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DEVELOPMENTS IN THE ESTIMATION OF THE VALUE OF HUMAN CAPITAL FOR AUSTRALIA

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This paper offers a brief summary of the Australian Bureau of Statistics (ABS) research program on the measurement of human capital. We employ the Jorgenson and Fraumeni (1989, 1992) lifetime labour income approach. This paper shows how we have modified their approach and applied it to Australian Census data in developing measures of the value of human capital stock and constructing the corresponding human capital accumulation account. Throughout we highlight the key methodological issues confronting practitioners in incorporating measures of human capital within the national accounts.

Key words: human capital, national economic accounting, lifetime labour income

I. INTRODUCTION

1. Nearly 50 years ago, economists developed and formulated human capital theory. The central message of this theory is that productive capacity embodied in human agents of production can be acquired and developed through education, training, health care and other means, which are generally referred to as investment in human capital. Over the past five decades, human capital theory has not only firmly established itself in the academic literature, but also the concept of human capital is frequently employed in discussions and formations of public policy. Today, fostering human capital through greater commitments to investment in education and other programs has become an important tool for governments to reduce income inequality and boost productivity and economic growth. From a sustainability perspective, the measurement of human capital arguably has taken on an added importance in the context of assessing the economic impact of ageing populations.[1]

2. Against this background, it is essential that human capital is measured properly in national accounts. However, economic activities involving the production of human capital are largely beyond the measurement scope of the conventional national accounts. In an effort to incorporate the stock of human capital and human capital formation within the national accounts, ABS has commenced on a research program on the measurement of human capital. The purpose of this paper is to offer a brief summary of this research program[2] which has focused on the estimation

[1] See Australian Government Treasury (2007) for a discussion of the sustainability of economic growth in light of Australia's ageing population and other factors.
[2] See Wei (2004, 2007a, 2008)

of the value of human capital stock and the construction of an accumulation account for human capital. In particular, it summarises: (1) how the value of human capital stock is estimated; and (2) how the corresponding human capital accumulation account is constructed.

3. To impute the value of human capital, we employ the Jorgenson and Fraumeni (1989, 1992) lifetime labour income approach. This paper shows how we have modified the Jorgenson-Fraumeni approach and applied it to Australian data. In our discussion, we highlight the key methodological issues confronting practitioners in incorporating measures of human capital stock and human capital formation within the national accounts.

4. There is still no international consensus concerning how human capital should be measured by national economic accounting. It is hoped that this paper could help generate robust debate and stimulate research effort about where to start in order to move human capital into official statistics.

II. VALUATION MODELS

5. The Jorgenson-Fraumeni lifetime labour income approach measures human capital per capita for a given sex/education/age group as the discounted present value of expected lifetime labour income per capita for that group. Expected income streams are derived from cross-sectional information on labour incomes, employment rates and school participation rates. The lifetime labour incomes are projected by backward recursion, which works as follows: an individual's present value of his or her lifetime income is equal to the current period income plus the present value of his or her lifetime income in the next period. Of course, the present value of his or her lifetime income in next period is not readily available and has to be estimated. By working backward from the lifetime income of individuals with the highest level of education and oldest working age, the present value of an individual's next period income can be derived. Jorgenson and Fraumeni assume that all individuals retire at age of 75. Holding sex and education level as constant, for example, an individual's present value of lifetime labour income at age 74 is just his or her current period's labour income; then, this individual's present value of lifetime labour income can be used to estimate the next period's present value of lifetime labour income for a 73 year old individual with the same sex and education level. By working backward in this way for all possible combinations of sex and education level, all individuals' present value of lifetime labour income in the next period can be derived.

6. Denoting the lifetime labour income, or the value of human capital of an individual in year y of given sex s, age a, and educational attainment e, by $life_{y,s,a,e}$ gives the following equation:

$$life_{y,s,a,e} = ymi_{y,s,a,e} + \{senr_{y,s,a,e} sr_{y,s,a,a+1} life_{y,s,a+1,e+1} + (1 - senr_{y,s,a,e}) sr_{y,s,a,a+1} life_{y,s,a+1,e}\} \frac{1+g}{1+r} \qquad (1)$$

where ymi is the average labour income in the current year, which includes both market and nonmarket incomes, $senr$ is the school enrolment rate and $sr_{a,a+1}$ is the probability of this person at age a surviving to age $a+1$. The first term in brackets is for those who will obtain an additional year of schooling by the next year, while the second term is for those who will remain at their current educational attainment. The real income growth rate and the discount rate during a one year period are denoted respectively by g and r.

