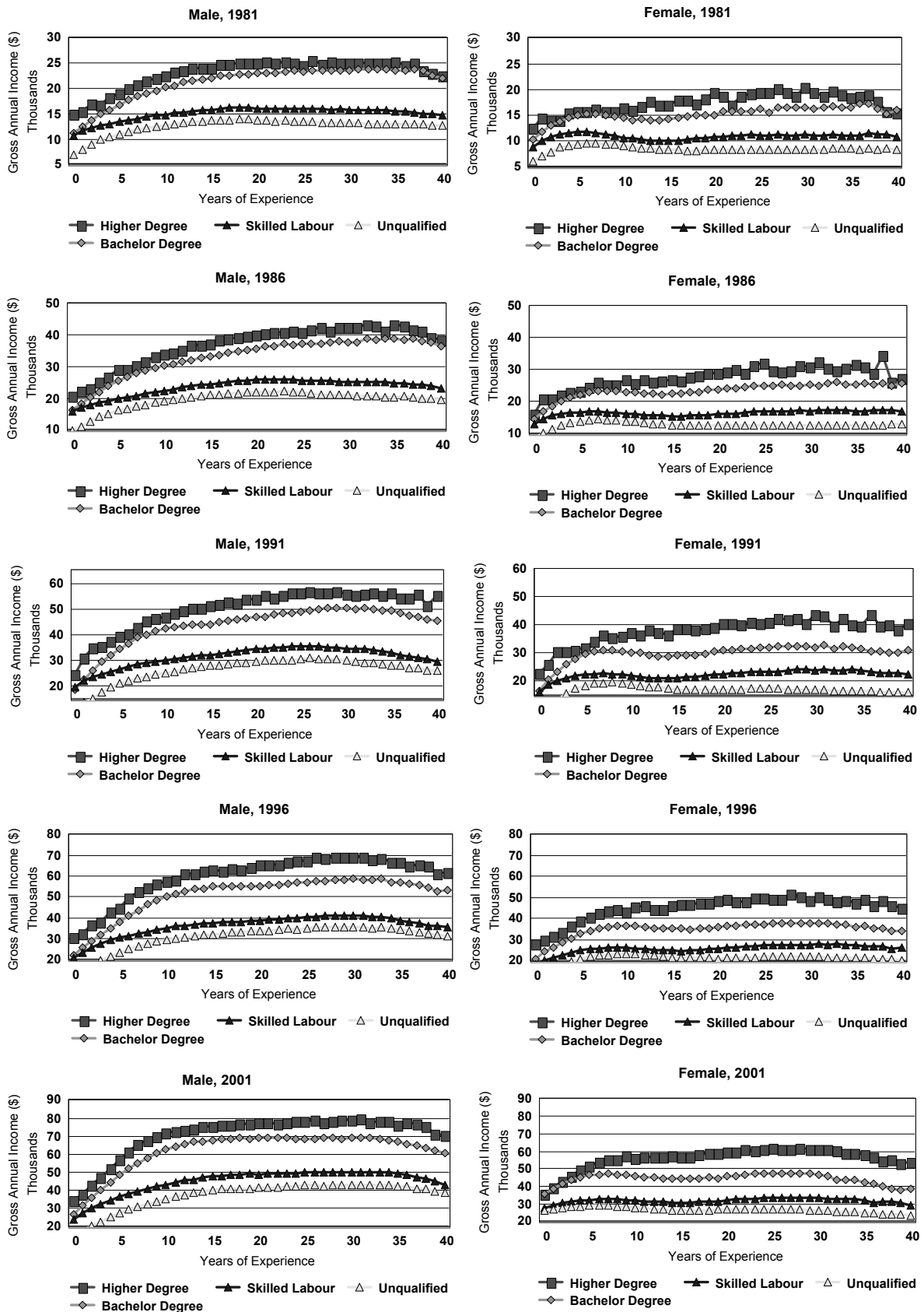**(millions of current dollars)**

		1981-86	1986-91	1991-96	1996-2001
Male	Higher Degree	499	3,015	4,368	5,301
	Bachelor Degree	19,173	36,995	57,048	61,451
	Skilled Labour	16,034	17,518	20,742	26,807
	Sub Total	35,706	57,528	82,158	93,559
Female	Higher Degree	292	2,039	4,147	7,500
	Bachelor Degree	14,993	44,822	61,829	75,575
	Skilled Labour	10,398	11,613	11,176	11,873
	Sub Total	25,683	58,474	77,152	94,948
Total		61,389	116,002	159,310	188,507

On-the-Job Investment On-the-job training is an important part of the classical analysis of investments in human capital. In the empirical analysis, as direct data on training and its effect on earnings are difficult to obtain and estimate, one expedient way to address this issue is to assess the impact of working experience on earnings. The standard procedure developed by Mincer (1974) is to use age profiles of earnings to derive estimates of working experience on earnings by assuming corresponding relationships between working experience and age for alternative educational groups.

