United Nations ECE/CES/2011/24

Economic and Social Council

Distr.: General
5 April 2011

Original: English

Economic Commission for Europe

Conference of European Statisticians

Fifty-ninth plenary session
Geneva, 14-16 June 2011
Item 5 of the provisional agenda
Measuring human capital

Human capital: why is it important, why measurement matters

Note by Statistics Canada

Summary

This paper reviews the drivers of the measurement of human capital and presents evidence of their use in several areas in Canada. It argues that the measurement of human capital investment and human capital stock can be useful in informing policy debates on the contribution of investment in human capital to economic growth, the output and productivity performance of the education sector, the effect of education on economic outcomes of an individual, and ascertaining whether an economy is on a path of sustainable economic development.

I. Introduction

1. The System of National Accounts (SNA 2008) defines assets as entities that must be owned by some units (individuals, businesses and governments), and from which economic benefits are derived by their owner(s) by holding or using them over a period of time (SNA 2008, 1.46). The SNA includes fixed assets, such as machinery, equipment and structures within its asset boundary. It also includes certain natural resources assets such as land, and mineral deposits over which individuals or governments are exercising effective ownership rights.

2. However, the SNA (2008) does not treat human capital as an asset, and the national accounts provide no estimates of human capital stock and investment in education and training. Rather, expenditures on education are classified by final consumption and expenditures on staff training are classified as intermediate inputs.

3. In recent years, there has been renewed interest in the measurement of human capital in the countries[1] of the Organisation for Economic Co-operation and Development (OECD). Those estimates of human capital are developed to make them compatible with the national accounts so as to enlarge their usefulness—by enabling the construction of better measures of productivity, more complete wealth accounts, facilitating measures of volume in the non-market sector in the Accounts, and allowing the Accounts to generate useful summary statistics to serve the discussions surrounding sustainability. The connection of these initiatives to the National Accounts framework distinguishes them from other data that are collected on human capital which include years of education, school enrollment, training, and literacy and numeracy scores (e.g. OECD 1998).

4. This paper reviews the drivers of the measurement of human capital and presents evidence of their use in several areas for Canada. It argues that the measurement of human capital investment and human capital stock can be useful in informing policy debates in the following areas:

(a) What is the contribution of investment in human capital to economic growth?

(b) Is an economy on a path of sustainable economic development?

(c) What is the volume of output and productivity performance of the education sector?

(d) What is the effect of education on economic outcomes of an individual?

II. Treatment of human capital in the System of National Accounts

5. In the System of National Accounts, expenditures on human capital such as expenditures on education and training are all regarded as current expenditures (rather than investment). This, in effect, means that outlays on education, child rearing and training are

[1] Those studies include Australia (Wei 2004, 2008), Canada (Gu and Wong, 2010), New Zealand (Le, Gibson and Oxley 2002), Norway (Greaker and Liu 2008), Sweden (Ahlroth, Björklund and Forslund 1997), the United Kingdom (O'Mahony and Stevens 2009), and the United States (Christian and Fraumeni, 2005; Chistian, 2009). More recently, OECD (2010) provided an experimental measure of human capital in a number of OECD countries.

classified as current expenditures. The expenditures on training are classified as intermediate inputs, and expenditures on education are classified as final consumption.

6. Yet the concept of expenditures on education being an investment and the existence of human capital as a form of wealth have been familiar in economics for at least 40 years (e.g., Schultz 1961a, 1961b; and Becker 1964). Expenditures on physical capital and on human capital are analogous in that they are linked by a common economic characteristic. Both result in some benefits that are realized in future periods.

7. While the SNA recognizes that human capital in terms of knowledge, skills and qualifications embodied in individuals are assets in a broad sense that affect the value of the flow of services provided by labour (SNA 3: 19:55), it does not treat human capital as a non-financial asset. Assets in the SNA include fixed assets such as produced assets (machinery and equipment, and structures), and natural resources capital (including land, mineral deposits) plus certain specified expenditures on services that add to the value of nonproduced assets.