7. To apply the Jorgenson-Fraumen method to the Australian economy, we have made a number of important modifications.

A. Confinement to working age population

8. Of the total population, the working age group is the most important component in terms of its impact on market economic activities. Recent research and policy studies focus on the relative size of the work force in the population. The ratios of the working age group over other age groups have important implications for economic growth and development. That is one of the central issues of population ageing studies.

9. Confinement to working age population does not imply that other age groups have no human capital at all. What we argue here is that the human capital embodied in the working age population is most directly related to economic activities and needs a separate treatment at the forefront of the measurement of human capital.

B. Excluding nonmarket activities

10. Market and nonmarket activities are different. The labour force participation rate is a very important economic indicator of concern to economists and policy makers. Encouraging people to participate in the labour market is a key policy priority in Australia and many other industrialised countries. By focusing on market activities, we can evaluate the contribution of changing labour force participation rates to the growth of human capital stock measured in market lifetime labour incomes.

11. In addition, how to value nonmarket labour activities is a contentious issue. The Jorgenson-Fraumeni model assumes that the value of time spent in unpaid household production or at leisure for any given age/sex/education group is the same as the value of time spent working. This choice attracts understandable concerns. For example, Rothschild (1992) 'doubt(s) that within the audience at a football game (or an opera) the quality of the experience varies directly with the market wage.' Or is it appropriate to value a PhD holder's work in the garden at a higher rate than that for someone who only completed secondary education? In order to avoid these complications, the estimates of human capital in our study are confined to market labour activities. This makes comparison with physical capital stock measures easier. The valuation of nonmarket activities is a topic for future research.

C. Educational credentials as measures of educational attainment

12. In the Jorgenson-Fraumeni accounting framework, educational attainment is measured in calendar years of schooling. While a 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, someone without a post-school qualification could choose to study for a vocational qualification or a university degree. In the Jorgenson-Fraumeni method, this individual's one year of study at a vocational institute or a university is treated as identical, and thus the returns to vocational or university study are assumed to be the same. In our study, educational attainment is measured using various institutional qualifications. Using levels of highest qualification completed as a measure of formal schooling, we hope to capture the impacts of alternative kinds of education on human capital formation.

D. Cohort-based Estimation of Future Earnings

13. One of the major concerns with the Jorgenson-Fraumeni approach is that estimation of lifetime labour incomes based on current cross-sectional information is subject to short-term business cycle effects: it tends to under-estimate lifetime labour incomes in recession years and over-estimate in booming years. This problem becomes obvious if the measurement of human capital is confined to labour market activities, which fluctuate with business cycles.

14. In addressing the business cycle effect on the projection of lifetime labour incomes, we use a cohort-based moving average method to derive ex-post or semi-ex-post income profiles over time for all groups (for some age cohorts their income profiles have to be based on combinations of observed and expected future incomes, so we term income profiles of this kind as 'semi-ex-post'). We start with the Jorgenson-Fraumeni method which decomposes lifetime labour incomes into two elements: current labour incomes and lifetime labour incomes for the group with the same sex/education characteristics but one year older. In the original Jorgenson-Fraumeni approach, the second element is approximated by current incomes of older age groups plus a uniform real income growth factor. By our simplified moving average method, the second element in the Jorgenson-Fraumenni framework is approximated by a linear combination of lifetime labour incomes of older age cohorts between Census years. Just like the Jorgenson-Fraumeni approach which calculates the incomes by a backward recursion, we work backward from the lifetime incomes of individuals in the most recent period, then move on to the next recent period and so on. In this way, all Census income data are chained together.