Figure 1 presents experience profiles of annual incomes of both men and women for five Census years.[3]This figure clearly shows that annual incomes differentials between university-educated groups and the groups without tertiary qualifications grow much faster at the early stage of working experience, with around 10 years in a row for men and 5 years for women. If these differentials are interpreted as reflecting varying amounts of investment in training, it follows that more-educated workers invest more in on-the-job training than less-skilled workers during the early years of entering the labour market. This figure also shows that relative productive capacity differentials for men, measured by educational attainment, tend to become stable after 15 years of work experience. Another notable feature revealed by this figure is that experience-earnings

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[3] It is assumed that the higher degree group starts working at age 25, the bachelor group at age 22, the skilled labour group at age 20 and unskilled labour group at age 18.

Figure 1   Experience Profiles of Annual Incomes

Male, 1981

Female, 1981

Male, 1986

Female, 1986

Male, 1991

Female, 1991

Male, 1996

Female, 1996

Male, 2001

Female, 2001

patterns for women are vastly different from those for men, suggesting that it may be less appropriate to use age-earnings profiles to extrapolate experience-earnings profiles for women, because many women have to take maternity leave from the labour market after some initial years of experience in the labour market.

It should be noted that experience profiles of earnings reflect not only investment behaviour, such as workplace training, learning by doing, and informal learning, but also institutional influences, as is suggested by efficiency wage theories. Examining the effect on age/experience profiles of earnings of institutional reform at the work place is beyond the scope of this paper.

Given the experience profiles of earnings compiled from the age profiles of annual incomes, investment in on-the-job training is measured as increments to lifetime labour incomes due to additional year of working experience.[4] The aggregate investments in on-the-job training are derived by summation across all age/education groups, which are reported in Table 3.5.

Table 3.5   Estimates of Investments in On-the-Job Training
(millions of current dollars)

		1981-86	1986-91	1991-96	1996-2001
Male	Higher Degree	270	588	1,117	1,702
	Bachelor Degree	2,836	3,642	5,455	8,358
	Skilled Labour	4,907	7,159	10,205	12,131
	Unskilled Labour	15,449	11,531	19,037	22,694
	Sub Total	23,462	22,920	35,814	44,886
Female	Higher Degree	42	127	303	687
	Bachelor Degree	480	1,088	2,846	6,144
	Skilled Labour	771	1,094	1,940	3,615
	Unskilled Labour	6,381	11,196	25,216	28,036
	Sub Total	7,674	13,504	30,304	38,482
Total		31,135	36,424	66,119	83,369

New Workers Table 3.6 presents the estimated numbers of new workers. In counting the additions of new workers to the existing human capital stock, the measurement focus is on 'raw bodies' of the new workers. The 'intellectual' component is captured in accounting for investment in education. Therefore, these estimates of new workers include all education categories. Table 3.7 presents the estimated values of new workers in current prices. In valuing these new workers, the lifetime labour income per capita for the baseline education group

(unskilled labour group) is used as a 'unit' price for each age/sex group. For example, as a new worker, a 22 year-old bachelor degree holder is valued in the same way as his/her unskilled labour counterpart. The additional human capital he/she has accumulated through tertiary education is captured in accounting for investment in education.

Table 3.6   Gross Human Capital Formation: Number of Persons of New Workers

	Age	1981-86	1986-91	1991-96	1996-2001
Male	18	124,792	131,077	121,174	128,581
	19	121,272	136,367	121,683	125,560
	20	119,746	138,519	120,892	123,395
	21	120,426	130,929	124,452	119,557
	22	123,691	124,563	125,358	115,830
Subtotal		609,927	661,455	613,559	612,923
Female	18	118,954	125,865	115,725	122,667
	19	115,931	131,696	117,502	120,955
	20	115,342	135,120	116,858	119,012
	21	116,869	127,172	120,606	114,722
	22	119,815	122,218	121,435	112,421
Subtotal		586,911	642,071	592,126	589,777
Total		1,196,838	1,303,526	1,205,685	1,202,700

Table 3.7 Values of New Workers   (millions of current dollars)

	Age	1981-86	1986-91	1991-96	1996-2001
Male	18	53,835	77,616	85,968	112,101
	19	53,462	83,710	88,369	112,895
	20	53,120	85,851	88,585	112,682
	21	53,085	80,522	90,570	108,436
	22	53,657	75,047	89,407	102,604
Subtotal		267,159	402,746	442,899	548,719
Female	18	37,724	55,284	63,390	83,524
	19	37,297	59,862	65,771	85,404
	20	36,608	60,968	65,334	85,057
	21	35,764	54,830	65,200	79,714
	22	35,495	50,258	62,691	73,906
Subtotal		182,887	281,202	322,386	407,605
Total		450,046	683,947	765,284	956,324

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[4] As dollar returns to on-the-job training tend to decline after a peak is reached, the estimates of this kind of investment in human capital are based on 15 years of working experience for men and 5 years for women. A constant 15% rate of return is assumed for each sex/education/age group.