8. However, the SNA does recognize that it is useful to treat human capital as an asset to answer certain economic questions (SNA 2008, 29.12). For example, it is useful to treat human capital as an asset in order to understand the sources of labour productivity growth. In addition, the SNA (2008) has recommended that the treatment of human capital should be included in the National Accounts research agenda (SNA 2008, A4.55):

> "Human input is the major input in most production processes, and the value of that input is to a large extent dependent on the knowledge that humans bring to the production process. It is well recognized that an educated population is vital to economic well-being in most countries. Despite the fact that there are major conceptual and practical problems with identifying the value of an educated labour force, there are repeated requests to address this issue within the SNA framework."

9. There are significant challenges for developing human capital accounts and integrating human capital in the System of National Accounts. However, the measurement of human capital using the framework of the National Accounts provides a richer and more comprehensive perspective on a number of important economic questions. It also has the potential to provide a more comprehensive examination of those economic issues. The remainder of the paper summarizes the economic questions and measures of human capital that are available for addressing those questions.

III. Investment in human capital and economic growth

10. While economic analysis has identified investment in human capital to be a major determinant of economic and productivity growth, the National Accounts does not provide direct estimates of investment in human capital and its contribution to labour productivity growth in its core accounts.

11. The key for examining the contribution of investment in human capital is to recognize that expenditures related to education and training is investment rather than intermediate inputs or consumption. The contribution of investment in human capital to economic growth and labour productivity growth is often assessed using the growth accounting framework that underlies estimates of multifactor productivity growth that are produced by statistical agencies.

12. Measures of investment in human capital can be generated from total expenditures related to human capital investment which includes the cost of child rearing, costs of educational institutions, and earnings forgone by students. These estimates of investment in human capital can be aggregated using the perpetual inventory method to derive estimates

of human capital stock and can then be included into an expanded growth accounts to examine the contribution that investment in human capital makes to economic growth.

13. Kokkinen (2008) has adopted this expenditure-based approach to examine the contribution of investment in human capital to labour productivity growth in Finland. The recent literature on the contribution of intangible capital which includes investment in training also adopted this approach (e.g., Corrodo, Hulten and Sichel, 2005, 2009, and van Ark et al., 2009). Intangible capital in those studies consists of three main categories: computerized information; innovative property; and economic competencies, which include training and firm-specific human capital expenditures as a main component.

14. As an alternative to this expenditure-based approach, economists have constructed an index of labour compositional changes to evaluate the contribution of investment in human capital to economic growth and labour productivity growth (Jorgenson, Gollop, and Fraumeni, 1987). The index captures the shift in labour composition towards more educated and skilled workers that are made possible with investment in human capital. The index essentially represents the flow of services yielded by investment in human capital. This approach has become standard in the growth accounting literature and has been adopted by a number of statistical agencies.

15. Jorgenson, Ho and Stiroh (2005) have constructed an index of labour composition for G7 countries and examined the contribution of labour compositional changes to labour productivity growth in the G-7 countries (Table 1). Investment in human capital as captured by the index of labour composition was found to account for between 0.2 and 0.4 percentage point to annual labour productivity growth.

16. Data from European Union level analysis of capital, labour, energy, materials and service inputs (EUKLEMS) generates similar findings for a large number of OECD countries (van Ark, 2008). The Canadian experience is similar (Baldwin and Gu, 2010). In Canada, it accounts for 30% of labour productivity growth over the period 1960-2008.