15. Given the above modifications, equation (1) is modified as:

$$mi_{y,s,a,e_i} = w_{y,s,a,e_i} empr_{y,s,a,e_i} + (1 - \sum_{e_j} senr^{e_j}_{y,s,a,e_i}) sr_{y,s,a+1} mi_{y,s,a+1,e_i} (1+g)(1+r)^{-1}$$
$$+ \sum_{e_j} \sum_{n=1}^{m} senr^{e_{jn}}_{y,s,a,e_i} sr_{y,s,a+m} mi_{y,s,a+n,e_j} (1+g)^{1+n} (1+r)^{-(1+n)} \qquad (2)$$

where mi is the per capita market lifetime labour income, with the subscripts y, s, a, e_i denoting year, sex, age and educational attainment at level i; w is the average market labour income for employees; $empr$ is the employment rate, defined as the probability of engaging in paid work; sr_{a+1} is the probability of an average person at age a surviving to age $a+1$; $senr^{e_j}_{y,s,a,e_i}$ is the percentage of those individuals with educational attainment e_i studying for a higher educational attainment e_j, the symbol n represents the index of years taken to obtain a higher educational qualification, and m is the average years to complete this study; g is the real income growth rate and r is the discount rate.

III. CONSTRUCTING AN ACCUMULATION ACCOUNT FOR HUMAN CAPITAL

16. In the Jorgenson-Fraumeni framework, the change 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.

17. The Jorgenson-Fraumeni accounting system only considers formal education in its estimates of investment in human capital that enhances individuals' skills and knowledge, with the component of on-the-job training being mixed with its estimation of depreciation on human capital. In commenting on the Jorgenson-Fraumeni measurement of human capital, Rosen (1989, p. 284) suggests 'the depreciation estimates … seem to include gross on-the-job investment as one of its components. It would be of substantial interest to present those estimates separately'. The standard human capital theory also emphasizes the role of on-the-job training in human capital formation. Our study provides separate estimates of investment due to working experience.

18. Our study has focused on the Australian working age population, which has important implications for constructing an integral accumulation account complementary to the measurement of the human capital stock. In the original Jorgenson-Fraumeni accounting framework, all individuals in the population are included, and all education, including primary and secondary, is counted as investment in human capital. Our study, by focusing on the human capital formation of the working-age population, only counts post-secondary education as investment in human capital formation. The base level human capital embodied in the working age population, formed through primary and secondary education, is not produced during the current accounting period, and thus should be excluded in the category of human capital formation. When a person becomes of working age with human capital not formed in the current accounting period, or a new migrant of working age comes to Australia with human capital formed somewhere else, this addition to the human capital stock is treated as an 'other change', equivalent to the category 'Other changes in assets account' in the SNA93.

19. Our proposed accumulation account for human capital is summarized by the following accounting identity:

1. The net value of human capital stock in the opening balance sheet;
Plus
2. Investment in Education
2.1 Gross human capital formation in post-school education for the working age population;
Minus
2.2 Depreciation of human capital formed by post school education;
Equals
2.3 Net human capital formation in post-school education;
Plus
3. Experience Factor
3.1 Gross human capital formation in working experience;
Minus
3.2 Depreciation of human capital formed by working experience;
Equals
3.3 Net human capital formation by working experience;
Plus
4. Demographic Changes
4.1 Persons becoming of working age;
Minus

4.2 Ageing of base level human capital;
Plus
4.3 Immigrants;
Plus
5. Revaluation;
Adjusted by
6. Omissions & errors (including emigrants);
Equals
7. The net value of human capital at the closing balance.

20. Each element in the above accounting identity could in theory be measured directly (and independently of the others). However, if there is missing information for any single element, the value of that element can be determined residually. Because revaluation and depreciation can be directly estimated, it might be more convenient to residually calculate some of the other items. Conceptually, any single element of change in human capital stock can be derived from information on other elements. However, in practice, measurement errors and inconsistencies lead to inevitable statistical discrepancy. These possible inconsistencies might be problematic when estimating human capital flows.

21. The estimation method used for measuring human capital is quite different from that conventionally used for physical capital, where in the latter the directly available information covers the quantity of new capital goods added to the existing capital stock. The magnitude of the stock is indirectly derived using the perpetual inventory method. As the owners and users of capital goods are often one and the same, the quantity of capital services has to be imputed indirectly as well.[3]

22. For human capital, it is the value of labour services that is directly observable (from labour market transactions), and the stock of human capital can be directly estimated from the present value of discounted lifetime labour income streams. Because the changes in the human capital stock between the beginning and the end of an accounting period must equal the sum of human capital flows, the amount of investment in human capital is indirectly derived by decomposing the stock changes into various components.