New Migrants The objective here is to estimate the numbers of adult migrants (aged 18-65) by educational attainment at the time of their arrival. There are two steps involved in estimating new migrants between Census years. The first step is to estimate number of migrants who completed their highest educational attainment before migrating to Australia. This is obtained by selecting those who completed their highest qualifications before the beginning of our accounting period, and then establishing those who arrived Australia during the accounting period. The figures obtained in this way are used as estimates of migrants with educational qualifications. Clearly, these figures are not total numbers of those migrated into Australia. Two groups of migrants — those without post-school qualifications and those who obtained higher educational qualifications in Australia since they arrived — are excluded from these estimates. Even some of those who completed their highest qualifications might be missed out in my estimation due to two possible reasons. First, as this step only accounts for those who 'first arrive in Australia' during the accounting period, those who arrived in earlier periods but migrated to Australia during the current period may be missed out. Second, those migrants who completed their highest qualifications before their arrival but obtained another similar qualifications in Australia might also be missed out, because they might report the year in which they obtained their highest qualifications in Australia as the year when they complete their highest qualifications.

In order to cover all those who migrated into Australia during the accounting periods, the second step is needed to account for the number of those migrants without post secondary educational qualifications, this is equal to the difference between the figures derived from the first step and the total numbers of migrants for each age group. The latter figures are derived by estimating the numbers of those who first arrived in Australia to live here for one year or more, regardless of their educational attainment when they first arrived in Australia.

Table 3.8 presents the estimates of migrants by highest educational qualifications they achieved before they arrived in Australia. These figures are roughly consistent with the rule of thumb — one hundred thousand migrants each year, considering under working-age and over-65 groups are excluded.

Table 3.8 Estimates of Migrants to Australia Aged 18-65

		1981-86	1986-91	1991-96	1996-2001
Male	Higher Degree	3,656	8,327	8,984	8,551
	Bachelor Degree	11,614	25,628	23,963	28,571
	Skilled Labour	42,728	43,173	29,188	31,398
	Unskilled labour	134,102	201,559	130,424	153,183
	Sub Total	192,100	278,687	192,559	221,703
Female	Higher Degree	1,616	3,900	4,999	5,117
	Bachelor Degree	8,417	22,173	25,220	30,473
	Skilled Labour	26,764	29,096	21,059	23,672
	Unskilled labour	158,256	234,714	166,351	176,870
	Sub Total	195,053	289,883	217,629	236,132
Total		387,153	568,570	410,188	457,835

Given the difficulties in estimating the numbers of migrants by educational attainment at the time of their arrival, it is very tricky to value migrants — how to value those who obtained higher or similar qualifications in Australia after their arrival, as their original qualifications are unknown. One way of dealing with this problem is to assume that these migrants on average are equivalent to unskilled labour. And those who completed highest qualifications are equivalent to their Australian counterparts before their arrival. Table 3.9 presents the value estimates of migrants during the period 1981- 2001.

Table 3.9 Economic Values of Migrants (millions of current dollars)

		1981-86	1986-91	1991-96	1996-2001
Male	Higher Degree	2,410	7,237	9,657	10,582
	Bachelor Degree	7,246	20,975	22,737	32,545
	Skilled Labour	17,840	24,223	18,835	24,377
	Unskilled Labour	49,551	101,619	79,470	115,997
	Sub Total	77,047	154,053	130,699	183,501
Female	Higher Degree	818	2,688	4,155	5,233
	Bachelor Degree	3,801	12,679	16,646	24,720
	Skilled Labour	8,076	11,996	9,948	13,335
	Unskilled Labour	37,711	76,062	69,242	92,773
	Sub Total	50,406	103,425	99,991	136,061
Total		127,453	257,479	230,690	319,562

Emigrants There is no direct information for emigration in the Australian Census. As a result of this, the numbers of emigrants have to be estimated by using information on the differences

between the numbers of persons at the beginning and those at the end of the accounting period and estimates of migrants. Referring to identity (3.1), as there are no separate observations for n^{in}, n^{out} and n^{im}, estimates for emigration have to be made at a broader sex/age level (excluding education). The number of emigrants for any sex/age group is set to be equal to the number of immigrants minus the difference between the number of persons at the beginning and the end of the accounting period.

3.3 Depreciation on Human Capital

The lifetime labour incomes of individuals (measures of their human capital) vary with their age. On one hand, as one grows one year older, there is one less year available for generating incomes in the labour market, therefore their human capital depreciates over time. On the other hand, as additional investment in on-the-job training is closely associated with age, being one year older may mean more investment in human capital. The net effect on human capital of ageing critically depends on their sex/education/age and other characteristics. The JF approach does not make separate estimates of these two effects.[5] As is pointed out in Section 2, this study attempts to make separate estimates of the effect on lifetime labour incomes of ageing. The positive side is captured through estimating investment in on-the-job training. The negative side is captured here through depreciation estimation. Depreciation on human capital is measured as the decreases in lifetime labour incomes for the same sex/education cohorts through different age periods.