IV. Human capital and sustainable development

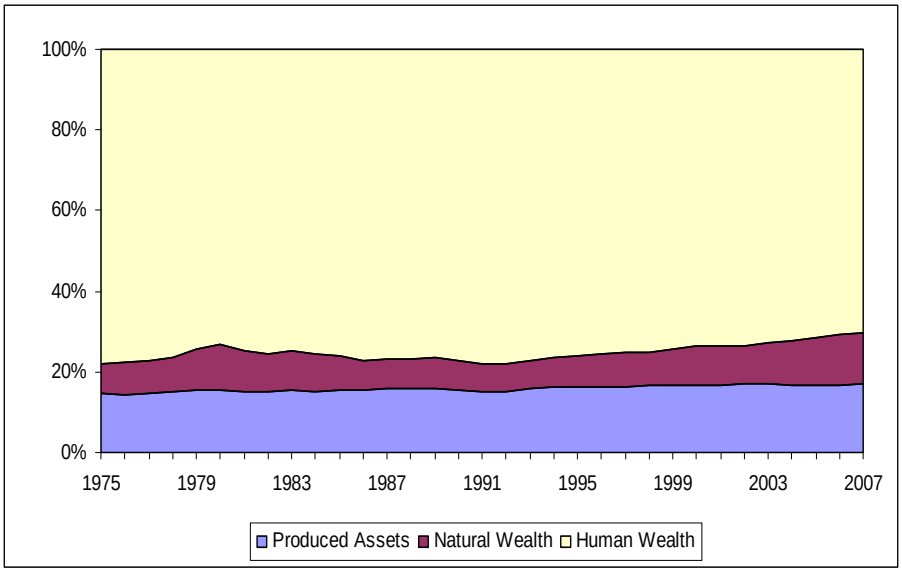
17. The so-called capital approach for sustainable development argues that an economy follows a path of sustainable development if total capital per capita does not decline (Arrow et al, 2007; United Nations Economic Commission for Europe (UNECE), 2009, Stiglitz Report, 2009). Total capital in these studies includes produced capital, natural capital, human capital, and social capital.

18. The World Bank (2006) estimated the total wealth of nations and concluded that human capital and the quality of institutions account for the majority of total wealth. The predominance of human capital in total wealth is also found in Arrow et al (2007) in their work on sustainable development for United States and China. It is also found in a number of other countries (including Australia, Canada, New Zealand, and the United States).

19. The predominance of human capital in total wealth suggests that the evolution of human capital per capita is an important indicator of whether an economy is on a path of sustainable development.

20. Gu and Wong (2010) developed an estimate of human capital for Canada and compared it to the value of produced capital and natural capital. The share of human wealth, produced capital and natural wealth is presented in Figure 1. The largest component of full wealth in Canada is human wealth, followed by produced capital and natural capital. Human wealth accounted for 70% of full wealth in 2007, while produced capital and natural capital accounted for 17% and 13%, respectively, in that year.

Figure 1
Distribution of total wealth in nominal dollars in Canada



Source: Gu and Wong (2010)

21. It is the change in the quantity or the volume index of total capital stock per capita that matters for sustainable development (Arrow, et al. 2007, Stiglitz Report, 2009).[2] Gu and Wong (2010) presents a measure of the quantity of total wealth per capita for Canada. Beween 1975 to 2007, total weath per capita in Canada has grown at 0.7% per year.

22. Changes in total wealth can be traced to changes in various components of total wealth. Gu and Wong (2010) find that human capital per capita declined in more recent years, which is offset by increases in the other two components of total wealth: produced capital and natural capital.

23. To examine the determinants of changes in human capital per capita over time in order to ascertain the sources of growth, Gu and Wong (2010) decompose the growth of Canadian human capital stock per capita into the contributions of changes in population characteristics such as age, gender and education. The relative effect of each is presented in Table 1.

24. Rising educational attainment in the Canadian population makes a positive contribution to the growth in aggregate human capital. It adds 0.9% to annual growth in human capital stock over the period from 1970 to 2007. It adds 1.4% per year to human capital growth in the 1970 to 1980 period and 0.7% per year to human capital growth in the 1980 to 2007 period.

25. The compositional effects of aging of the Canadian population after the early 1980s made a negative contribution to the growth in human capital stock, and it lowered the annual growth in human capital by 0.5% in the 1980-to-2000 period, and by 0.6% in the

[2] In general, the price of natural capital should reflect the shadow value of that asset (Stiglitz report, 2009), which involves large uncertainties for the case of natural capital and human capital. For the social capital, it is more difficult to estimate the nominal value and the corresponding price index.