IV. EXPERIMENTAL ESTIMATES OF HUMAN CAPITAL FOR AUSTRALIA

23. To measure the stock of human capital and construct the corresponding accumulation account for human capital, a database has been constructed using the Australian Censuses of population and housing conducted in 1981, 1986, 1991, 1996 and 2001. For each age/sex/education cohort, the following variables have been derived: annual gross income, employment rate, school enrolment rate and the number of people in each cohort.

24. Given the variables constructed above, combined with information on life expectancy, per capita lifetime labour incomes for all sex/education cohorts are projected by using equation (2). The calculations assume a discount rate of 5 percent and an expected income growth rate of 1.75 percent for all cohorts. They are the same rates that have been adopted by the Australian Government Treasury (2002) in projecting future national incomes.

[3] Hulten (1990) provides an excellent discussion of the measurement issues of physical capital facing the statistical agencies.

25. The information on differences between lifetime labour incomes for cohorts with alternative educational attainment is useful for estimating the extra value created by investing in additional education. Table 1 presents lifetime labour income per capita in 2001 dollars for 25 year olds, classified by sex and educational attainment. According to the Jorgenson-Fraumeni general framework (1992), the product of the education industry is investment in human capital, and the output of education is thus defined as the addition to lifetime labour income from additional schooling. Within this framework, per capita measures of lifetime labour income could be used to estimate investment in human capital and the output of education.

Table 1 Lifetime labour income per capita for 25 year olds (thousands of 2001 dollars)

	1981	1986	1991	1996	2001
Male					
Higher degree	1,313.94	1,400.77	1,345.92	1,424.41	1,529.29
Bachelor degree	1,237.97	1,305.02	1,221.54	1,273.43	1,396.91
Skilled labour	861.92	912.96	863.41	886.82	991.23
Unskilled labour	703.65	754.92	728.44	755.92	832.68
Female					
Higher degree	1,008.92	1,075.65	1,042.87	1,090.70	1,217.25
Bachelor degree	898.3	947.9	867.17	897.93	1,012.79
Skilled labour	632.56	658.69	633.94	648.07	709.54
Unskilled labour	481.51	503.31	479.1	529.01	595.14

Data source: Australian Census 1981-2001.

Table 2 The stock of human capital for Australia: 1981-2001 (millions of 2001 dollars)

	1981	1986	1991	1996	2001
Male					
Higher degree	42,917	52,562	92,185	127,009	161,362
Bachelor degree	244,123	315,558	448,212	607,439	733,190
Skilled labour	840,709	943,680	1,039,949	1,143,195	1,259,752
Unskilled labour	1,540,987	1,685,260	1,889,659	1,950,974	1,957,450
Subtotal	2,668,736	2,997,060	3,470,005	3,828,618	4,111,754
Female					
Higher degree	9,485	14,002	30,389	55,730	90,579
Bachelor degree	106,458	160,347	305,251	489,443	663,789
Skilled labour	349,437	420,986	429,201	488,993	553,664
Unskilled labour	1,251,790	1,353,062	1,569,421	1,623,914	1,616,411
Subtotal	1,717,170	1,948,398	2,334,262	2,658,080	2,924,442
Total	4,385,906	4,945,457	5,804,266	6,486,698	7,036,196

Data source: Australian Census 1981-2001.

26. Applying per capita measures of lifetime labour income derived above to the number of persons in the corresponding cohort and aggregating across all cohorts, we obtain the estimates of the human capital stock for Australia. Table 2 presents the experimental estimates of the human capital stock for Australia in 2001 dollars.

27. Table 3 presents the experimental estimates of human capital accumulation account in 2001 dollars. The numbers in the opening balance are taken from the subtotals in Table 1. The investment in post-school education, measured as incremental increases to lifetime labour incomes due to additional schooling activities, includes schooling activities for bachelor, higher degree and vocational studies. To match the definition of investment in human capital, depreciation is defined as deletions of additional lifetime labour incomes of those individuals with post school education due to their ageing. The investment in working experience is

measured as incremental increases in lifetime labour incomes to those with additional years of working experience.