Table 3.10   Depreciation of Human Capital by Ageing
(millions of current dollars)

		1981-86	1986-91	1991-96	1996-2001
Male	Higher Degree	2,389	4,709	11,706	19,839
	Bachelor Degree	11,293	21,127	42,491	69,601
	Skilled Labour	44,008	75,095	111,700	143,389
	Unskilled Labour	78,446	127,586	192,887	233,506
	Sub Total	136,136	228,517	358,784	466,336
Female	Higher Degree	426	1,052	3,205	7,243
	Bachelor Degree	4,035	9,869	27,554	53,304
	Skilled Labour	15,448	28,365	39,487	54,662
	Unskilled Labour	65,150	115,800	190,300	231,290
	Sub Total	85,059	155,085	260,545	346,499
Total		221,194	383,602	619,330	812,836

Table 3.10 presents estimates of human capital depreciation for those who are still of working-age. Only individuals of working age throughout the accounting period are accounted for in deriving these figures, as no comparison between beginning and ending lifetime labour incomes could be made for those who enter or exit from the working-age population in the middle of the accounting period. For higher degree groups, for example, it covers 28-65 age cohorts in the current period (it is assumed that the minimum age for a higher degree holder is 23) and 24-27 age cohorts are excluded in accounting for depreciation of human capital caused by ageing.

Another component of the depreciation is exit of people from the labour force (retirement). Based on the assumption that people retire at age 66, it is very straightforward to account for those who are over 65. Table 3.11 presents the numbers of persons in 66-70 age cohorts for each Census period. Throughout the 1980s and 1990s, older persons with qualifications, in particular for women, were departing the working age population at a faster pace, though the opposite is true for the unskilled labour groups.

Table 3.11 Estimates of Number of Persons Reaching Retirement Age
(numbers of persons)

		1981-86	1986-91	1991-96	1996-2001
Male	Higher Degree	1,109	2,852	4,316	5,318
	Bachelor Degree	5,803	11,141	14,686	16,755
	Skilled Labour	52,468	66,289	76,852	85,789
	Unskilled Labour	182,665	215,984	221,630	206,336
	Sub Total	242,045	296,266	317,484	314,198
Female	Higher Degree	300	726	1,212	1,696
	Bachelor Degree	2,281	5,827	9,894	15,911
	Skilled Labour	26,289	24,246	29,157	30,749
	Unskilled Labour	254,129	304,188	301,435	284,774
	Sub Total	282,999	334,987	341,698	333,130
Total		525,044	631,253	659,182	647,328

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[5] Graham and Webb (1979) adopt the same approach. In case of net positive effect on lifetime earnings of ageing, they term it appreciation or negative depreciation.

Table 3.12   Depreciation of Human Capital by Retirement
(millions of current dollars)

		1981-86	1986-91	1991-96	1996-2001
Male	Higher Degree	79	225	670	988
	Bachelor Degree	362	977	1,652	2,328
	Skilled Labour	2,228	4,965	6,293	7,764
	Unskilled Labour	5,999	10,754	14,449	16,174
	Sub Total	8,669	16,921	23,064	27,254
Female	Higher Degree	17	45	137	217
	Bachelor Degree	90	254	707	1,172
	Skilled Labour	719	1,761	2,056	2,479
	Unskilled Labour	6,089	11,077	13,848	16,562
	Sub Total	6,914	13,136	16,747	20,430
Total		15,583	30,057	39,812	47,684

Table 3.12 presents value estimates of human capital depreciation due to retirement, which are measured by the lifetime labour incomes of 61-65 age cohorts at the beginning of each accounting period in terms of the ending year dollars.

3.4 Changes in Inventories: Under Working-age Population

The under working-age population is defined as those individuals under 18 years old. As this study is confined to the economic values of human capital, the under working-age individuals are distinguished from those working-age adults. The juniors are the most important source of the labour force but are not ready for immediate employment in the labour market. The under working-age individuals are divided into four groups: new born babies during the accounting period; children still experiencing parenting care, primary and secondary education during the accounting period; those who reach working age at the end of the accounting period; and migrants during the accounting period.

In accounting for changes in the under working-age population, new born babies, those reaching working-age and migrants are valued by potential per capita lifetime labour incomes (discounted to the present) at the end of accounting period. For the group who remains in the under working-age population throughout the accounting period, the changes in their human capital are decomposed into two components: appreciation with age and revaluation with time. Appreciation are measured by increments to the potential lifetime labour incomes to these children during the accounting period. As these increments could be attributed to parenting

care, primary and secondary education, therefore the appreciation component is termed as an investment. Table 3.13 reports the decomposition results of the changes in the human capital stock embodied in the under working-age population. A clear message from these figures is that the growth of human capital stock represented by under working-age population slowed down dramatically throughout the 1980s and early 1990s and showed some sign of recovery for the second half of the 1990s.