2000-to-2007 period. Over the period 1980 to 2007, the aging of the Canadian population reduced human capital growth by 0.6% per year.

26. The results show that investment in education is an important determinant of growth in human capital per capita and thus sustainable development. The demographic change associated with the aging of the population presents a major challenge for sustainable development. For more recent years, the negative impact of the aging of the population on growth in human capital per capita more than offset the positive impact of investment in education, which leads to an overall decline in human capital per capita.

Table 1
The source of annual growth in human capital per capita

	1970 to 2007	*1970 to 1980*	*1980 to 2000*	*2000 to 2007*
		Percent		
Human capital stock	1.7	3.1	1.2	1.0
Working-age population	1.5	2.1	1.2	1.3
Human capital per capita	0.2	0.9	0.0	-0.2
First-order indices of human capital per capita				
Gender	0.0	0.0	0.0	0.0
Education	0.9	1.4	0.8	0.5
Age	-0.4	-0.1	-0.5	-0.6

Source: Gu and Wong (2010)

27. Alternatively, the evolution of human capital stock over time can be examined by decomposing the changes in human capital stock into three components: gross investment in human capital, depreciation on human capital and revaluation of human capital. The latter comes from changes in earning power that arise from short and long-run fluctuations in the economic environment. The methodology for constructing the accumulation accounts is similar to the one for decomposing the change in produced capital stock and was developed by Jorgenson and Fraumeni (1989).

28. Table 2 presents the accumulation accounts for human capital in Canada. Investment in human capital reflects additions to population due to the rearing of children (the arrival of new members of the native-born population into the workforce), formal education (skills upgrading from schooling post high school) and migration (new members of the population from outside Canada). The depreciation on human capital is the change in human capital stock because of aging, death and emigration. Gross investment net of depreciation represents net investment, or net saving (World Bank, 2006). The revaluation of human capital represents the change in human capital over time for individuals with a given set of demographic characteristics—gender, education and age—caused by changes in the macro environment.

29. Gross investment in human capital in constant prices rose by 0.3% per year over the period from 1990 to 2007. The depreciation due to aging, death and emigration increased at a faster rate than gross investment in human capital. As a result, net investment rate in human capital in Canada has been declining in recent years.

Table 2
Components of changes in human capital stock (billions of 2002 dollars)

	Gross investment	*Depreciation*	*Revaluation*	*Change in human capital*
1990	511.6	345.6	176.6	435.5
1991	436.2	349.5	173.5	380.2
1992	460.8	356.4	175.3	429.5
1993	453.5	360.9	194.3	442.7
1994	521.2	366.9	188.5	479.1
1995	536.3	371.2	205.3	514.9
1996	492.9	371.8	369.9	490.5
1997	462.6	378.5	289.5	367.2
1998	498.8	390.3	280.5	387.1
1999	487.3	397.2	282.5	371.4
2000	490.3	405.8	284.2	368.6
2001	501.5	419.3	287.0	370.8
2002	541.5	429.8	291.3	403.0
2003	513.0	436.9	295.1	371.4
2004	467.8	444.3	299.4	336.3
2005	472.9	452.1	302.4	338.4
2006	513.6	462.1	306.3	361.2
2007	534.4	469.7	309.5	372.6

Source: Gu and Wong (2010)

V. Investment in human capital and education sector output

30. In the System of National Accounts, the educational services produced by schools, colleges, and universities are treated as final consumption, either by households or government (SNA 2008). This treatment of education costs as final consumption is consistent with the definition of assets since the SNA excludes human capital as an asset.

31. As the expenditures on education are classified as final consumption, the value of education output is often deflated by the consumer price index to obtain the volume measure of education output. This measure of education output provides an imperfect measure of productivity performance in the education sector.

32. Recent advances in the measurement of education output and productivity performance start by recognizing that expenditures in the education sector involve investments in human capital that provide a future stream of earnings over the lifetime of an individual (Abraham, 2010). The output of the education sector represents the increase in

human capital in the form of knowledge and skills acquired by students during their educational years (Jorgenson and Fraumeni, 1992b).