Table 3 Human capital accumulation accounts (millions of 2001 dollars)

	1981–86	1986–91	1991–96	1996-2001
MALE				
Opening Balance	2,668,736	2,997,060	3,470,005	3,828,618
Investment in Education				
Investment in post-school education	62,060	81,564	103,468	102,938
Depreciation on post-school investment	-30,378	-35,773	-51,368	-68,249
Net formation by post-school investment	31,682	45,791	52,100	34,690
Experience Factor				
Gross on-the-job investment	319,558	308,898	296,896	274,426
Depreciation on the job investment	-178,938	-225,414	-276,644	-313,712
Net on-the-job investment	140,620	83,484	20,251	-39,286
Persons Turning Working Age	485,721	554,633	534,861	549,963
Ageing of Base Level Human Capital	-432,825	-437,324	-427,979	-410,168
Immigrants	136,760	208,898	155,619	184,047
Revaluation	76,679	131,589	151,234	120,925
Omissions & Errors (including emigrants)	-110,314	-114,125	-127,473	-157,034
Changes in Human Capital Stock	328,323	472,945	358,613	283,136
Closing Balance	2,997,060	3,470,005	3,828,618	4,111,754
FEMALE				
Opening Balance	1,717,170	1,948,398	2,334,262	2,658,080
Investment in Education				
Investment in post-school education	37,593	63,876	87,765	90,750
Depreciation on post-school investment	-11,419	-15,760	-24,384	-37,642
Net formation by post-school investment	26,174	48,116	63,380	53,108
Experience Factor				
Gross on-the-job investment	123,785	110,013	140,482	145,821
Depreciation on the job investment	-111,043	-151,766	-195,887	-220,242
Net on-the-job investment	12,742	-41,754	-55,405	-74,420
Persons Turning Working Age	340,898	404,026	394,857	410,493
Ageing of Base Level Human Capital	-226,040	-217,106	-255,622	-271,219
Immigrants	90,999	145,939	120,448	136,928
Revaluation	55,078	113,785	128,765	89,715
Omissions & Errors (including emigrants)	-68,623	-67,143	-72,605	-78,243
Changes in Human Capital Stock	231,228	385,864	323,818	266,362
Closing Balance	1,948,398	2,334,262	2,658,080	2,924,442

28. The accumulation account sheds light on the sources of growth of human capital stock over time. Through this accumulation account, we can allocate the change in the human capital stock during an accounting period across three factors: quality change, quantitative change and revaluation. The quality factor consists of two elements: net investment in post-school education and net investment in working experience. The quantitative factor consists of two elements: net population growth, which is measured by the sum of the item ‘persons turning working age’ and the item ‘ageing of base level human capital’; net migration, which is approximated by the sum of the item ‘immigrants’ and the item ‘Omissions and errors (including emigrants)’. The revaluation factor reflects the impact of other unaccounted factors on the growth of human capital over time.

29. Post-school education and working experience are two sources of quality growth in human capital. From 1981 to 2001, the gross human capital formation, in particular investment in formal education, grew at a rapid pace: its contribution to the growth of human capital stock rose from 19% for men and 16% for women during the early 1980s, to 36% for men and 34%

for women in the period 1996–2001. However, the magnitudes of depreciation also have trended upwards strongly since the first half of 1990s, which have significantly slowed the growth of human capital stock. As a result, the growth of net human capital formation slowed significantly. This phenomenon essentially reflects the impact of population ageing on long-term growth prospects of human resources available for sustainable economic growth and development.

30. In terms of net human capital formation, post-school education exceeds on-the-job training from the period 1991–2001 to become the dominant driver of quality growth in human capital for men. For women, post-school education is the main driver of quality growth in human capital for all accounting periods. The different patterns of net investment in working experience for men and women may be due to the much flatter earnings-age profiles for women.

31. The quantitative changes in human capital can be assessed by examining the items on other changes in human capital stock. The differences between the item 'persons turning working age' and the item 'ageing of base level human capital' are indicative of contributions of natural population growth to the growth of human capital stock. As the item 'omissions & errors' largely represents the value of emigrants, its differences with immigrants may be indicative of contributions of net migration to the growth of human capital stock.