Table 3.13 Accumulation Account for Human Capital: Under Working-age Population
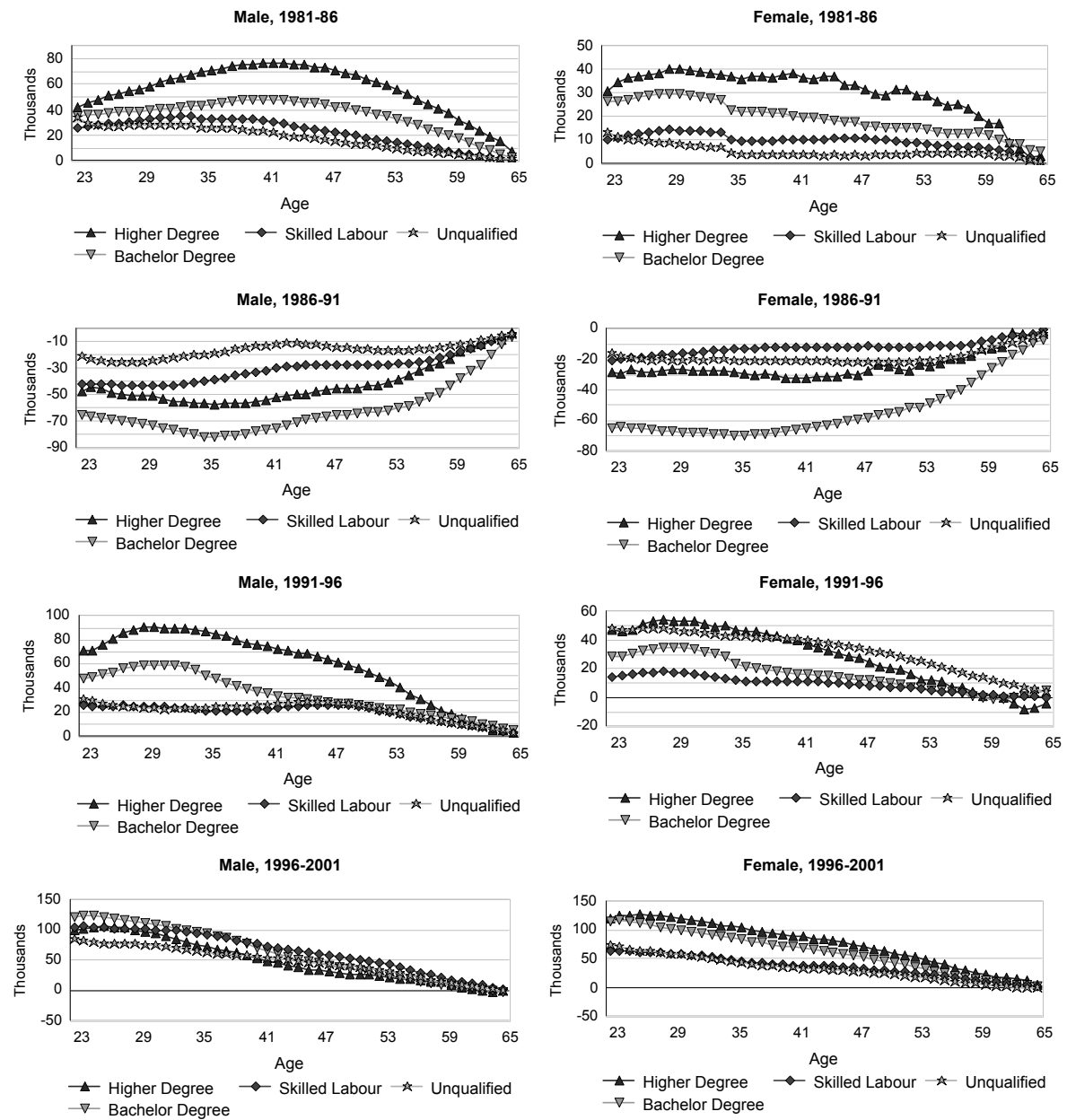(millions of current dollars)

		1981-86	1986-91	1991-96	1996-2001
Boys	New babies	158,333	231,547	277,997	336,007
	Investment	49,648	80,839	117,088	142,743
	Revaluation	229,453	205,687	158,412	223,083
	Maturity	147,584	271,857	347,568	417,405
	Net migration	16,225	40,781	13,438	48,719
	Sub total	306,075	286,996	219,367	333,147
Girls	New babies	110,905	162,727	203,772	249,128
	Investment	34,544	56,472	82,358	104,993
	Revaluation	162,768	148,476	138,961	174,264
	Maturity	101,800	190,367	245,081	305,716
	Net migration	9,960	28,288	12,553	33,654
	Sub total	216,377	205,597	192,563	256,323
Total changes		522,453	492,593	411,930	589,470

3.5 Revaluation of Human Capital

It is interesting to examine the changes in the quality of human capital over time at micro levels. Quantifying changes in lifetime labour incomes from period to period for individuals with a given sex/education/age characteristics could provide some measures of this kind. Figure 3.2 displays per capita changes in real lifetime labour incomes (net of price effect) for all age/sex/education groups over the four Census periods. A few observations can be made. First, it seems that the revaluation patterns for men are different to that of women. Is this confirming the suggestion that the labour market for men is separate from that for women?