33. The notion that the output of the education sector represents investment in human capital still leaves open the question of the extent to which increase in the value of education represent increase in the volume of knowledge and skills acquired by students through education, or whether it represents increase in the price index of education.

34. Attempts to measure the real output of the education sector often assume that students with the same education level and other characteristics have the same level of knowledge and skills. The output of education sector is then calculated as the weighted sum of student enrolments using expenditures that are incurred on students. Alternately, it is estimated as a weighted sum of student enrolments using the effect of education on the lifetime income as weights.

35. Gu and Wong (2011) construct the cost-weighted and income-weighted index of student enrolment for Canada as a measure of education output. They find that the two measures have similar *growth* rates. But there is a large difference in the *level* of education output produced by these two approaches. The total expenditures on education (teachers' labour compensation, capital costs, and intermediate input costs) are much less than the income-based measure of education output. The income-based estimate of the nominal value of education service was about 7 times as large as the cost-based estimate in 2005, since the income-based estimate includes the value of non-market activities such as student time in the estimate of education output.

VI. Investment in human capital and the return to education

36. A comprehensive treatment of human capital as an asset in the National Accounts should include the estimates of inputs and outputs (Fraumeni, 2008). Estimates of the increments in human capital in terms of lifetime income coming from increases in education levels can be compared to estimates of investments made in the education system to generate rates of return to education. The outputs and inputs of human capital accounts complement one another and provide information that is useful for evaluation of the efficacy of investments in education, or alternately, methods of testing the coherence of human capital accounts.

37. McGrattan (2010) has observed that there are few linkages between the research on human capital accounts and the research on the economic impact of education. That need not be the case. Recognizing human capital as an asset in the national accounts and the development of human capital accounts has the potential to provide a comprehensive overview of the return to education.

38. The research on returns to education is often based on estimating the Mincer regression of log earnings on years of schooling and years of post-school work experience. The coefficient on the schooling in that equation is often interpreted as an estimate of the rate of return to education (Mincer 1962 and 1981). Heckman et al. (2008) argue that the functional form of the Mincer model no longer adequately describes labour earnings for U.S. workers. They propose an alternative empirical framework that involves the calculation of present discounted value of lifetime earnings—the methodology used in creating the human capital accounts.

39. The comparison of lifetime incomes and expenditures on education should provide a more accurate estimate of returns to education. The lifetime income calculation takes into account the differences in hourly earnings, hours worked, the employment rate, and differences in the working life between people with different education levels. It is well

documented that people with more education are more likely to be employed, tend to work longer hours, have higher hourly earnings. But they may have shorter working life due to the longer time they spent in school. The human capital accounts can take into consideration all these factors.

40. Wei (2010) provides an example of how the income and cost estimates related to human capital can be used to calculate the returns to education in Australia. He finds that the estimates of rate of returns to education from human capital calculation differ from the results from estimating the Mincer type earnings regression. He attributes the difference to the assumption implicit in the Mincer model that the return to experience for an individual is independent of the individual's education level.

41. The existing estimates of human capital for other countries can be also used to provide an estimate of returns to education. As an illustration, Table 3 presents the present discounted value of average lifetime labour income for a person with different education levels for Canada (Gu and Wong, 2011).

42. The percentage point increase in the lifetime income between two education levels over the time period that is required for an individual to attain the higher education level provides an estimate of returns to education, if we ignore the costs of education. The estimates are presented in the bottom panel of Table 3. To calculate the return to education, it is assumed that individuals with zero to eight years of schooling take three years to complete the next education level (some or completed high school); that individuals with some or completed high school take two years to complete some post-secondary education; that individuals with some post-secondary education take two years to complete a bachelor's degree and that individuals with a bachelor's degree take two years to complete a master's degree or above.

43. These estimates reveal that there are relatively larger returns to the secondary education than from post-secondary education. Heckman et al (2008) reports similar results for the U.S. However, it should be noted that the returns to education calculation in Table 3 does not control for the gender characteristics and differences in student abilities.