32. Finally, revaluation of human capital represents net gains of human capital, which gauges the impact of other unaccounted factors on the growth of human capital over time. These factors include increasing quality of schooling over time, inter-generational externalities of human capital, investment in health and formation of social capital. These factors played an increasingly important role in the growth of human capital for both men and women. To quantify the contributions of these factors to the growth of human capital stock is an interesting future topic in the measurement of human capital.

V. IMPACT OF POPULATION AGEING

33. The ultimate cause of depreciation on human capital is finite work life. As people get older, they have less working periods available for market activities. The estimates of depreciation are measures of the impact of population ageing on the stock of human resources in the economy in dollar terms. This depreciation can be examined through a number of components in Table 3: ageing of base level human capital; depreciation on the investment in post school education; and depreciation of on-the-job investment. Ageing of the base level human capital is, to some extent, compensated for by persons turning working age. As can be seen from Table 3, the net effect of these is negative and the gap between the two is increasing over time. It is more pronounced for males than females. Indeed for females the increased labour force participation of women during the 1980s as more women combined work with family responsibilities meant that contribution to human capital growth of young women turning working age exceeded the loss due to ageing. However by the 1990s the pattern for women was similar to males. As can be seen also from Table 3, the growth of human capital has slowed down since 1991, from $473bn to $283bn in 2001 for males and from $386bn to $266bn for females. Both depreciation on the investment in post school education and on-the-job investment are contributing to this.

34. It has long been recognised that human capital is an important source of long-term economic growth. Our figures show that population ageing is reducing the net growth of

human capital. To counter the impact this may have on long-term economic growth various solutions and policy options might be contemplated. Our measurement framework could be used for quantifying the effects of these policy choices on the size of human capital stock. For example, it could help to answer the following questions: What is the necessary percentage increase in the labour force participation rate to counteract the impact of population ageing in the short term? To what extent could the increase in productivity through investment in education and training compensate the depletion of human resources caused by population ageing?

VI. OTHER ABS RESEARCH WORK ON THE MEASUREMENT OF HUMAN CAPITAL

A. Measuring economic benefits of completing secondary education

35. Using the lifetime labour income approach, this study[4] quantifies the economic benefits of completing secondary education in Australia. The purpose of focusing on secondary school education is to highlight the importance of base level education in the production of human capital over life cycles of young men and young women. The distinctive feature of this study is that it attempts to calculate the option values generated by completing secondary education: the opportunities for obtaining more advanced human capital skills through undertaking tertiary study programs. Option values are calculated as differences between alternative lifetime labour incomes associated with the corresponding schooling choices upon completing secondary education. The empirical results show that option values make up significant proportions of total returns to secondary education, ranging from 20 percent to 30 percent for men, and from 28 percent to 44 percent for women over the period 1986-2001. In particular, option values have become increasingly prominent in recent years, which have witnessed strong demand for more educated workers.

B. Estimating rates of return to post-school education

36. This study[5] estimates the rates of return to post-school education in Australia, with a focus on bachelor degrees. Both the financial method and Mincer's human capital earnings function method are applied. The expected private rates of return from investment in bachelor degrees increased over time for males, from 13.1 percent in 1981 to 19.6 percent in 2001, and then dropped to 15.3 percent in 2006; the range was 18.0 percent to 17.3 percent for females over the same period. This study also compares the two estimation methods. The key difference is that the financial method can account for the effect on earnings of enriched working experience associated with higher educational attainment, while the Mincer's method assumes parallel earnings experience profiles across educational levels. This study argues that the growth of human capital through increased working experience is an important economic benefit of investment in education, and therefore should be captured in calculating rates of return to education.

VII. FUTURE DEVELOPMENT AND CHALLENGES AHEAD

37. To move our research program forward, we have been developing measures of human capital at industrial and occupation levels. This research could shed light on the allocation of

[4] See Wei (2007)
[5] See Wei (forthcoming).

human capital among different industries over time and the process by which human capital grows from low skilled occupations toward high skilled occupations.

38. The Jorgenson and Fraumeni measurement system of human capital is based on a rich database constructed through decades of research effort. In contrast, our present study only uses Census data. Another possible research initiative is therefore to construct a comprehensive database, combining Census data, labour force statistics, data on labour earnings and hours worked, education statistics and migration statistics. To reconcile inconsistencies between alternative data sources is a daunting task.