Second, the revaluation patterns for both men and women vary across different periods. These variations need to be interpreted in terms of technological and organisational changes observed in Australia during these periods. These changes certainly affect demand and supply for various levels of skilled workers and therefore their wage and salary growth rates. For example, during

Figure 3.2   Real Gains of Human Capital Per Capita
(thousands of current dollars)

Male, 1981-86

Female, 1981-86

Male, 1986-91

Female, 1986-91

Male, 1991-96

Female, 1991-96

Male, 1996-2001

Female, 1996-2001

the first half of the 1990s, the per capita values of human capital for higher educated groups skilled labour group exceeded the bachelor degree group starting from late 30s age groups.

Table 3.14   Real Gains of Human Capital
(millions of current dollars)

		1981-86	1986-91	1991-96	1996-2001
Male	Higher Degree	2,537	-2,087	4,717	4,150
	Bachelor Degree	9,210	-20,582	15,886	36,796
	Skilled Labour	30,941	-43,116	31,150	105,544
	Unskilled labour	54,234	-47,513	69,567	159,345
	Sub Total	96,922	-113,297	121,319	305,835
Female	Higher Degree	366	-423	997	4,476
	Bachelor Degree	3,273	-13,049	7,865	43,566
	Skilled Labour	7,477	-10,694	8,783	36,309
	Unskilled labour	19,055	-62,795	130,198	129,847
	Sub Total	30,171	-86,962	147,844	214,198
Total		127,071	-200,262	269,144	519,998

Human capital revaluation records changes in values of human capital during the accounting period, equivalent to holding gains for physical capital at the Australian Systems of National Accounts. These changes in values are decomposed into nominal gains and real gains. The nominal gain is defined as changes in monetary value over time, and the real gain is defined as the nominal gain net of price change effect. Table 3.14 presents aggregate estimates of the net gains of human capital. It shows that real human capital revaluation declined during the 1980s (negative in the second half of the 1980s), and then rose to a peak in 2001 for most more-educated groups, with exceptions for male higher degree group and female unskilled labour group. For example, the rate at which the value of human capital for men appreciated more than doubled during the 1990s. These dramatic value increases for human capital are reflective of increasing productive power of the Australian economy.

3.6 Accumulation Accounts for Human Capital

Table 3.15 provides the whole picture of human capital formation by putting together all estimates of human capital formation, depreciation, changes in inventories and revaluation during the four accounting periods. As these measures have to be based on certain assumptions in regard to estimating numbers of persons who obtained higher educational qualifications and numbers of migrants by sex/education/age details, the sums of individual elements could not be fully reconciled with the actual stock changes. Besides, some measurement errors associated

Table 3.15 Human Capital Accumulation Accounts

(millions of current dollars)

	1981-86	1986-91	1991-96	1996-2001
Male				
Gross Human Capital Formation				
Investment in education	35,706	57,528	82,158	93,559
On-the-job investment	23,462	22,920	35,814	44,886
New workers	267,159	402,746	442,899	548,719
Migrants	77,047	154,053	130,699	183,501
Less emigrants	63,667	121,545	151,156	211,748
Subtotal	339,707	515,702	540,414	658,917
Depreciation	144,805	245,437	381,848	493,590
Net Human Capital Formation	194,902	270,265	158,566	165,327
Changes in inventories	306,075	286,996	219,367	333,147
Revaluation	514,844	528,309	411,592	611,462
Statistical discrepancies	26,936	64,913	76,562	100,243
Total stock changes	1,042,757	1,150,483	866,087	1,210,179
Female				
Gross Human Capital Formation				
Investment in education	25,683	58,474	77,152	94,948
On-the-job investment	7,674	13,504	30,304	38,482
New workers	182,887	281,202	322,386	407,605
Migrants	50,406	103,425	99,991	136,061
Less emigrants	31,702	45,156	74,806	98,239
Subtotal	234,948	411,449	455,027	578,857
Depreciation	91,973	168,222	277,292	366,929
Net Human Capital Formation	142,975	243,227	177,735	211,928
Changes in inventories	216,377	205,597	192,563	256,323
Revaluation	303,282	321,225	334,687	423,795
Statistical discrepancies	12,854	13,688	35,816	48,642
Total stock changes	675,488	783,737	740,801	940,688

with variables such as educational attainment are inevitable. [6] Though these possible

measurement errors do not directly affect measures of the human capital stock, their existence

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[6] A recent US study (Black et al., 2003) suggests that there are serious measurement errors associated with educational attainment in the US Census and population surveys. According to that research, people tend to

does compromise the quantitative decomposition of the changes in the human capital stock occurred during the accounting periods.

The measures presented in Table 3.12 are based on the stock measures extended to cover all individuals including the under working-age population. This table shows that investment in education and training plays an increasing role in the human capital formation process, contributing from just over 17% for men and 14% for women during the early 1980s, to well over 20% for men and 23% for women in the late 1990s-early 2000s. However, the proportion of depreciation over gross human capital formation also increased dramatically during the same period, from just over 40% to 75% for men, and from 40% to well over 60% for women. This trend reflects the ageing population. As human capital growth in the form of new babies (measured by changes in inventories) and net migration (measured by the difference between migration and emigration) slowed down, the key issue for sustainable development of human capital is investment in education and training.