Table 3
Average present discounted value of lifetime labour income per student and returns to education

	Primary	*Secondary*	*Post-secondary*	*Bachelors Degree*	*Masters Degree or above*
	Lifetime income (000s dollars)				
1997	145.6	434.1	547.5	691.6	735.9
1998	149.5	445.6	553.7	702.7	742.7
1999	155.2	458.0	564.2	699.2	743.8
2000	153.7	468.5	584.2	713.0	743.5
2001	160.6	481.2	594.4	726.8	742.8
2002	163.5	488.5	600.8	737.0	759.1
2003	168.0	492.9	611.6	743.8	776.3
2004	181.6	512.0	633.9	786.9	816.6
2005	194.3	540.1	649.7	800.5	823.3
2006	213.2	563.3	668.7	830.3	873.1
2007	220.1	585.2	691.0	848.7	874.7
	Rates of return to additional year of education				
1997		36.4	11.6	11.7	3.1
1998		36.4	10.9	11.9	2.8

	Primary	*Secondary*	*Post-secondary*	*Bachelors Degree*	*Masters Degree or above*
1999		36.1	10.4	10.7	3.1
2000		37.2	11.0	10.0	2.1
2001		36.6	10.6	10.1	1.1
2002		36.5	10.4	10.2	1.5
2003		35.9	10.8	9.8	2.1
2004		34.5	10.7	10.8	1.8
2005		34.1	9.2	10.4	1.4
2006		32.4	8.6	10.8	2.5
2007		32.6	8.3	10.3	1.5

Source: Gu and Wong (2010)

44. Another illustration of how human capital estimates can be used to provide information on returns to education is presented in Table 4. This table contains an estimate of the effect of an additional year of education on the present discounted value of the future lifetime income, and total education expenditures per student in Canada. One additional year of college education increases the value of lifetime earnings by 109,000 dollars in 2005, which is much higher that total expenditures on college education per student in that year. The difference is partially attributed to the value of the time that students spend in school. More detailed study holds the potential for identifying this component and isolating the residual that is the return to education.

Table 4
Returns to education and expenditures on education in thousand dollars

	Effect of additional year of education on lifetime income					*Costs per student*
	Grade 0-8	High school	College or above	Primary and secondary	College	University
1997	40.3	93.9	108.1	7.0	11.0	13.5
1998	41.6	92.0	109.8	7.1	10.4	14.1
1999	42.6	94.6	107.8	7.2	10.6	14.6
2000	43.2	103.6	109.5	7.5	10.4	15.7
2001	44.9	99.3	113.0	7.8	10.7	16.5
2002	45.2	111.1	111.3	8.1	10.9	17.1
2003	45.1	117.1	106.3	8.5	10.5	17.5
2004	47.2	98.7	110.6	9.0	10.9	18.1
2005	49.5	93.0	109.0	9.3	11.6	18.8

Source: Gu and Wong (2011)

VII. Conclusions

45. The products that have been described here differ in terms of importance. There are some products that can be regarded as key products that are essential to central activities. Productivity programs that measure multifactor productivity have become key mainstays of many statistical agencies. And these require the data that are foundational for the estimates of human capital. Moving from the data bases required to produce multifactor productivity to estimates of human capital is a relatively short step.

46. When this is done, estimates of human capital provide valuable inputs for those interested not just in how skilled labour contributes to economic growth; they also inform the debate on sustainability, help to develop an extended Financial or Wealth Accounts, provide ways to measure the volume of output in the non-market education sector and allow for an examination of the rates of return to education.

47. Whether a statistical agency chooses to proceed to produce either experimental or final products in these areas will depend on whether there is a desire to experiment with the type of new products that follow—whether statistical agencies choose to support requests for estimates of productivity that take into account the skill level of workers; aid in evaluating the sustainability of economies; whether there is a will to experiment with expanding the boundaries of the Wealth Accounts to consider more forms of assets; to understand whether and how societies are replacing human capital with other forms of physical capital as their population ages and stocks of human capital decline; whether there is a desire to experiment with ways of filling out the National Accounts to provide better volume estimates of the non-market sector in education; and whether there is a desire to see how the production boundaries of the National Accounts can be expanded as Human Capital Accounts are extended to take into account household production.