39. Capital theory is one of the most difficult and contentious topics in economic theory, and accordingly the measurement of capital is one of the most complex dimensions in the official national accounting system.[6] It has taken many years for statisticians to develop and establish the existing physical capital measurement system as it is with the System of National Accounts 1993. Even so, there is still disagreement on several important issues. In the case of human capital, its measurement is probably more complex. Two aspects of human capital measurement differentiate it from that of physical capital: the productive capacity (human capital) embodied in an individual is typically not observed, and secondly, as an output of non-market activities, the value of human capital has to be imputed. The first aspect is the primary focus of the literature in understanding differences in human abilities and skills, their origins and their evolution over the lifecycle, while the latter raises many of the theoretical and practical issues in estimating returns to and investment in education and other ways of investing in people. It will be a long journey to reach significant international consensus on how to measure human capital by national economic accounting.

VIII. REFERENCES

Australian Government Treasury (2002) Intergenerational Report 2002-2003, Budget Paper no. 5, 14 may, Commonwealth of Australia.

Australian Government Treasury (2007) Intergenerational Report, Commonwealth of Australia.

Becker, G.S. (1964) *Human Capital*, First edition, Columbia University Press, New York.

Hill, P. (2003) "The Measurement of Intellectual Capital Formation in the System of National Accounts", Unpublished project paper.

Hulten, C. (1990) "The Measurement of Capital, In Fifty Years of Economic Measurement", in Berndt and Triplett (eds), *Studies in Income and Wealth*, 54, National Bureau of Economic Research.

Jorgenson, D.W. and Fraumeni, B.M. (1989) "The Accumulation of Human and Non-Human Capital, 1948–1984", in Lipsey, R.E. And Tice, H.S. (eds), *The Measurement of Savings, Investment, and Wealth*, pp. 227–282, University of Chicago Press, Chicago.

[6] According to Triplett (1996), "Controversies in the theory of capital have had their counterparts in the measurement of capital, which Hulten (1990) and others have called one of the most difficult tasks in economics" (p. 93).

Jorgenson, Dale W. and Fraumeni, Barbara M. (1992) "The Output of the Education Sector", in Griliches, Z. (ed.), *Output Measurement in the Service Sectors*, University of Chicago Press, Chicago.

Rosen, S. (1989) "Comment on 'The Accumulation of Human and Non-Human Capital, 1948–1984' ", in Lipsey, R.E. and Tice, H.S. (eds), *The Measurement of Savings, Investment, and Wealth*, University of Chicago Press, Chicago.

Rothschild, M. (1992) Comment on the Output of the Education Sector, in Z. Griliches (ed.) *Output Measurement in the Service Sectors*, The University of Chicago Press, Chicago.

Schultz, T.W. (1961) "Investment in Human Capital", *American Economic Review*, 51(1), pp.1-17.

Triplett, J. (1996) "Depreciation in Production Analysis and In Income and Wealth Accounts: Resolution of an Old Debate", *Economic Inquiry*, 34, January, pp. 93–115.
40. Wei, H. (2004) "Measuring the Stock of Human Capital for Australia", *Australian Bureau of Statistics Working Paper*, cat. no. 1351.0.55.001, ABS, Canberra.

Wei, H. (2007a) "Measuring Australia's Human Capital Development: The Role of Post-school Education and the Impact of Population Ageing", *Statistical Journal of International Association of Official Statistics*, 24(3), pp. 183-191.

Wei, H. (2007b) "Measuring Option Values and Economic Benefits of Completing Secondary Education in Australia", *Australian Bureau of Statistics Research Paper*, cat.No.1351.0.55.082, ABS, Canberra.

Wei, H. (2008) "Measuring Human Capital Flows for Australia", *Australian Bureau of Statistics Working Pape*r, cat. no. 1351.0.55.023, ABS, Canberra.

Wei, H. (forthcoming) "Measuring the Economic Returns to Post-school Education in Australia: Evidence From the Australian 1981-2006 Censuses", *Australian Bureau of Statistics Research Paper*, forthcoming.

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