4 Concluding Remarks

This paper proposes an accounting framework to measure human capital formation in Australia, and presents preliminary estimates of relative contribution of education and training and net migration to the human capital formation in Australia. It also provides estimates of the impact of ageing and through-time changes in human capital value (revaluation) on the human capital stock for Australia. This information may be very useful for research and policy in the areas of education, migration, ageing and other social and economic issues.

The proposed accounting system draws on the JF human capital accounting system, with a few modifications designed to be more consistent with the SNA conventions and suitable for the Australian circumstances. As this measurement framework is based on a number of controversial assumptions, the limitations of its estimates are obvious. First, this paper treats the differences in the existing wage structure as reflecting the different amounts of human capital invested through education and training. In the Australian institutional setting, this assumption could be questioned. Second, human capital plays an equally important role in non-market activities. As

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over-report their education levels. The existence of this kind of measurement error has significant implications for estimating returns to education.

the estimates of human capital presented in this paper are confined to market activities only, the full value of human capital embodied in the whole population is obviously underestimated.

In spite of these reservations, this paper does draw attention to the issue of systematic measurement of human capital, with a pertinent policy implication: increasing investment in human capital including health (which could make work-life longer), and faster labour productivity are the key choice for addressing ageing Australian society.

In a recent review essay on economic growth, Rogers (2003) writes:

Empirically testing the role of human capital requires its measurement and this turns out to be difficult….A strong message from the literature (of economic growth) is that there is great difficulty in measuring human capital…

Despite these difficulties, it is essential for us to provide empirical measures for assisting and encouraging the analysis of the role of human capital in long-term economic growth. Therefore, this project attempts to meet this challenge. It is hoped that some of the methods and results developed here will also be applicable to the study of other economic and social concepts empirically difficult to measure.

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Appendix: Decomposition Formula

In order to empirically estimate the magnitudes of human capital formation and associated flow concepts, it is essential to be clear about these definitions and relationships in quantitative terms. In the JF papers, most of the definitions and relationships in regard to the human capital formation process and associated accounts are described in words. To apply such an accounting system to the Australian data, some modifications have to be made. It is essential to develop mathematical formulae to represent these definitions and relationships in mathematical notations.

At the beginning of the accounting period, which is supposed to be previous Census year, the human capital stock for the working-age population (18-65) can be written as

$$HCS_{y-t} = \sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=18}^{60} n_{y-t,s,e,a}mi_{y-t,s,e,a} + \sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=61}^{65} n_{y-t,s,e,a}mi_{y-t,s,e,a} \qquad (1)$$

where   HCS = human capital stock

       y=1981, 1986, 1991, 1996, 2001 —calendar year.

       s=1, 2 — sex, male or female.

       e= 1 (higher degree), 2 (bachelor degree), 3 (skilled labour), 4(unskilled labour) — educational attainment.

       a=18, 19….63, 64,65 —age.

       n=number of persons

      mi=lifetime labour income per capita

       t= number of years

The first item on the right-hand side of the accounting identity (1) represents those human capital that will be 'transferred' to the next period; while the second item for those that will be out of productive service due to retirement;

At the end of the accounting period, which is supposed to be current Census year, the human capital stock can be written as

$$HCS_y = \sum_{s=1}^{2}\sum_{e=2}^{3}\sum_{a=18}^{22} n_{y,s,e,a} mi_{y,s,e,a} + \sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=23}^{65} n_{y,s,e,a} mi_{y,s,e,a} \qquad (2)$$

The first item on the right-hand side represents the new component of human capital formed from under working-age population, the second item for the human capital 'transferred' from the previous period.

Accounting identity (2) - accounting identity (1) gives

$$HCS_y - HCS_{y-t} = \sum_{s=1}^{2}\sum_{e=01}^{4}\sum_{a=23}^{65} n_{y,s,e,a} mi_{y,s,e,a} - \sum_{s=1}^{2}\sum_{e=01}^{4}\sum_{a=18}^{60} n_{y-t,s,e,a} mi_{y-t,s,e,a}$$
$$+ \sum_{s=1}^{2}\sum_{e=02}^{3}\sum_{a=18}^{22} n_{y,s,e,a} mi_{y,s,e,a} - \sum_{s=1}^{2}\sum_{e=01}^{4}\sum_{a=61}^{65} n_{y-t,s,e,a} mi_{y-t,s,e,a} \qquad (3)$$

The first two items represent over-time changes in human capital stock for the same sex/education cohorts. The number of persons in each sex/education/age cohort at the end of accounting period is equal to the sum of number of persons at the beginning of the accounting period, plus number of persons who transferred in from lower educational groups due to additional schooling activities (investors in education), minus number of persons who transferred out to higher educational groups, minus number of emigrants. That is,

$$n_{y,s,e,a} = n_{y-t,s,e,a-t} + n_{y,s,e\neq4,a}^{in} - n_{y,s,e\neq1,a}^{out} + n_{y,s,e,a}^{im} - n_{y,s,e,a}^{em} \qquad (4)$$

where n^{in} = number of persons who have been 'promoted' into this education group
    from a lower education group;
n^{out} = number of persons who have left this education group to join a higher
    education group;
n^{im} = number of immigrants;
n^{em} = number of emigrants.