48. Much of these efforts will involve experimentation before the new products meet acceptable standards. But innovation in statistical agencies often requires experimentation. What is noteworthy about the human capital agenda is the range of areas where promising advances are likely to be made.

VIII. References

Abraham, Katharine G. 2010. “Accounting for Investments in Formal Education”, University of Maryland.

Ahlroth, S., A. Björklund and A. Forslund. 1997. “The Output of the Swedish Education Sector.” *Review of Income & Wealth.* Vol. 43. No.1. p. 89–104.

Arrow, K., P. Dasgupta, L.H. Goulder, K. Mumford, and K. Oleson. 2007. *China, the U.S., and Sustainability: Perspectives based on Comprehensive Wealth*” Stanford (California). Stanford University. Stanford Center for International Development, Working Paper No. 313.

Baldwin, J.R, and W. Gu. 2010. “Productivity Performance in Canada, 1961 to 2008: An Update on Long-term Trends,” *The Canadian Productivity Review.* Catalogue 15-205. No. 25. Ottawa: Statistics Canada.

Becker, G.S. 1964. *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education.* New York. Columbia University Press.

Christian, Michael S. 2009. “Human Capital Accounting in the United States: 1994 to 2006.” Wisconsin Center for Education Research. Unpublished working paper.

Christian, Michael and Barbara M. Fraumeni. 2005. "Measuring the Education Function of Government." Unpublished. Bureau of Economic Analysis.

Corrado, C.A., Hulten, C.R, and D.E. Sichel. 2005. "Measuring Capital and Technology: An Expanded Framework." In C. Corrado, J. Haltiwanger and D. Sichel (eds) Measuring Capital in the New Economy. NBER Studies in Income and Wealth. Volume 65. Chicago and London: University of Chicago Press.

Corrado, Carol, Charles Hulten, and Daniel Sichel, 2009. "Intangible Capital and U.S. Economic Growth," *Review of Income and Wealth*, 55, 661–85.

European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations and World Bank, 2009. *System of National Accounts 2008*, New York.

Fraumeni, B.M. 2008. "Human capital: From indicators and indexes to accounts." *Joint OECD – Fondazione Giovannni Agnelli Workshop on the Measurement of Human Capital.* Turin, Italy. November 3–4.

Fraumeni, Barbara M., Marshall B. Reinsdorf, Brooks B. Robinson and Matthew P. Williams. 2008. "Price and Real Output Measures for the Education Function of Government: Exploratory Estimates for Primary and Secondary Education." National Bureau of Economic Research Working Paper No. 14099. July.

Greaker, M., and G. Liu. 2008. "Measuring the stock of human capital for Norway: A lifetime labour income approach." *Joint OECD – Fondazione Giovanni Agnelli Workshop on the Measurement of Human Capital.* Turin, Italy. November 3–4.

Gu, Wulong, and Ambrose Wong. 2010. "Estimates of Human Capital in Canada: The Lifetime Income Approach" Economic Analysis Research Paper Series no. 62 Ottawa: Statistics Canada.

Gu, Wulong, and Ambrose Wong. 2011. "Investment in Human Capital and the Output of the Education Sector" Economic Analysis Research Paper Series no. 63. Ottawa: Statistics Canada. forthcoming

Heckman, James J., Lance J. Lochner, and Petra E. Todd. 2008, "Earnings Functions and Rates of Return", J*ournal of Human Capital*. Vol. 2(1), 1-31.

Jorgenson, Dale W., Frank M Gollop, and Barbara M Fraumeni, 1987, *Productivity and U.S. Economic Growth,* Harvard University Press.

Jorgenson, D.W., and B.M. Fraumeni. 1989. "The Accumulation of Human and Nonhuman Capital, 1948–84." *The Measurement of Savings, Investment, and Wealth.* R.E. Lipsey and H. Stone Tice (eds.). Chicago. University of Chicago Press. p. 227–286.

Jorgenson, D.W., and B.M. Fraumeni. 1992a. "The Output of the Education Sector." *Output Measurement in the Service Sectors.* Zvi Griliches (ed.). Chicago. The University of Chicago Press. p. 303–338.

Jorgenson, Dale W., and Barbara M. Fraumeni. 1992b. "Investment in Education and U.S. Economic Growth." *Scandinavian Journal of Economics.* Vol. 94. No. 0 (Supplement). p. S51–70.

Kendrick, J.W. 1976. *The Formation and Stocks of Total Capital.* New York. Columbia University Press for the National Bureau of Economic Research.

Kokkinen, A. 2008. "Human capital and Finland's economic growth in 1910–2000. Assessing education-based human capital accumulation inside the National Accounts Framework." *The 30th General Conference of the International Association for Research in Income and Wealth.* Portoroz, Slovenia. August 24–30.

Le, T.V.T., J. Gibson and L. Oxley. 2002. "A Forward Looking Measure of the Stock of Human Capital in New Zealand." *Annual conference of the New Zealand Association of Economists*. Wellington.

McGrattan, Ellen R. 2010, Comments: "Human Capital Accounting in the US: 1994-2006", Federal Reserve Bank of Minneapolis and University of Minnesota.

Mincer, J. 1962. "On-the-job Training: Costs, Returns and Some Implications." *Journal of Political Economy.* Vol. 70. No. 5 (Part 2). p. 50–79.

Mincer, J. 1989. "Human Capital and the Labor market." *Educational Researcher.* Vol. 18. No. 4. p. 27–34.

O'Mahony, M., and P. Stevens. 2009. "Output and Productivity Growth in the Education Sector: Comparisons for the US and UK." *Journal of Productivity Analysis.* Vol. 31. p. 177–194.

Organisation for Economic Co-operation and Development (OECD). 1998. *Human Capital Investment: An International Comparison*. Paris. OECD.

Organisation for Economic Co-operation and Development (OECD). 2010. "The OECD Human Capital Project: Progress Report", Paris. OECD.

Schreyer, Paul. 2009. *Towards Measuring the Volume of Health and Education Services, Draft Handbook*. Paris: OECD.

Shultz, T.W. 1961a. "Investment in Human Capital." *American Economic Review*. Vol. 51. No. 1. p. 1–17.

Shultz, T.W. 1961b. "Investment in Human Capital: Reply." *American Economic Review*. Vol. 51. No. 5. p. 1035–1039.

Stiglitz Commission, 2009, "Report by the Commission on the Measurement of Economic Performance and Social Progress", Paris.

United Nations Economic Commission for Europe (UNECE). 2009. *Measuring Sustainable Development*. Geneva and New York. United Nations. Prepared in cooperation with the Organisation for Economic Co-operation and Development and the Statistical Office of the European Communities.

Van Ark, B., J.X. Hao, C. Corrado, and C. Hulten. 2009. "Measuring Intangible Capital and its Contribution to Economic growth in Europe," EIB papers.

Van Ark. B., M. O'Mahoney, M. P Timmer. 2008. "The Productivity Gap between Europe and the United States: Trends and Causes" Journal of Economic Perspectives, 22(1) 25-44.

Wei, H. 2004. "Measuring the Stock of Human Capital for Australia: A Lifetime Labour Income Approach", Australian Bureau of Statistics Research Paper.

Wei, H. 2008. "Measuring Human Capital Flows for Australia: A Lifetime Labour Income Approach", Australian Bureau of Statistics Research Paper.

Wei, H. 2010. "Measuring Economic Returns to Post-School Education in Australia: Evidence from the 1981-2006 Australian Censuses", Australian Bureau of Statistics Research Paper.

World Bank. 2006. "Where is the Wealth of Nations? Measuring Capital for the XXI Century, Working Paper no. 14