Substituting Equation (4) into Equation (3) gives

$$HCS_y - HCS_{y-t} = \sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=23}^{65}(mi_{y,s,e,a} - mi_{y-t,s,e,a-t})n_{y-t,s,e,a-t}$$

$$+\sum_{s=1}^{2}\sum_{e=1}^{3}\sum_{a=23}^{65}n_{y,s,e\neq4,a}^{in}mi_{y,s,e\neq4,a} - \sum_{s=1}^{2}\sum_{e=2}^{3}\sum_{a=23}^{65}n_{y,s,e\neq1,a}^{out}mi_{y,s,e\neq1,a}$$

$$+\sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=23}^{65}n_{y,s,e,a}^{im}mi_{y,s,e,a} - \sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=23}^{65}n_{y,s,e,a}^{em}mi_{y,s,e,a}$$

$$+\sum_{s=1}^{2}\sum_{e=2}^{4}\sum_{a=18}^{22}mi_{y,s,e=4,a}n_{y-t,s,e,a-t} + \sum_{s=1}^{2}\sum_{e=2}^{3}\sum_{a=20}^{22}mi_{y,s,e\neq1\&4,a}n_{y,s,e\neq1\&4,a}^{in}$$

$$\qquad\qquad (5)$$

$$-\sum_{s=1}^{2}\sum_{e=3}^{4}\sum_{a=18}^{22}mi_{y,s,e=3\&4,a}n_{y,s,e=3\&4,a}^{out}$$

$$+\sum_{s=1}^{2}\sum_{e=2}^{4}\sum_{a=18}^{22}n_{y,s,e,a}^{im}mi_{y,s,e,a} - \sum_{s=1}^{2}\sum_{e=2}^{4}\sum_{a=18}^{22}n_{y,s,e,a}^{em}mi_{y,s,e,a}$$

At broader level, for any shift between two education groups, the following relationship must hold

$$n_{y,s,e\neq4,a}^{in} = n_{y,s,e\neq1,a}^{out} \qquad\qquad (6)$$

Substituting (6) into (5) gives

$$HCS_y - HCS_{y-t} = \sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=23}^{65}(mi_{y,s,e,a} - mi_{y-t,s,e,a-t})n_{y-t,s,e,a-t}$$

$$+\sum_{s=1}^{2}\sum_{e=1}^{3}\sum_{a=23}^{65}n_{y,s,e\neq4,a}^{in}(mi_{y,s,e\neq4,a} - mi_{y,s,e\neq1,a})$$

$$+\sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=23}^{65}n_{y,s,e,a}^{im}mi_{y,s,e,a} - \sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=23}^{65}n_{y,s,e,a}^{em}mi_{y,s,e,a}$$

$$+\sum_{s=1}^{2}\sum_{e=2}^{4}\sum_{a=18}^{22}mi_{y,s,e=04,a}n_{y-t,s,e,a-t} \qquad\qquad (5a)$$

$$+\sum_{s=1}^{2}\sum_{e=2}^{3}\sum_{a=20}^{22}n_{y,s,e\neq4,a}^{in}(mi_{y,s,e\neq4,a} - mi_{y,s,e\neq2,a})$$

$$+\sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=18}^{22}n_{y,s,e,a}^{im}mi_{y,s,e,a} - \sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=18}^{22}n_{y,s,e,a}^{em}mi_{y,s,e,a}$$

By manipulating the first item, putting together similar items of the above equation, renaming some of the variables and rearranging item orders, we have the decomposition result:

$$HCS_y - HCS_{y-t} = \sum_{s=1}^{2}\sum_{e=2}^{4}\sum_{a=18}^{22} n_{y,s,e,a} mi_{y,s,e=4,a} + \sum_{s=1}^{2}\sum_{e=1}^{3}\sum_{a=20}^{65} n_{y,s,e,a}^{ej}(mi_{y,s,ej,a} - mi_{y,s,ei,a})$$

$$+\sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=18}^{65} n_{y,s,e,a}^{im} mi_{y,s,e,a} - \sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=18}^{65} n_{y,s,e,a}^{em} mi_{y,s,e,a}$$

$$-\sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=61}^{65} n_{y-t,s,e,a} mi_{y-t,s,e,a} + \sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=23}^{65} n_{y-t,s,e,a-t}(mi_{y-t,s,e,a} - mi_{y-t,s,e,a-t})$$

$$+\sum_{s=1}^{2}\sum_{e=1}^{4}\sum_{a=23}^{65} n_{y-t,s,e,a-t}(mi_{y,s,e,a} - mi_{y-t,s,e,a})$$

(7)

Identity (7) decomposes the changes in the human capital stock for working-age during the accounting period into the various components:

- First item: new members of working-age population from the maturing of under working-age population;
- Second item: investment in education;
- Third item: immigrants;
- Fourth item: emigrants;
- Fifth item: retirement;
- Sixth item: changes in lifetime labour incomes with age, which can be further decomposed into on-the-job investment and depreciation;
- Seventh item: revaluation of human capital, which could be further decomposed into neutral (due to price effect) and real gains.